МИНИСТЕРСТВО ОБРАЗОВАНИЯ И НАУКИ РОССИЙСКОЙ ФЕДЕРАЦИИ
Федеральное государственное бюджетное образовательное учреждение
высшего профессионального образования
**«НАЦИОНАЛЬНЫЙ ИССЛЕДОВАТЕЛЬСКИЙ
ТОМСКИЙ ПОЛИТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ»**

PETROLEUM ENGINEERING
COURSE BOOK

НЕФТЕГАЗОВОЕ ДЕЛО
КНИГА ДЛЯ СТУДЕНТОВ

Рекомендовано Учебно-методическим объединением по образованию в области лингвистики Министерства образования и науки Российской Федерации в качестве учебного пособия для студентов старших курсов и магистрантов высших учебных заведений, обучающихся по геологическим, нефтяным и нефтегазовым специальностям, включая направление «Экономика на предприятиях нефтяной и газовой промышленности»

Под редакцией
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Данное пособие предназначено для студентов IV курса и магистрантов ИГНД, прослушавших курсы профессиональных дисциплин на русском языке и изучающих вопросы нефтегазового дела в рамках профессионального иностранного языка.

Цель пособия – подготовить студентов к профессиональному общению на английском языке в соответствии с рабочей программой дисциплины «Профессиональный иностранный язык».

Может использоваться как для аудиторной, так и для самостоятельной работы студентов. Тексты составлены на основе аутентичной учебной и научной литературы.

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PETROLEUM ENGINEERING

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INTRODUCTION

Petroleum Engineering (Part I, II, and III), content-based instruction, is suitable for engineers and technicians who need English in developing academic content knowledge and foreign language proficiency. Content-based instruction (CBI) is by no means a new concept to language education. Since the 1960s, interest in teaching language for specific purposes has led educators to explore the inclusion of meaningful content in language classrooms abroad. Many foreign universities have increasingly focused on developing content proficiency in second-language learners (Eastern Michigan University, Georgetown University, Monterey Institute of International Studies, etc.). Key Russian education institutes have accumulated concrete experience in English language teaching method approaches for engineer-students, one of which is Tomsk Polytechnic University (TPU). In the walls of this University the above-mentioned problem – language competence formation of future engineers- was discussed and a multi-level up-dated language-training program was designed As it has been noted, CGI in Russian engineering education system still remains an unexplored research area. Tomsk Polytechnic University (namely, Geology & Petroleum Engineering Institute) has become a resource center in the field of developing new CBI courses. The results from this piloting course could serve as a model course for university engineering curriculum reform as a communicative aspect in the professional area of a future engineering specialist (in our case, Petroleum Engineering).

The Approach and Principles

Petroleum Engineering has been designed to meet the needs of both learners and teachers. Our course is based on such defining characteristics in CBI as:

- learners are exposed to language while learning about other content areas;
- content areas are relevant to the learner's academic\ professional needs;
- language is contextualized through these relevant areas;
- support is provided for learner's linguistic development;
- focus is placed on developing academic\ professional language proficiency;
- authentic materials are used to present content matter;
- use of authentic materials lends itself to *the integration of skills, to increased motivation and to increased cognitive and linguistic complexity*.

  (*Content, Tasks and Projects in the Language Classroom, Monterey Institute*, *2004, pg. 28–29)*

Several elements in particular have shaped this course approach:

1. no explicit grammar instruction – in our case, we considered the approach *focus on form S.* The grammatical forms themselves become the focus of the lesson, rather than the meaning being conveyed;
2. only authentic materials are used – this enables learners to interact with the language of native speakers, including grammatical features, discourse structures, sociolinguistic features and cultural referents. Selected materials are in various formats, but audio and visual materials are limited, so the course materials are mostly in written form;
3. material resources – Internet, articles from journals, books on a particular theme topic for native speakers of English, content-based ESL textbooks, encyclopedias;
4. reading and writing tasks – mostly done outside the classroom as assignments and then used for interaction activities in class.

Thus, this new CBI course in *Petroleum Engineering* is organized around a subject-matter core and is appropriate to the needs of specific groups of students. The main purpose is language proficiency development for 4th–5th year students of Geology & Petroleum Engineering Institute. This is the first attempt to develop a technology of interaction between linguistic teachers and engineering departments. The integration between specialist studies / activities and the language is that factor which makes it possible to transfer from professional-orientated teaching to professional communicative teaching, adapting to the international requirements in engineering education and to meet the challenges of the international academic and professional workplaces.

The Course

The main emphasis throughout *Petroleum Engineering* is on developing the following communicative language principles:

- student-centered classroom;
- focus on meaning and use rather than form and usage;
- extensive use of pair and group work;
- cooperative learning;
- integration of four language skills;
- teacher's role as a facilitator.

(Content, Tasks and Projects in the Language Classroom, Monterey Institute, 2004, pg. 1–2)

This course is designed for those learners who have achieved pre-intermediate /intermediate level and can be used in the following way:

1. from start to finish, i.e. it takes about 76 hours (+72 hours of self-assessment) to complete this course;
2. as a dip-in resource, i.e. each unit and each section of this course is free-standing, so sections can be selected and used out of sequence according to the needs of particular students;
3. as a revision course, i.e. for those students who have already taken such a course, and want to add a new practical dimension to their professional English.

Course Components

As this innovative course *Petroleum Engineering* is an implementation of a content-based EFL curriculum, it includes the following components:

Course Book – *Introduction to Petroleum Engineering* is the core book that students will need for class work. Special focus is placed on the development of learner autonomy, where three principles: individualization, interdependence and interaction are integrated. It has two parts:

Part I – Introduction which includes 4 common topics: Petroleum Engineering, Oil Companies, Petroleum Geology and HSE (Health, Safety and Environment).

Part II – includes 5 sustained content courses, organized around specific themes and topics. In these course materials conveyed content information is on such topics as Geophysics, Oil Exploration, Pipeline Engineering, Drilling, Hydroecology and Geoecology. These courses are free-standing sections. There are Appendixes for additional information, which can be used for pairwork activities and self-assignments.

Part III – Environmental Control in Petroleum Engineering is intended for the students of all Petroleum Engineering Specialities who are interested in solution of ecological problem as well as in decrease of risk resulted from oil and gas exploration and production activities.

Guideline – *Guide to Effective Technical Writing & Professional Communication* is a course where academic subjects are taught in English. It is tailored to the specific needs of students in their technically oriented majors. It will aid those who plan to continue technical careers that require sufficient knowledge of technical writing and professional communication. A CD is available which includes presentations on all discussed topics.

Teacher's Book – gives recommendations of advisory character. It offers keys for every unit in both parts and introduces a framework for structuring and shaping the whole course material and references for the teacher's convenience.

Test Booklet – includes review sections for each part and unit. These tests take around an hour to complete and they revisit and consolidate key language from earlier studied sections and units.

Recordings – includes all listening material for three parts**,** available in CD form.

ACKNOWLEDGEMENTS

This course would not have been possible without the knowledge we acquired during the past 10 years through consulting, teaching and conducting workshops at Tomsk Polytechnic University. Many people have contributed in a variety of ways in the preparation of this innovative course «*Petroleum Engineering*». We would like to thank the specialists of Geology & Petroleum Engineering Institute, TPU, all of whom brought their professionalism and expertise to guiding and shaping this course in its various stages. Our special thanks to Professor, Head of Geoecology and Geochemistry Department of TPU Leonid P. Rikhvanov, Associate Professor of Tomsk State University Olga Nagel, our indefatigable reader and Associate Professor, Head of English Language Department, TPU N. Kachalov, our editor.

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INTRODUCTION TO PETROLEUM ENGINEERING

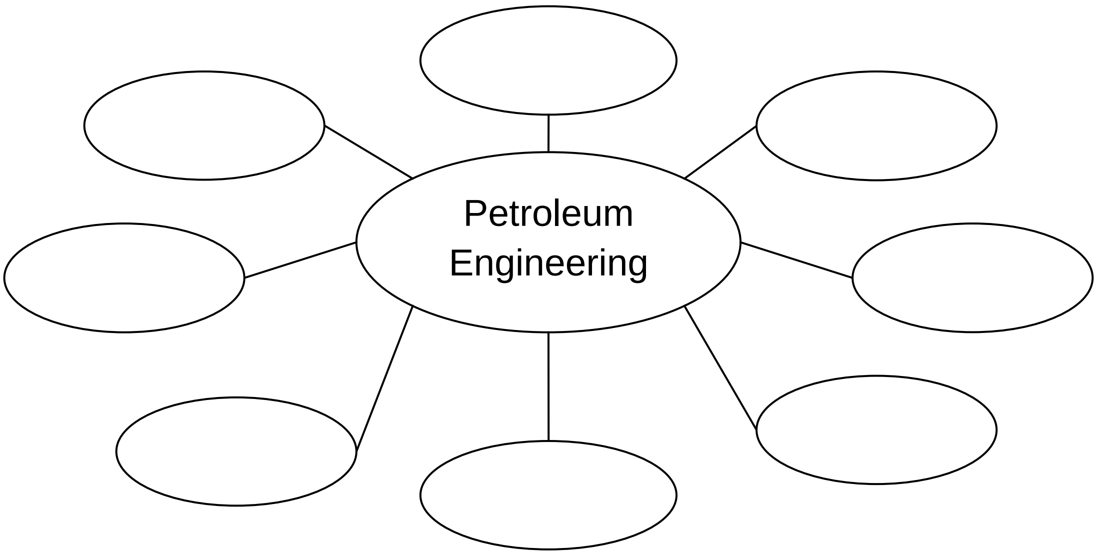
UNIT 1

PETROLEUM ENGINEERING

Petroleum engineering refers to the subsurface engineering activities related to the production of hydrocarbons which can be either crude oil or natural gas.

Lead-in

Fill in the spidergram with the words associated with Petroleum engineering.



Explain your associations**.**

Terms and Vocabulary

upstream	разведка и добыча / Блок Разведки и Добычи (Апстрим)
downstream	переработка и сбыт / Блок Переработки и Сбыта (Даунстрим)
supply	поставка, снабжение

well completion	заканчивание скважины
depletion	истощение, выработка
implement	внедрять, вводить в действие
artificial lift	механизированная добыча
downhole flow control	регулирование дебита скважины
workover	капитальный ремонт (КРС)
waterflooding	Заводнение
vendor	Поставщик
reserves	экономические запасы
lease	контракт на аренду нефтеносного участка
bit program	программа использования буровых долот
probability analysis	анализ вероятности
enhanced oil recovery	добыча нефти с искусственным поддержанием энергии пласта
(well) placement	размещение (скважин)
interface	поверхность раздела (двух фаз или слоёв жидкости)
regulatory body	контролирующий орган
hydrocarbon recovery	добыча, отбор (нефти, газа из коллектора); отдача (коллектора)
surveillance	осмотр; обследование; технический надзор; контроль
material balance (modeling)	материальный баланс
inflow\outflow	приток\выход
simulation modeling	(имитационное) моделирование
offset (v)	уравновешивать, нивелировать, сводить на нет
layout	план, схема
(hydrocarbon) release	Выделение
formation breakdown	разрыв пласта
via	посредством чего-л.
toolbox	инструментарий
layoff	приостановка
be savvy in	быть осведомленным, разбираться (в к.-л. вопросах)
involve	вовлекать, быть связанным
refer **to**	относиться, отсылать; обращаться
hold (held) to a high standard	предъявлять высокие требования
compare **to**	сравнивать; сопоставлять
contend **with**	бороться; справляться, противостоять

become commonplace **in**	стать привычным делом, обычным явлениям
be concerned **with**	иметь дело, рассматривать, иметь отношение
be of particular interest **to**	представлять особый интерес для к.-л.
play a (central) role **in**	играть, выполнять роль
specialize **in**	Специализироваться
be in charge **of** (N)	быть ответственным за, отвечать
measure (v)	измерять, замерять
in conjunction **with**	в соединении; в связи; вместе
cover a wide range **of**	охватывать широкий диапазон (круг)

1. Read and learn the pronunciation.

[i:] complete, completion, deplete, depletion, increasingly, recent, scheme, machine, upstream, downstream, continuous
[e] bury, estimate, vendor
[o:] wellbore, forecast, audit, hydraulics, support
[ə:] survey, reserves, concerned, refer, subsurface, curve, thermodynamics
[ju:] consumer, computer, accurate, numerical, value
[ai] provide, supply, decline, design, divide, specify, high, type, optimize, maximize
[aiə] require, acquire, environment, via
[k] mechanics, chemistry, scheme, technique

2. Pay attention to the stress in the following words.

′reservoir	tech′nique
proba′bility	′regulatory
en′hanced	sur′veillance
′drastically	′discipline

3. Read the text, do the exercises.

Petroleum engineering

Petroleum engineering is involved in the exploration and production activities of petroleum as an **upstream** end of the energy sector. Upstream refers to the process of finding and extracting oil, which is usually buried deep beneath the earth's surface, to provide a continuous **supply** to consumers "**downstream".** Petroleum engineering covers a wide range of topics, including economics, geology, geochemistry, geomechanics, geophysics, oil drilling, geopolitics, knowledge management, seismology, tectonics, thermodynamics, well logging**, well completion**, oil and gas production, reservoir development, and pipelines.

Petroleum engineering has become a technical profession that involves extracting oil in increasingly difficult situations as the "low hanging fruit" of the world's oil fields are found and depleted. Improvements in computer modeling, materials and the application of statistics, **probability analysis**, and new technologies like horizontal drilling and **enhanced oil recovery**, have drastically improved the **toolbox** of the petroleum engineer in recent decades.

As mistakes may be measured in millions of dollars, petroleum engineers are held to a high standard. Deepwater operations can be compared to space travel in terms of technical challenges. Arctic conditions and conditions of extreme heat have to be contended with. High Temperature and High Pressure (HTHP) environments that have become increasingly commonplace in today's operations require the petroleum engineer to **be savvy** in topics as wide ranging as thermohydraulics, geomechanics, and intelligent systems.

Petroleum engineers must **implement** high technology plans with the use of manpower, highly coordinated and often in dangerous conditions. The drilling rig crew and machines they use becomes the remote partner of the petroleum engineer in implementing every drilling program. Petroleum engineering has historically been one of the highest paid engineering disciplines; this is **offset** by a tendency for mass **layoffs** when oil prices decline. According to a survey published in Dec 2006 the average income was $116,834. Petroleum engineers divide themselves into several types:

- Reservoir engineers work to optimize production of oil and gas **via** proper **well placement**, production levels, and enhanced oil recovery techniques.
- Drilling engineers manage the technical aspects of drilling both production and injection wells.

- Production engineers (also known as completion or subsurface engineers) manage the **interface** between the reservoir and the well, including perforations, sand control, **artificial lift, downhole flow control,** and downhole monitoring equipment.

Reservoir engineering is a branch of petroleum engineering, typically concerned with maximizing the economic recovery of hydrocarbons from the subsurface.
Of particular interest to reservoir engineers is generating accurate reserves estimates for use in financial reporting to the SEC and other **regulatory bodies**. Other job responsibilities include numerical reservoir modeling, production forecasting, well testing, well drilling and **workover** planning, economic modeling, and PVT analysis of reservoir fluids.

Reservoir engineers also play a central role in field development planning, recommending appropriate and cost effective reservoir **depletion** schemes such as **waterflooding** or gas injection to maximize **hydrocarbon recovery.**
Reservoir engineers often specialize in two areas:

- **Surveillance** (or production) engineering, i.e. monitoring of existing fields and optimization of production and injection rates. Surveillance engineers typically use analytical and empirical techniques to perform their work, including decline curve analysis, **material balance modeling**, and **inflow/outflow** analysis.
- **Simulation modeling**, i.e. the conduct of reservoir simulation studies to determine optimal development plans for oil and gas reservoirs.

Drilling engineering is a subset of petroleum engineering, involved in the design and drilling of production and injection wells. The planning phases of drilling an oil well typically involve estimating the value of sought reserves, estimating the costs to access **reserves,** acquiring property by a mineral **lease**, a geologic survey, a wellbore plan, and a **layout** of the type of equipment depth of the well.

Drilling engineers are engineers in charge of the process of planning and drilling oil wells. Their responsibilities include:

- Designing casing strings in conjunction with drilling fluid plans to prevent blowouts (uncontrolled **hydrocarbon release**) and **formation breakdown.**
- Designing or contributing to the design of drill strings, cement plans, directional plans, and **bit programs**.
- Specifying equipment, material and ratings and grades to be used in the drilling process.
- Providing technical support and audit during the drilling process.

- Performing cost estimates and analysis.
- Developing contracts with **vendors.**

It is their responsibility to ensure that the well is drilled in a safe, cost-effective and effective manner.

(www. Wikipedia.ed)

4. Match the English terms in column «A» with their Russian equivalents in column «B».

A	B
1. depleted	A.буровая бригада
2. enhanced oil recovery	B. заканчивание скважины
3. exploration	C. каротаж
4. production	D. добыча нефти усовершенствованным методом
5. drilling rig crew	E. нагнетательная скважина
6. reservoir development	F. добыча
7. well completion	G. истощённый (о запасах)
8. well logging	H. разработка пласта
9. injection well	I. трубопровод
10. pipeline	J. разведка

5. Find the synonyms to the following words in the text.

To deal with, to put into operation, simulation, to improve, to exhaust, to finish, evaluating, observation, to be responsible for.

6. Find the antonyms to the following words in the text.

Outflow, above, downstream, to minimize, beginning.

7. Decipher the following abbreviations used in the text.

SEC, PVT, HTHP.

8. Fill in the gaps with the appropriate prepositions.

1. Easily accessible oil can be compared_____ low hanging fruits. 2. Petroleum engineers are **_____**charge of implementing high technology plans with the use of manpower. 3. Drilling engineering is concerned **____**designing and drilling oil wells. 4. The profession of petroleum

engineering is involved______ exploration and extraction of oil. 5. Designing casing a string is performed in conjunction ______ drilling fluid plans. 6. Reservoir engineers optimize production of oil and gas ________proper well placement and enhanced oil recovery.

9. Give English equivalents to Russian words.

1. Petroleum engineers ***(предъявляются)*** to a high standard as mistakes may cost too much. 2. High Temperature and High Pressure conditions have become ***(обычное явление)*** in today's oil recovery. 3. Petroleum engineering ***(охватывает широкий диапазон)*** of topics, including geology, geophysics, and geochemistry. 4. Generating accurate reserves estimates is ***(представлять особый интерес)*** to reservoir engineer. 5. Petroleum engineer should be ***(разбираться, быть осведомленным)*** in topics as wide ranging as thermohydraulics and geomechanics. 6. The remote partner of the petroleum engineer is ***(буровая бригада)*** in implementing drilling program.

10. Find the meaning of the words in the box in a dictionary. Match the terms with the definitions.

petroleum engineer	upstream
reservoir	oil well
hydrocarbons	crude oil
downstream	petroleum
casing	

1. Petroleum engineer	A. Compounds which contain only carbon and hydrogen. Petroleum consists of them.
2. Reservoir	B. A fuel found in mineral deposits under the ground. It comes from the Greek words for «rock» and «oil». Therefore, rock oil or oil found in rock.
3. Hydrocarbons	C. Pipes run in a hole and cemented during drilling in order to consolidate well bore walls and prevent their collapse.
4. Downstream	D. A professional trained in the drilling, completion and production of oil and gas. Types of these specialists include drilling, completion and reservoir engineers.
5. Upstream	E. A porous and permeable formation containing an individual and separate natural accumulation of producible hydrocarbons. It is confined by impermeable rock or water barriers and is characterized by a single natural pressure system.
6. Oil well	F. Exploration, drilling and production operations for crude oil and natural gas.
7. Crude oil	G**.** A well completed for the production of crude oil from at least one oil zone or reservoir.
8. Petroleum	H. Transportation and pipe lining, refining and marketing operations for crude oil and natural gas.
9. Casing	I. A mixture of hydrocarbons that existed in a liquid phase in natural phase in natural underground reservoirs and remains liquid at atmospheric pressure after passing through surface separating facilities.

11. Classify the responsibilities of a reservoir engineer and a drilling engineer into two groups.

Estimation of cost to access reserves, maximization of economic recovery of hydrocarbons from the subsurface, numerical reservoir modeling, geologic survey, well drilling and workover planning, estimation of the sought reserves value, development of contacts with vendor, PVT analysis, wellbore plan, production forecasting.

12. Complete the sentences, using the information from the text.

1. According to the survey published in December 2006 ………
2. Deepwater operations can be compared to …………………….
3. Such modern technologies as ……………… have improved the toolbox of the petroleum engineer.
4. Petroleum engineering covers a wide range of topics including …..
5. Petroleum engineers can be divided into several types: …………..
6. Two areas in which reservoir engineers usually specialize are ……

13. State whether the sentences are true or false according to the text. If true, add the information on the statement. If false, correct the sentence.

1. Petroleum engineering covers a wide range of disciplines.
2. Operation in HTHP environment is a rare case for a petroleum engineer today.
3. Petroleum engineers are usually well paid.
4. Petroleum engineers deal with oil field close to the Earth's surface.
5. Petroleum engineers are subdivided into two types.
6. Reservoir engineering is concerned with reservoir modelling.
7. Drilling engineers have to perform PVT analysis of the well.

14.

PART 1. Read the following information, then listen to the tape and match the dates with the stages of petroleum engineering development.

1. The 1910's	A. It was recognized that the characteristics of the oil reservoir had to be taken into consideration.
2. The 1920's	B. Consolidation and integration of four elements took place in petroleum engineering.
3. The 1930's	C. Petroleum industry research developed. It was directed toward the principles, processes and methods for improvement of oil recovery.
4. The 1950's	D. Petroleum engineering was recognized as a new field of practice.
5. The 1990's	E. Petroleum engineering centered on the drilling, completing and producing activities associated with individual wells.

PART 2. Listen to the second part of the text once more; give the examples on the methods of each element.

Elements	Examples of methods
1. Extending the capabilities	
2. Development of methods for detailed study of subsurface formations and surroundings	
3. Recovering a greater portion of the oil within reservoir	
4. Development of technological management and its introduction into business decision making	

15. Answer the following questions.

1. What topics does PE cover?
2. How has the toolbox of the petroleum engineer been drastically improved?
3. Can you say that petroleum engineers are held to a high standard? Prove it.
4. Why is petroleum engineering considered to be the highest paid discipline?
6. What are the types of petroleum engineers?
7. What PE branches do you know?
8. What do reservoir engineers specialize in?
9. What fields are drilling engineers involved in?
10. What processes are drilling engineers responsible for?

16. Work in pairs.

You are going to explore a new oil field. **Student A** – a reservoir engineer and **Student B** – a drilling engineer. Discuss the distribution of your responsibilities and order of operations. Use as many expressions under study as possible.

17. Discuss the following issues.

1. The significance of petroleum engineering nowadays.
2. The reasons for high payment for petroleum engineering job.
3. The main types of petroleum engineers.
4. Reservoir engineers (their responsibilities, areas of specialization).
5. Drilling engineers (their responsibilities, areas of specialization).

18. Role Play the following situation.

Imagine that one of you is a TV/Radio Presenter with an oil industry background and the rest are the representatives of an oil company and you are having 5 min talk show regarding the company you work for, your roles and responsibilities and current energy sector state.

19. Prepare a poster-presentation «My specialty, its prospects and future».

UNIT 2

OIL COMPANIES

Oil company is an industry that produces and delivers oil and oil products.

Lead-in

Name all the Western and Russian oil companies you know.
What company would you like to work in? Why?
What position would you like to occupy?

Terms and Vocabulary

Midstream	Мидстрим
refining	Переработка
refinery	нефтеперерабатывающий завод
crude oil	сырая нефть
natural gas	природный газ
retail outlets	предприятия розничной торговли
commodities	изделия, товары
natural gas liquids (NLG)	сжиженный газ
headquarters/head office/central office	центральный офис
revenue	годовая прибыль
procurement	материально-техническое обеспечение
listing	Номенклатура
processing	Переработка
subsidiary	дочернее предприятие
core business	основной вид деятельности
trading	Продажа
shipping	Перевозка
high gravity	высокий удельный вес
open joint stock company	открытое акционерное общество (ОАО)
Russian Trading System (RTS)	Российская торговая система
New-York Stock Exchange (NYSE)	Нью-Йоркская фондовая биржа
London Stock Exchange (LSE)	Лондонская фондовая биржа
market value	рыночная стоимость
Health, Safety and Environment (HSE)	охрана труда, окружающей среды и техника безопасности
seismic acquisition	сейсмические исследования

seismic processing	обработка сейсмических данных
formation evaluation	определение параметров пласта
well testing	испытание скважины
directional drilling	наклонно-направленное бурение
report to smb.(v)	подчиняться кому-либо
Asset Based Organisation (ABO)	организационная структура на базе активов
asset	Актив
functional approach	функциональный подход
allocate budget	распределять бюджетные средства
set targets	устанавливать цели/плановые показатели
Human Resources (HR)	отдел кадров
General Director (GD)	генеральный директор
Chief Engineer (CE)	главный инженер
Chief Geologist (CG)	главный геолог
Chief Financial Officer (CFO)	финансовый директор
Chief Executive Officer (CEO)	главный исполнительный директор
Executive Vice-President (EVP)	исполнительный вице президент

1. Read the words, learn the pronunciation.

[a:] advantage, plant, demand
[ə:] search, fertilizer, refer, entrepreneur
[u:] crude, include, lubricant
[ju:] pharmaceutical, consumer, fuel, butane
[ou] own, negotiate, solely
[e] head, head office, headquarters, immense, synthetic
[ʃ] negotiate, initial

2. Read the following word formations and learn their pronunciation. Pay special attention to the stress.

Market – marketer – marketing
Refine – refinery – refinement
Explore – exploration – exploratory
Produce – producer – production
Dominate – dominated – dominance

3. Read the text and do the exercises.

Oil Industry Sectors

The entire oil industry is often divided into three major sectors: **upstream, midstream and downstream.**

Downstream (oil industry)

The **downstream oil sector** is a term commonly used to refer to the **refining** of crude oil, and the selling and distribution of **natural gas** and products derived from **crude oil.** The downstream sector includes oil **refineries**, petrochemical plants, petroleum product distribution, **retail outlets** and natural gas distribution companies. The downstream industry touches consumers through thousands of products such as gasoline, diesel, jet fuel, heating oil, asphalt, lubricants, synthetic rubber, plastics, fertilizers, antifreeze, pesticides, pharmaceuticals, natural gas and propane.

Upstream (oil industry)

The **upstream oil sector** is a term commonly used to refer to the searching for and the drilling and production of crude oil and petroleum natural gas. The upstream oil sector is also known as the exploration and production (E&P) sector. The upstream sector includes the searching for potential underground or underwater oil and gas fields, drilling of exploratory wells, and subsequently operating the wells that recover and bring the crude oil and/or raw natural gas to the surface.

Midstream (oil industry)

However, midstream operations are usually simply included in the downstream category. The **midstream sector** processes, stores, markets and transports **commodities** such as crude oil, natural gas and **natural gas liquids (NLG**) such as ethane, propane and butane.

The process of oil production, transportation, refinery and sale is managed by oil companies (producers), but there are also service companies that work as contractors to the oil companies. They are deeply involved in the oil business providing services that help oil companies to carry out their operations.

(www. Wikipedia.ed)

4. State whether the sentences are true or false. If true, add the information on the statement. If false, correct the sentence.

1. Oil industry is divided into three sectors.	T	F
2. Downstream begins from refinery to product distribution.	T	F
3. Upstream sector includes only drilling and exploration.	T	F
4. Midstream is part of the upstream sector.	T	F
5. Midstream transports such products as crude oil, natural gas and NGL.	T	F
6. Service companies help oil companies in different operations.	T	F
7. Oil companies can also be contractors.	T	F

5. Read the texts about three different oil companies and do the exercises.

The Seven Sisters of the petroleum industry is a term coined by an Italian entrepreneur, Enrico Mattei, that refers to seven oil companies that dominated mid-20th century oil production, refinement, and distribution.
These companies were the following:

1. Standard Oil of New Jersey (Esso), which merged with Mobil to form ExxonMobil.
2. Royal Dutch Shell Anglo-Dutch.
3. British Anglo-Persian Oil Company (APOC), which later became BP.
4. Standard Oil of New York (Socony). This later became Mobil, which merged with Exxon to form ExxonMobil.
5. Standard Oil of California (Socal), now Chevron.
6. Gulf Oil. Most of this became part of Chevron.
7. Texaco. Merged with Chevron in 2001. Texaco remains as a Chevron brand name.

ROYAL DUTCH SHELL

Type: public
Founded: 1907
Headquarters: The Hague, the Netherlands
Industry: oil and gas
Products: oil, natural gas, petrochemicals

Royal Dutch Shell PLC is a multinational oil company («oil major») of British and Dutch origins. It is one of the largest private sector energy corporations in the world and one of the six «supermajors» (vertically integrated private sector oil exploration, natural gas, and petroleum product marketing companies). The company's head offices (also known as the «central offices») are in The Hague and London (Shell Centre). The company's main business is the exploration for and the production, **processing**, transportation and marketing of hydrocarbons (oil and gas). Shell also has a significant petrochemical business (Shell Chemicals). Shell is incorporated in the UK with its corporate **headquarters** in The Hague, its **tax residence** is in the Netherlands, and its primary **listings** on the London Stock Exchange. Shell's **revenues** of $318.8 billion in 2006 made it the second-largest corporation in the world by revenues behind only ExxonMobil. Its 2006 gross profits of $26 billion made it the world's second most profitable company, after ExxonMobil and before BP. Forbes Global 2000 in 2007 ranked Shell the eighth largest company in the world. It operates in over 140 countries. In the United States, its Shell Oil Company **subsidiary,** headquartered in Houston, Texas, is one of Shell's largest businesses. One of the original Seven Sisters, Royal Dutch/Shell is the world's second-largest private sector oil company by revenue, Europe's largest energy group and a major player in the petrochemical industry. Shell has five **core businesses**: Exploration and Production ("Upstream"), Gas and Power, Refining and Marketing, Chemicals ("Downstream"), and **Trading/Shipping**.

ROSNEFT
Type: public
Founded: 1993
Headquarters: Moscow
Industry: oil and gas
Products: natural gas, petroleum

OJSC Rosneft Oil Company is a Russian integrated oil company. Rosneft conducts oil and gas exploration and production activities on Sakhalin island, in Siberia, in the Timan-Pechora province, and in southern Russia, including Chechnya. It also owns and operates two refineries. Its plant in Tuapse, on the Black Sea, focuses on refining **high-gravity** oil from western Siberia. Another plant located in Komsomolsk-on-Amur is the easternmost oil refinery in Russia. Rosneft operates shipping companies, pipeline companies and marketing companies. Although the company is an **open joint stock company,** according to its website, it seems to be completely owned by the Russian Federation, as represented by the Federal Property Management Agency.

Market value of the company on the 29th of December was valued at $83.908 billion.

Type: public
Founded: 1927
Headquarters: the Netherlands, principal offices in Houston, Paris and the Hague
Industry: oilfield services
Products: oilfield services

Schlumberger Limited is the world's largest oilfield services corporation operating in approximately 80 countries, with about 70,000 people of 140 nationalities. Schlumberger supplies a wide range of products and services from **seismic acquisition and processing; formation evaluation; well testing** and **directional drilling** to well cementing and stimulation; artificial lift and well completions; and consulting, software and information management. Schlumberger also provides similar products and services for the groundwater industry.

Pronunciation of the name

The company name is that of its eponymous founders, the French Alsatian Schlumberger brothers. It is pronounced [ʃlʌmbʊɹʒeɪ] in IPA notation (phonetic: «*shlum-bur-ZJAY*»).

(www. Wikipedia.ed)

6. Translate the following word groups into Russian.

Oil refinery, pipeline company, market value, production activity, oil and gas exploration, groundwater industry, software and information management, market leader, private sector energy corporation.

7. Give the synonyms to the following words.

the whole, to provide, to look for, to include, survey, manufacturer, corporation, estimation.

8. Classify the words into Business terms and Petroleum Engineering terms.

Crude oil, retail outlet, refinery, joint venture, market value, profit, pipelines, formation evaluation, share, artificial lift, headquarters, vendor, seismic acquisition, well completion, offshore location, consumer, raw natural gas, revenue.

9. Translate from Russian into English.

Сырая нефть, вся нефтяная промышленность, удобрения, нефтеперерабатывающий завод, точки розничной торговли, центральный офис, синтетический каучук, определение параметров пласта, принадлежащий государству, совместное предприятие, рыночная стоимость, наклонно-направленное бурение, сейсмическая обработка, филиал.

10. Fill in the gaps with necessary prepositions.

1. The oil industry is often divided __________ three major sectors.
2. The downstream oil sector is a term commonly used to refer ________ the refining _________crude oil, and the selling and distribution of natural gas and products derived _________ crude oil.
3. The upstream sector includes the searching _________ potential underground or underwater oil and gas fields.
4. Midstream operations are usually simply included __________the downstream category.
5. The process of oil production, transportation, refinery and sale is managed _______oil companies.
6. These are deeply involved _______ the oil business providing services that help oil companies to carry ________ their operations.
7. The company's main business is the exploration _________and the production, processing, transportation and marketing of hydrocarbons.
8. Shell is incorporated in the UK with its corporate headquarters in The Hague, its tax residence is _______ the Netherlands, and its primary listings _______ the London Stock Exchange.
9. Shell's revenues _______ $318.8 billion _______2006 made it the second-largest corporation in the world ______ revenues behind only ExxonMobil.
10. Rosneft conducts oil and gas exploration and production activities _______ Sakhalin island, _____ Siberia, ________ the Timan-Pechora province, and ___southern Russia, including Chechnya.
11. Its plant _______ Tuapse, ________ the Black Sea, focuses __________ refining high-gravity oil from western Siberia.

12. According _________its website, it seems to be completely owned _______ the Russian Federation.

11. What do the following abbreviations stand for?

RTS, NYSE, ABO, NLG, GD, HSE, LSE, HR.

12. State whether the sentences are true or false according to the text. If true, add the information on the statement. If false, correct the sentence.

1. The upstream oil sector touches consumers through thousands of products such as gasoline, diesel, jet fuel, heating oil, asphalt, etc.
2. Service companies manage oil production, transportation, refinery and sale.
3. Shell's head offices are located in The Hague and London (Shell Centre).
4. Shell is incorporated in the UK with its corporate headquarters in The Hague, its tax residence is in London (UK), and its primary listings on the London Stock Exchange.
5. Forbes Global 2000 in 2007 ranked Shell the eighth largest company in the world.
6. Shell has four core businesses: Exploration and Production, Refining and Marketing, Chemicals, and Trading/Shipping.
7. Rosneft conducts oil and gas exploration and production activities on Sakhalin island, in Siberia, and in southern Russia, including Chechnya.
8. Although Rosneft is an open joint stock company, it seems to be completely owned by a individual businessman.
9. Schlumberger Limited is the third world's largest oilfield services corporation operating in approximately 80 countries.
10. Schlumberger supplies a wide range of products and services from seismic acquisition to software and information management.

13. Listen to the tape and answer the questions given below.

1. Conoco Phillips as the third major oil company in the States is based on what?
   A. market capitalization
   B. oil and natural gas reserves
   C. market capitalization and gas reserves
   D. responsibility to deliver energy in a safe, environmentally and socially responsible manner

3. In what area is Conoco Phillips NOT technologically advanced?
   A. in reservoir management and exploration
   B. drilling and completion
   C. 3-D Seismic technology
   D. sulfur removal

4. How many people does Conoco Phillips employ?
   A. in the region of 32,500 people
   B. less than 32,500 people
   C. more than 32,500 people
   D. exactly 32,500 people

5. Which of the following is NOT one of the Company's core businesses according to the text given?
   A. Refining, Marketing, Supply and Transportation
   B. Chemicals and Plastics
   C. Finding Reserves
   D. Natural Gas to Liquids

6. In how many countries does the Company search for hydrocarbons?
   A. over two dozen countries
   B. over one dozen countries
   C. less than two dozen countries
   D. less than one dozen countries

7. Where is the Company central office located?
   A. Dallas, Texas
   B. Houston, Texas
   C. Anchorage, Alaska
   D. Denver, Colorado

8. What is the Company's stock exchange ticker?
   A. COP
   B. SOP
   C. CHOP
   D. CP

9. Who is the most important person in the Company?
   A. Ames J. Mulva
   B. John A. Carrig
   C. Mulva James
   D. Robert Dudley

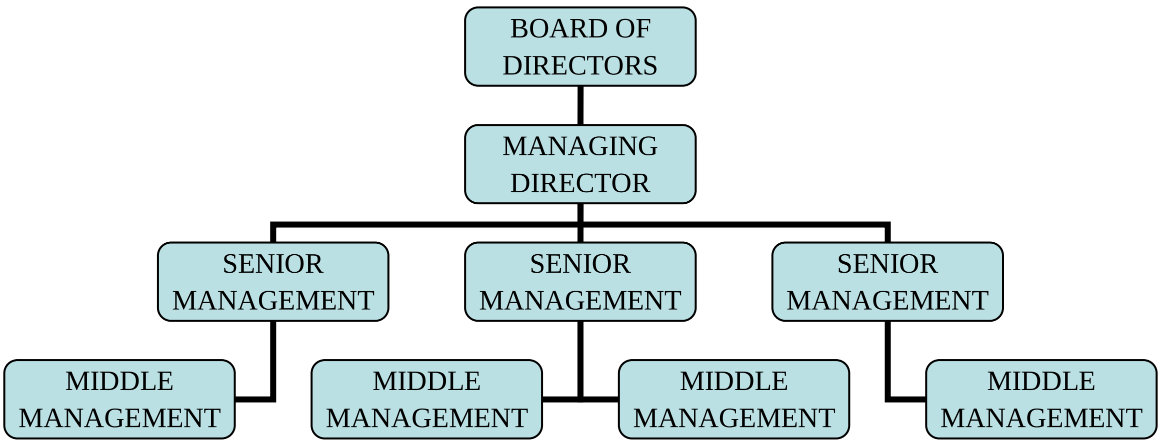
(www.conocophillips.com)

14. Fill in the chart with the information on domestic and foreign oil companies. Use additional resources: for example, www. Wikipedia.ed.

Name	Type	Founded	Headquarters	Industry	Products	Description
Mobil	**Public**	**1999** **1911** **1911** **1870**	**Irving,** **Texas,**	**Oil and gas**	**Fuels,** **Lubricants,** **Petrochemicals**	

15. A. Listen to the text, learn the key words.

Most companies are made up of three groups of people: the **shareholders** (who provide the capital), the **management** and the **workforce**. The management structure of a typical company is shown in this **organization chart**.



At the top of the company hierarchy is the **Board of Directors**, headed by the **Chairperson** or **President.** The board is responsible for policy decisions and strategy. It will usually appoint a **Managing director** or **Chief Executive Officer**, who has overall responsibility for the running of the business. **Senior managers** or **company officers** head the various departments or functions within the company, which may include the following:

A Marketing
B Public Relations or **PR**
C Information Technology or **IT**
D Personnel or **Human Resources**
E Finance
F Production
G Research and Development or **R and D**

B. Listen to seven people talking about their work and decide which department each one works for.
1… 2. … 3. … 4. … 5. … 6. … 7. …

(Tullis G., Trappe T. New Insight into Business. Longman, 2005.)

16. Study the definitions in Appendix 1. Match departments and personnel with their definitions.

1. Accountant Department	11. Personnel Department
2. AGM	12. President (US)
3. Board of Directors	13. Production Department
4. Chairman	14. Purchasing Department
5. Director	15. Marketing Department
6. Executive Officer	16. R and D Depart.ment
7. Headquarters	17. Reception
8. Manager	18. Sales Department
9. Managing director	19. Shareholders
10. Organization chart	20. Vice President

A. Any of several executive officers, each responsible for a separate division.
B. A member of the board of directors.
C. Person who holds or owns shares in or a part of company or corporation.
D. Department responsible for finding and buying everything for a company.
E. A company’s principal or main office or centre of control.
F. Group of people chosen to establish policy and control a company.
G. Department responsible for administration of company’s financial affairs.
H. Department that puts goods on market including packaging, advertising, etc.
I. The place where visitors and clients report on arrival at a company.

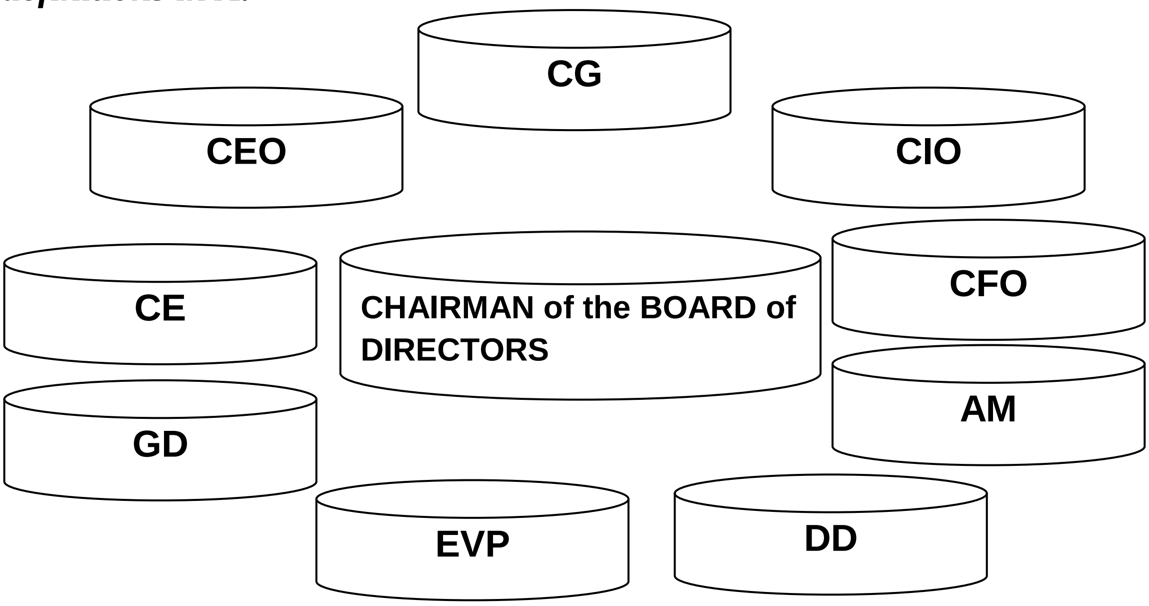
J. A table or plan showing a company's structure graphically.
K. Annual General Meeting of a company's shareholders.
L. Department responsible for finding customers and making sales.
M. The highest executive officer of a company, head of the company.
N. Department responsible for Research and Development of (new) product.
O. Person who heads a Board of Directors.
P. Department responsible for physical creation of a product.
Q. Senior director after the chairman responsible for day-to-day direction.
R. Department responsible for recruitment and welfare of staff or employees.
S. Person managing the affairs of a corporation, there are several of them in a company.
T. Person responsible for day-to-day running of a department.

17. Match the job title with the definition.

A. Chief Executive Officer (CEO)	1. refers to a rank in senior management, usually reports directly to the president or CEO of the company, could be more than one in different areas (Upstream, Downstream, Oilfield services)
B. Chief Financial Officer (CFO)	2. a person in charge of the Board of Directors
C. Chief Information Officer (CIO)	3. a mid-level manager who has a specialized, but multidisciplined understanding of everything related to exploration and production, is responsible for tactical decisions within a subsidiary, reports to a managing director
D. Chairman of the Board of Directors	4. a job title for somebody who is a second in command after a General Director in an oil producing subsidiary
E. Executive Vice-President (EVP)	5. job title for the head of the information technology group within an organization
F. Development Director (DD)	6. is the highest-ranking corporate boss in charge of total management of a corporation, company, or organization

G. Asset Manager (AM)	7. a person who deals with all the governmental authorities regarding the licenses and permits, and also looks after the reservoir development
H. General Director (GD)	8. is responsible for financial planning and record-keeping, as well as financial reporting to higher management
I. Chief Engineer (CE)	9. a lower-level manager whose decisions are generally short-term, responsible for operational decisions related to an asset, in some companies reports to a Development Director
J. Chief Geologist (CG)	10. a person in charge of a legal entity or a subsidiary, reports to the headquarters, but usually is located in the region

18. Complete the diagram showing the company structure using the definitions in A.



19. Complete the sentences.

1. The most important person in charge of an oil company is ………..
2. ……………. defines the strategy and set targets for the company.
3. More profitable is ………………………………………………….
4. An oil company consists of ……………………………………….
5. Chief engineer is more important than …………….

20. Read the text and discuss the after-text questions. See Appendix 2.

An Example of a Difference between Russian and Western Operating Company Structure

The information about the companies that are mentioned above refers to the Central Headquarters of these companies. This could be described as the **mother company**. All of these companies have **operating companies** that are spread out regionally or internationally which report to the Central Headquarters, where financial and **performance indicators** are consolidated. An example of this is Royal Dutch Shell that has its Central Headquarters in The Hague in Holland. Royal Dutch Shell also has operating companies in Nigeria, Oman, Australia and many other countries around the world. Rosneft has headquarters in Moscow and operations in Sakhalin island, in Siberia and the Timan-Pechora province.

An **Integrated Asset Based Organization** that you would typically find in a western operating company is centered around Asset teams. These **asset teams** look after and are responsible for ALL activities relating to an asset (or a group of assets). In a way an Asset team can be seen as a micro company within the main company. To operate in this way the Asset team needs to contain an integrated team of specialists. The reason for working in this way is the idea in the west that integrated teams are more effective than the functional approach. The Asset based organization also allows management **to allocate budget**, **set targets** and manage improvements more effectively because each Asset Manager is responsible for his Asset. The disadvantage of an Asset based organization is that it is difficult to maintain the technical level of functional specialists.

Until twenty years ago **Functional based organizations** as seen in Russian operating companies were also typical in Western companies. In such organizations all specialists of one function work together in one room and support all of the operating companies assets. The advantage of this system is that by working closely together within the function, specialists maintain a high level of technical expertise. The disadvantage is that integrated team work is absent and responsibility for a **single asset** is held only at the General Director level (see pictures below) this system is that by working closely together within the function, specialists maintain a high level of technical expertise. The disadvantage is that integrated team work is absent and responsibility for a single asset is held only at the General Director level.

21. Answer the following questions:

1. What does an Asset Based Organization consist of?
2. What does a Functional Based Organization consist of?
3. What are advantages and disadvantages of an integrated asset based organization?
4. What are advantages and disadvantages of a functional based organization?
5. Give your own examples of organizations of both types.
6. Name the positions within an oil company that belong to a corporate level (the headquarters) and regional level?

22. ROLE PLAY: You are welcoming a visitor to your company.

a. Introduce yourself.
b. Make a presentation of your company. Use the following plan.

A. Title page

B. Content

C. General Overview of the Company (industry, geographical location, number of employees, and etc)

D. Structure of the Company (general level – key people)

E. Performance Overview – Major achievements \ successes (2-3 slides)

F. Conclusion

23. Answer all necessary questions concerning your company.

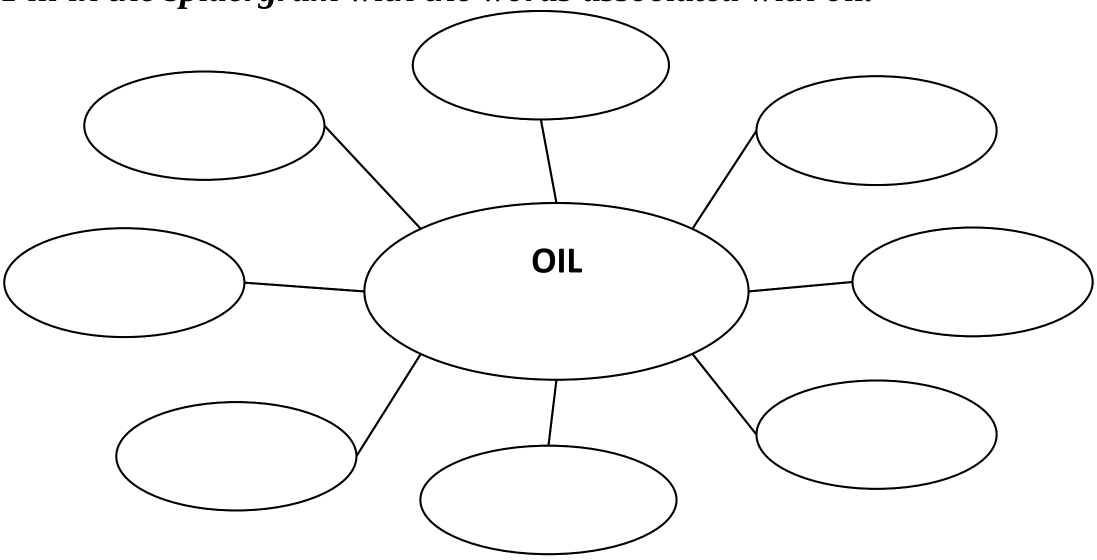
UNIT 3

OIL FORMATION

Oil, natural gas and petroleum have been foremost on people's minds for the past years. Nations and the world are run by oil. It fuels our cars, our homes and provides us with electricity. It is used in the making of plastics and cosmetics. Oil is also prevalent in our lives, but most people don't know where the oil we use comes from.

Lead-in

Fill in the spidergram with the words associated with oil.



Explain your associations.

What does the word «petroleum» mean?
What do you think crude oil is?
What is natural gas?
What are hydrocarbons?

Terms and Vocabulary

crude oil	сырая нефть
mixture	смесь
hydrocarbons	углеводороды
separation	разделение, разложение на части
refining	очистка, перегонка (нефти)
volatile	летучий, быстро испаряющийся

viscous	густой, вязкий
residue	остаток
reservoir rock	порода-коллектор
source rock	нефтематеринская порода
porous	пористый
porosity	пористость
permeable (impermeable)	проницаемый (непроницаемый)
permeability	проницаемость
cap rock	покрывающая порода, покрышка залежи
sulphur	сера
nitrogen	азот
oxygen	кислород
feedstock	исходное сырье
split up (v)	разделять
be arranged	быть систематизированным, упорядоченным
tarry	смолистый
alter (v)	изменить
sink (v)	погружаться
decay	гнить, перегнивать
fine-grained	мелкозернистый
exert (v)	оказывать давление
trap (n,v)	ловушка; заключать в ловушку
property	свойство
shale	сланец
accumulate (v)	накапливать; накоплять
limestone	известняк
sandstone	песчаник

1. Read the words, learn their pronunciation.

[aɪ] nitrogen, hydrocarbon, refining
[e] residue, buried, dead, lenses, ethane
[eɪ] chain, available, able, locate, basin
[ə:] permeable, exert, refer, occur, preserve
[i:] feedstock, heat, unique
[o:] source, porous, fault, salt, alter, molecule
[tʃ] mixture, structure, manufacture, saturated
[ʃ] pressure, partially, depression, sufficiently, ocean
[k] chemical, unique

2. Read the text and do the exercises.

1. **Crude oil** is a complex **mixture of hydrocarbons** with minor proportions of other chemicals such as compounds of **sulphur, nitrogen** and **oxygen**. To use the different parts of the mixture they must be separated from each other. This **separation** is called **refining.**

2. Crude oils from different parts of the world, or even from different depth**s** in the same oilfield, contain different mixtures of hydrocarbons and other compounds. This is why they vary from light colored **volatile liquids** to thick, dark oils – so **viscous** that they are difficult to pump from the ground.

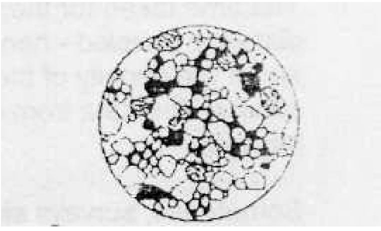
3. Hydrocarbons vary in structure depending on the number of carbon atoms and the way in which the hydrogen atoms combine with them. Hydrocarbons can **be arranged** as straight chains, branched chains or closed rings. There are two main chemical families of hydrocarbons – the alkanes and the alkenes.

4. As the structure of hydrocarbons varies so much, thousands of synthetic products can be manufactured with many different **properties**. Hydrocarbons with small molecules make good fuels. Methane (CH_4) has the smallest molecules, and is a gas, used for cooking and heating and generating electricity. Gasoline, diesel, aviation fuel and fuel oil are all liquid fuels.

5. Hydrocarbon molecules can **be split up** into smaller ones or built up into bigger ones, or **altered** in shape, or modified by adding other atoms. This is why they are a very useful starting point (called a chemical **feedstock**) for making other materials. Even the thick black **tarry residue** left after distillation is useful. It is called bitumen and is used in tarmac for road surfacing and for roofing.

6. Oil is formed from the remains of tiny plants and animals (plankton) that died in ancient seas between 10 and 600 million years ago. After the organisms died, they **sank** into the sand and mud at the bottom of the sea. Over the years, the organisms **decayed** in the sedimentary layers. In these layers there was little or no oxygen present. So microorganisms broke the remains into carbon-rich compounds that formed organic layers. The organic material mixed with the sediments, forming **fine-grained shale**, or **source rock.** As new sedimentary layers were deposited, they **exerted** intense pressure and heat on the source rock. The heat and pressure distilled the organic material into crude oil and natural gas. The oil flowed from the source rock and **accumulated** in thicker, more **porous limestone** or

sandstone, called **reservoir rock**. Movements in the Earth **trapped** the oil and natural gas in the reservoir rocks between layers of **impermeable rock**, or **cap rock**, such as granite or marble.



Close-up of reservoir rock (oil is in black)

(www. Wikipedia.ed)

3. Match the headings and the paragraphs of the text you have read. There is one extra heading.

a) Arrangement of hydrocarbon molecules.
b) What is crude oil?
c) Production of chemical feedstock.
d) Modification of hydrocarbon molecules.
e) Oil formation.
f) Oil and gas products.
g) Different mixtures of hydrocarbons.

4. Read the following word combinations and give Russian equivalents.

complex mixture of hydrocarbons
different depths in the same oilfield
vary from light coloured volatile liquids to thick viscous oils
depending on the number of carbon atoms
many different properties
be altered in shape
tarry residue left after distillation
organic material mixed with the sediments
exerted intense pressure and heat
organic material distilled into crude oil
trap between layers of impermeable rock

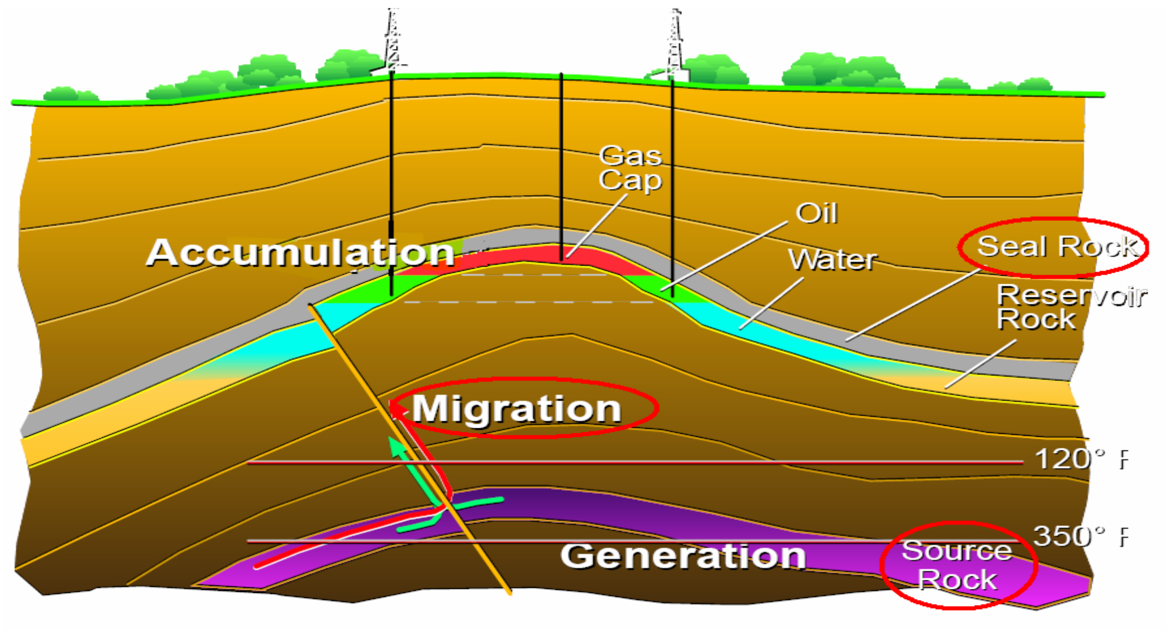
5. Find English equivalents to the following terms and phrases.

Незначительное количество, компоненты смеси, из пласта, различаются от …… до, содержат смеси, способ соединения атомов, могут располагаться, на более мелкие, для производства других материалов, остатки крошечных растений и животных, за многие годы, органика, мелкозернистый сланец, пористый известняк, непроницаемая порода, температура и давление, осадок, азот, сложное химическое соединение.

6. Complete the following sentences.

1. Crude oil is a mixture ……………………………………………………..
2. Different parts of the mixture can be used only after ………………
3. Different depths in one and the same oilfield contain………………
4. Hydrocarbons are difficult to pump from the ground because of ……
5. Hydrocarbon structure depends on ……………………………………
6. Two main chemical families of hydrocarbons …………………………
7. Hydrocarbon molecules are chemical feedstock for ………………..
8. Thick black tarry residue left after distillation is ……………………..
9. Bitumen is used in ………………………………………………………
10. The smaller the hydrocarbon molecules, the better they…………

7. Describe the process of oil formation using the diagram.



8. Work in pairs.

Student A – a lecturer and **Student B** – a petroleum geology student.
Student A – write 6–8 questions on the text about hydrocarbons and oil formation. **Student B** – be ready to answer. Use as many expressions under study as possible. Use the expressions of agreement and disagreement .

Agreement	**Disagreement**
I (fully) agree.	I'm against it (object to).
I am of the same opinion.	You are wrong (mistaken).
In a way, yes.	There's something in what you say, but…
I suppose (expect \ believe) so.	On the contrary.
I won't deny.	I disagree with you (on that point).

9. Read the following text "How Oil Becomes Oil" and do the exercises.

Terms and Vocabulary

depression	впадина
restricted basin	ограниченный бассейн
decompose – decomposition	разлагаться – разложение
expansion	распространение (на большую площадь)
recover oil	добывать нефть
adjacent (to)	смежный, прилегающий
pocket	карман
apex	вершина
fold	складка
migrate (v)	мигрировать, перемещаться
lens	чечевицеобразная залежь, линза
pinch out (v)	выклиниваться
unconformity	несогласное напластование
truncated, adj	срезанный, эродированный
fracture	разлом, трещина
interweave (v)	перемешивать, вкраплять
compaction	уплотнение
mudstone	аргиллит
thrust fault	сброс
cook (v)	подвергаться тепловой обработке
kerogen	кероген
abundance	распространённость
preserve (v)	сохранять

How Oil Becomes Oil

Petroleum (literally rock oil, from the Greek *petra-* for rock and Latin *-oleum* for oil) is a general term used to refer to all forms of oil and natural gas that is mined from the earth. What most people concern themselves with is crude oil, the liquid mixture of naturally occurring hydrocarbons and natural gas, which is a gaseous mixture of naturally occurring hydrocarbons. Hydrocarbons are complex molecules that are formed from long strings of hydrogen and carbon, such as propane (C_3H_8) or butane (C_4H_{10}).

Petroleum is the final product that we get out of the ground. But how does it get there? Petroleum begins as living animals, microscopic organisms (like diatoms or plankton) that live in the oceans. When these organisms die, their bodies sink and collect on the ocean floor. These organisms live all over the oceans and their bodies fall and collect on the ocean bottoms all over the world. When the organic matter becomes buried and begin to decompose, they are referred to as **kerogen.** Despite the apparent **abundance** of dead organisms raining down on the ocean bottoms, there are specific conditions that must be met for these organisms to be transformed into petroleum.

First, the area that the kerogen collects must be a **restricted basin**, a depression where sediment can accumulate and where there is poor water circulation. When the oxygen is gone, the **decomposition** stops and the remaining matter are **preserved**. The kerogen must be buried under sediment where it will be altered through high temperatures and high pressures. As the heat and pressure breaks down the kerogen, the hydrocarbon chains are freed. Long chains of hydrocarbon are oil; shorter chains are gas, generally methane (CH_4) and condensates such as ethane, propane and butane. As the heat and pressure continues, the longer chains will continue to break into shorter chains. If the process continues long enough, all that will remain will be methane.

Compaction of the sediment and the **expansion** of the kerogen as it is transformed into petroleum cause it to be forced out of the rock it was created in (the source rock) and into nearby sediments. If these sediments are porous enough (have microscopic holes) and permeable enough (allowing for the flow of liquids), then the petroleum will migrate through the rock. Since gas and oil are lighter than water, they can travel through water-saturated rock. Eventually the oil will stop migrating as it meets rock that is not porous or permeable, and will collect in a trap. It is these petroleum traps that geologists search for and that the oil companies drill into **to recover the oil**.

Despite the simplicity, there are several conditions that must occur, otherwise, no oil will be made.

First, there needs to be a source rock that contains the organic matter to be converted into petroleum. This source rock is generally shale or other **mudstones**. There must be a reservoir rock, usually sandstone or limestone that is porous and permeable where the oil can be stored and transported. There needs to be a trap, something that is non-porous and non-permeable that will hold the petroleum in the reservoir and prevent it from migrating further. Finally, there needs to be enough heat and pressure to sufficiently **cook** the oil and gas **out of** the kerogen. If anyone of these conditions is not met, then petroleum cannot be formed.

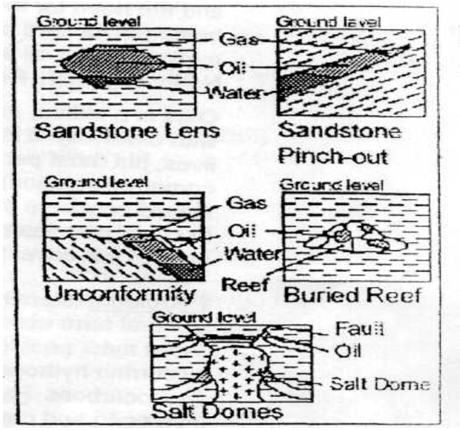
The important step in the process is the trap. Something needs to block or trap the petroleum so it will accumulate into a large enough deposit for geologists to be able to locate it. Petroleum traps come in several varieties, in various sizes and can be made through structural processes (like folds and faults), or by sedimentary processes.

Structural traps work by folding or breaking the reservoir rock and placing it **adjacent** to an impermeable rock layer, like shale. There are three types of structural traps. One of the most common is a trap from the folding of the rocks. Anticlines bend the reservoir rock and create **a pocket** at the **apex** of the **fold** where the petroleum cannot **migrate.** Normal and **thrust faults** can result in petroleum traps by breaking the reservoir rock and moving it so that it is against an impermeable rock layer.

The other way to trap petroleum is through stratigraphic traps. The diagram shows five different types of stratigraphic traps. The differences between these and structural traps is that these traps occur by the nature of how the sediment was deposited and not whether it was broken or folded. The first two, sandstone **lenses** and sandstone pinch-outs, are the result of the changes in deposition of the sediment. Thick layers of mud are covered by thinner layers of sand from migrating shoreline, or by the sand deposited by large rivers. As sea level changes or rivers migrate, the different sand and mud layers are **interwoven** creating lenses or **pinch-outs**. These sand layers allow the petroleum to accumulate and the mudrock layers trap the petroleum.

Unconformities can create traps by burying **truncated** sandstone or limestone layers with layers of mudstone.

Finally, salt domes can push up through buried sediment and deform the overlying layers of rock. This causes folds and **fractures** to form in the rock, trapping the oil. Salt domes are the primary places where the oil is found.



(Author: Geoff Habiqer Published on: September 3, 2001)

10. Give Russian equivalents to the following English words.

gasoline
kerogen
to recover = to mine = to produce
oil = petroleum
mixture
decompose
hydrocarbons
organic matter
specific conditions
fold
fault
thrust faults
unconformity
salt dome
fracture
trap
sediment
accumulate

11. Give definitions to the following terms.

petroleum
crude oil
natural gas
hydrocarbons
migrate
kerogen
porous
permeable
source rock
trap

12. State whether the following sentences are true or false.

1. A restricted basin is not the place for the kerogen to collect.
2. Decomposition does not stop when the oxygen is gone.
3. The oil continues migrating in porous and permeable rocks.
4. The traps are important steps in the process of oil accumulation.

5. Structural geology is the subject for the students to miss.
6. Structural traps are of two types.
7. Stratigraphic traps are the ones that occur by nature.
8. It takes thousands of years for the petroleum to be made.
9. There are some specific conditions for the organisms to be met.
10. Shorter hydrocarbon chains are oil.

13. Put the facts into the correct order showing how oil becomes oil.

1. Hydrocarbon chains are freed.
2. Kerogen is developed.
3. The matter becomes buried.
4. Longer chains break into shorter ones, and methane remains.
5. The petroleum is forced into nearby sediments.
6. The organic matter begins to decompose.
7. Kerogen is broken down.
8. The petroleum will stop migrating if rocks are not porous or permeable.
9. Dead organisms accumulate on the ocean floor.
10. The petroleum will collect in a trap.
11. Kerogen is altered through high temperature and high pressure.
12. The petroleum will migrate in the rocks which are porous and permeable enough.

14. ***You will hear a lecture on petroleum. For questions 1–6, choose the best answer A, B, or C.***

1. Crude oil is

A. natural liquid
B. mixture of hydrocarbons
C. alkanes

2. Shorter hydrocarbons are

A. natural gas
B. viscous
C. paraffin wax

3.Petroleum may contain…

A. natural gas liquid
B. metallic elements
C. chemical compounds

1. Crude bitumen is

   A. crude oil mixed with sand
   B. dark brown liquid
   C. sand with semi-solid form

2. Petroleum has become the most important source of energy because it

   A. is the raw material for useful chemical products
   B. produces energy and is easily transportable
   C. is easily converted into other materials

3. Recoverable oil reserves are less than total oil-in-place because

   A. they are severely limited
   B. its consumption increases
   C. there are some technological problems

15. Discuss the following questions.

1. What product do we get out of the ground?
2. What collects on the ocean bottoms all over the world?
3. Is there an abundance of dead organisms?
4. What is needed for organisms to be transformed into petroleum?
5. What conditions are needed for the oil to be made?
6. How do structural traps work?
7. What are structural traps?
8. What is the difference between structural and stratigraphic traps?
9. Can you name some of the stratigraphic traps?
10. What are salt domes for?

16. Scan the text given below and describe the main oil properties based on the information you have learnt. Complete the table.

Property	Characteristic features

Physical and Chemical Properties of Oil

Oil is described by the physical properties of density, color, viscosity, thermal expansion and other properties related to the number of carbon atoms in the molecules.

Petroleum can be of different colors. Oil colors vary in a very wide range from oilfield to oilfield: from pale yellow, yellow and even colourless to dark grey, green and dark brown shades.

The SI unit is kg\ m^3 at a reference temperature, typically 15 °C. Knowledge of density is required for quantity calculations. In the USA and some other countries the density of petroleum products is defined in terms of API gravity. This is an arbitrary scale adopted by the American Petroleum Institute for expressing the relative density of oils. The API gravity scale is read "backwards". The higher the API number, expressed as degrees API, the less dense (lighter) the oil is. Conversely, the lower the degrees API, the more dense (heavier) is the oil. Density of oils range from 0.65 to 1.0 gr\$cm^3$ and more at 20 °C. According to density, oils may be light, medium and heavy. Light oil is characterized by the density of 0.5–0.87; medium oil: 0.871–0.910 and heavy oil is described being as 0.910–1.05 gr\$cm^3$.

Viscosity is a property of fluids that indicates their resistance to flow, defined as ratio of shear stress to shear rate. Crude oils range in consistency from water-like to tar-like solids. Fluid with a high viscosity such as syrup deforms more slowly than fluid with a low viscosity such as water. Absolute viscosity is measured in Poise. The oil specific viscosity is usually defined as ratio of absolute viscosity of a given fluid to absolute viscosity of water at the same temperature. The viscosity of oil is dependent upon temperature, pressure and shear rate. Viscosity decreases as temperature increases because molecules vibrate and interact less. Conversely, the viscosity of oil increases as temperature decreases and it can become grease-like at very low temperature.
The volume of given oil mass increases with temperature, therefore, its density decreases. The degree of expansion is expressed as the coefficient of thermal expansion. Thermal expansion is useful to determine the size of container needed when the oil is heated. Thermal expansion is expressed as the ratio of volume change to initial volume after heating 10 °C.

Crude oils are complex mixtures containing hundreds of different hydrocarbon compounds that vary in appearance and composition from oil field to oil field, therefore, in various oil fields the oil composition can vary significantly. All hydrocarbons are divided into two groups: saturated hydrocarbons and unsaturated hydrocarbons. Saturated hydrocarbons are not capable of attaching atoms and molecules while unsaturated hydrocarbons are capable of attaching atoms and molecules. The latter take part in chemical reactions easier. Hydrocarbons can be as simple as methane, but many are highly complex molecules and can occur as gases, liquids or solids. An "average" crude oil contains about 84 % carbon, 14 % hydrogen, 1–5 %

sulfur, and less than 1 % of nitrogen, oxygen, metals and salts. In the refinery, most of these non-hydrocarbon substances are removed and the oil is broken down into various compounds and blended into useful products.

17. Make a presentation on one of the topics.

1. Source rock
2. Reservoir rock
3. Types of trap
4. Geological process in the formation of petroleum system

UNIT 4

Health, Safety, Environment (HSE)

HSE is an abbreviation for **H**ealth, **S**afety and **E**nvironment. These three issues are of paramount importance to the drilling and drilling fluids community, as they are to the entire petroleum industry.

Lead-in

Work in pairs. Discuss the questions.

1. What incidents could happen in the process of oil production?
2. What precautions should be taken to avoid incidents?
3. What harm could oil production do to the environment?

Terms and Vocabulary

HSE (Health, Safety and Environment)	охрана здоровья (ОЗ), техника безопасности (ТБ) и охрана окружающей среды (ООС)
legal responsibility	юридическая ответственность
to ensure (v)	обеспечивать, гарантировать
emergency	аварийная ситуация, чрезвычайная ситуация
operational meeting	оперативное совещание
performance	эффективность деятельности
accident	авария
security	безопасность
harm to (v)	причинять вред
damage to (v)	наносить ущерб
emissions	выбросы (загрязняющие вещества в атмосфере)
discharge	сброс (загрязняющие вещества в водной среде)
to be held accountable	быть привлеченным к ответственности
to accomplish HSE goals	достигать поставленные задачи по технике безопасности, охране здоровья и окружающей среды
leadership	руководство
to follow the rules	следовать правилам
incident investigation	расследование происшествия
to report	сообщать, докладывать
near misses	предпосылки к происшествию

severe	тяжелый (степень тяжести происшествия)
to prevent (v)	предотвращать, предупреждать наступление последствий
Personal Protective Equipment (PPE)	средства индивидуальной защиты (СИЗ)
injury	травма, травматизм
contractor	подрядчик
abuse	злоупотребление
to permit (v)	разрешать, допускать
to be under the influence of smth	быть под воздействием ч-л
to be addicted to smth (v)	злоупотреблять ч-л (алкоголь и наркотические вещества)
risk assessment	оценка рисков
an escape plan	план эвакуации
hazardous	связанные со скрытой опасностью
hand rails	поручни
preventer/safety line	страховочное устройство для работы на высоте
lifting operations	работы на высоте
to be certified (v)	быть аттестованным
up to date	соответствующий современным требованиям, обновленный
seat belts	ремни безопасности
fire extinguisher	огнетушитель
first aid kit	аптечка первой помощи
to exceed (v)	превышать
license	водительское удостоверение
headlights	ближний свет фар
to meet the standards	соответствовать стандартам
green house gas	парниковый газ
to eliminate (v)	устранять, ликвидировать
associated gas flaring	сжигание на факеле попутного газа
biodiversity preservation	сохранение биологического разнообразия
impassible obstacles	непреодолимые препятствия
water table	уровень грунтовых вод
learnings	сбор информации

Read the words, learn the pronunciation.

[aɪ] crisis, height, certify
[e] health, headlight
[ə:] emergency, occurring
[æ] accident, management, attitude, mandatory, hazardous
[i:] vehicle, machinery, employee, leadership, key
[o:] performance, source, storage, worn
[ʃ] ensure, efficiently, emission
[k] mechanical, archaeological, technical
[dʒ] injury, danger, emergency
[u:] polluting, including, improve

1. Read the text and do the exercises.

HSE

In the modern business world the abbreviation **HSE** stands for **Health, Safety and Environment**. In practice this means that any business has **legal responsibilities to ensure** the health and safety of employees and other people affected by their business activities while operating in an extremely friendly manner towards the environment.

If you happened to be present at any meeting in a western oil company the first thing you would notice is that the meeting starts with a brief safety introduction, that is to say an action plan that you have to follow in case of **emergency**. Another example of how seriously HSE is taken is that at every **operational meeting** or meeting related to the general company performance one of the first indicators to be discussed is **performance** in HSE. The lower the number of incidents or **accidents**, the better it is for the company.

Oil companies put HSE first amongst their priorities because the stock market and the shareholders consider the HSE performance of companies to be the main indicator of the professionalism of the company. Everybody who works in companies like these, anywhere, is responsible for getting HSE right. Good HSE performance and the health, safety and **security** of everyone who works for the Company are critical to the success of its business.

Goals can be simply stated: no accidents, no **harm to** people, no **damage to** the environment. Under these circumstances companies continue to improve the environmental and health impact of their operations by reducing waste, **emissions** and **discharges**, and using energy efficiently. They will produce quality products that can be used safely by their customers. All leaders within companies **are held accountable** for **accomplishing the HSE goals** by demonstrating correct HSE behaviors, by clearly defining HSE roles and responsibilities and by providing needed resources and by measuring, reviewing and continuously improving HSE performance. In many companies the yearly bonus is not paid, if the HSE targets are not achieved.

The l**eadership** is responsible for the HSE performance of its workforce. They should do this by personal example, by developing employee's positive attitude towards HSE, setting clear goals and objectives and creating the environment where employees understand it is all right for them to stop the work if they think HSE **rules are not being followed**.

All accidents**, incidents** or any other event causing danger to health safety or environment (including **near misses** – an accident that nearly happens), no matter how **severe**, need **to be reported**. Once reported they should be **investigated** and analyzed to develop **learnings** which can be used to **prevent** the same accident from occurring again. These learnings are distributed throughout the company.

Personal protective equipment (PPE) provides the last line of defense in protecting employees from **injury** and illness in the workplace. It does not replace prevention of an accident in the first place but it is an essential part of the HSE management system.

Alcohol and drug use is not **permitted** by the company and leaders shall ensure people **under the influence of** alcohol or drugs are not permitted to work on any company location. Storage or distribution of alcohol is not permitted anywhere under the company control. The company will carry out random testing for alcohol and searches for drugs and alcohol. If an employee is found **to be addicted to** drugs or alcohol the company will contribute to medical treatment.

No work shall commence until the number of HSE **conditions are met. Risk and safety assessment** have been done. All personnel are appropriately trained to do the work. The correct PPE is being worn. An **escape plan** form the place of work is in place. A permit to work for **hazardous** areas has been obtained. If any changes are made to the work conditions after the relevant permissions are obtained then work will stop.
When work is to be carried out at less than 2 m from the edge at a height of 1.3 m or more, the following HSE rules must be followed: a fixed platform with **hand rails** shall be used; a **preventer (safety line)** shall be used that can

bear the weight of at least 700 kg per person attached; special instructions and training for persons working at height shall be given.

Lifting operations utilizing cranes, hoists, or other mechanical devices can be carried out under the following conditions: risk assessment has been carried out prior to the work starting; all involved staff (crane operators, assistants etc) have been trained and **certified** (and carry the certificates) to operate the lifting machinery. The lifting equipment should have an **up to date** technical inspection certificate.

Vehicle Requirements: all vehicles must be fit for the purpose and be maintained and in a safe condition; seat belts must be present and functional and the vehicles should be fitted with a **fire extinguisher** and **first aid kit**; the number of passengers and loads should not **exceed** the manufactures specifications.

Drivers Requirements: seat belt must be worn by all the occupants at all times, whenever a vehicle is in motion; drivers must hold the appropriate **licenses;** drivers must not be under the influence of drugs or alcohol; **headlights** are to be used day and night during the winter; mobile phones are not to be used when the vehicle is on motion.

Contractors are one of the key factors in the company's HSE performance. Contractors are expected to follow the same HSE requirements as the employees, therefore contracts will contain an HSE section. The company will use contractors that **meet the standards** of HSE required and will work with other contractors to help them improve. The company will also continuously monitor the contracts HSE performance and demand improvements when identified.

The crisis and emergency management system is a system of interaction between various company units to manage the company's activities in the event that various incidents, accidents and other emergencies arise.

In the air protection area the company shall: monitor all polluting emissions including **green house gas** emission; **eliminate** continuous **flaring of associated gas.**

*In the area of **biodiversity preservation** the company shall:* strive to avoid working in environmentally protected or sensitive areas; strive to avoid installing **impassable obstacles** that may prevent migration of animals; minimize the impact on wildlife.

In the area of water control and protection the company shall: minimize the consumption of fresh water; not discharge waste water into the **water table**; carry out its operations in a manner that doesn't contaminate water sources; continuously monitor its water usage and discharge.

In the area of land protection the company shall: optimize land usage to minimize the industrially effected area; avoid operating in native habitation areas or sites of archeological or cultural value; minimize soil erosion.

(www.tnk-bp.com)

3. Pay attention to the following word-formations.

Lead – leader – leadership
Pass – passable – impassable
Prevent – prevention – preventer
Manage – manager – management
Employ – employer – employee – employment
Permit - permission

4. Fill in the gaps with the word(s) from the list below. Explanation of these terms are given in the brackets.

performance appropriate remediation PPE risk assessment impact preventer near misses

1. Before starting oil exploration a company should perform________ including identification of risks and hazards as well as the ways of removing them **(defining risks out of the work).**
2. The accident took place because of the absence of _______and other necessary equipment at the workplace **(safety line).**
3. Labour protection includes application of ___________in the process of operation **(safety clothes and footwear).**
4. The personnel of our company is specially trained in safety method of work ________ **(doing, fulfilment).**
5. At the beginning of field development an oil company should assess the possible __________to the environment **(influence).**
6. The drivers are required to hold the __________ driving licenses **(proper, relevant).**
7. To prevent accidents from occurring again it is necessary to investigate not only incidents, but also _________**(an accident that nearly happens).**

5. Fill in the correct preposition, then choose two items and compose sentences.

1. to prevent sb. **…** doing sth.
2. to be **…** motion
3. to protect sb. **…**sb./sth.
4. **…** practice
5. to carry **…** the work
6. to be responsible **…** sth.
7. **…** case of emergency
8. **…** the circumstances

6. Match the problems with the ways of their solution.

1. The crewmember can fall from the platform at 2 meter height	A. The personnel should wear PPE
2.The employee was found drunkard on the company location	B. Mobile phones are not to be used when vehicle is on motion
3. The operator collapses in the process of pumping fluid	C. The company will remediate the impact to the environment
4. The accident happened because the driver was distracted by mobile phone call	D. A preventer shall be used that can bear the weight of at least 700 kg per person attached
5. Great damage is done to landscape of the area in the process of field development	E. The employee should contribute to medical treatment

7. Make collocations from the following words

to meet *greenhouse* *escape* *near*
to wear *to discharge* *first aid* *fire*

1. … PPE
2. … waste water
3. … gas emissions
4. … extinguisher
5. … requirements
6. … kit
7. … plan
8. … misses

8. Match the items with their function.

1. seat belts	A. a special tool for extinguishing fire
2. respirator	B. safety tools given for every worker
3. fire extinguisher	C. a special rope intended for working at height
4. personal protective equipment	D. straps in a car to prevent passengers from falling out of it
5. ear-protector	E. a means of protecting breathing organs from inhaling harmful gases
6. preventer	F. a means of protecting ears from laud noises

9. Classify the words into 2 categories. Guess what these categories are. Add more items to each category.

Risk assessment, greenhouse gas emissions, disturbed land, personal protective equipment, major incidents, incident investigation, near misses, contamination of water sources, environmental monitoring, impassable obstacles.

10. Study the definitions given in Appendix 3.
Now listen to the tape and find the right term for the definitions given on the tape:

1)
   A. Toolbox talk
   B. Action plan
   C. Lost time accident
2)
   A. Serious Accident
   B. Minor Accident
   C. Fatal Accident
3)
   A. Personal Protective Equipment (PPE)
   B. While at Work
   C. Accident

4)
   A. Lost Time Accident
   B. Serious Accident
   C. Fatality

5)
   A. Personal Protective Equipment (PPE)
   B. While at Work
   C. Accident

6)
   A. Toolbox talk
   B. Action plan
   C. Lost time accident

7)
   A. Major Accident
   B. Minor Incident
   C. Minor Accident

8)
   A. Lost Time Accident
   B. Lost Time Incident
   C. Fatality

11. Read the text again and make notes under the following headings, then talk about HSE performance.

Labour protection Environmental safety Safety management system

12. Read the introduction to BP's 8 golden rules. Find the words in the text that mean the same as the words and phrases below.

Getting the basics right

BP's safety policy states no harm to people and no accidents. Everyone who works for, or on behalf of, BP is responsible for their safety and the safety of those around them.

The following safety rules will be strictly enforced to ensure the safety of our people and our communities.

Although embedded in each of these rules, it is important to emphasize that:

– Work will not be conducted without a pre-job risk assessment and a safety discussion appropriate for the level of risk.

– All persons will be trained and competent in the work they conduct.
– Personal protection equipment will be worn as per risk assessment and minimum site requirements.
– Emergency response plans, developed from a review of potential emergency scenarios, will be in place before commencement of work.
– Everyone has an obligation to stop work that is unsafe.

1. Injury or damage (n): __________________
2. Made to happen (v, past participle): ______________________
3. Analysis of possible dangers: ___________________________
4. Having the skill to do something well: ____________________
5. Things that must be done on the site: _____________________
6. Plans of how to react in a dangerous situation: ____________
7. Start (v): _________________________________
8. Duty: ____________________________________

13. Write in a safety rule next to its explanation.

Energy isolation	Management of change (MOC)	Ground disturbance
Working at heights	Driving safety	Lifting operations
Permit to work	Confined space entry	

BP's 8 golden rules of safety

1. ________________: Before conducting work that involves confined space entry, work on energy system, ground disturbance or hot work in potentially explosive environments, a permit must be obtained. This should be authorized by a responsible person; it should also identify hazards, assess risk and establish control measures.

2.__________________: Working at heights of two meters or higher above the ground cannot begin unless the workers are competent to do this work, and the correct equipment is in place and has been inspected.

3._________________: An isolation of energy systems, mechanical, electrical, process, hydraulic and others, cannot proceed unless the method and discharge of stored energy are agreed and executed by a competent person. They should also test that the isolation is effective and continue to monitor effectiveness periodically.

4. ________________: Entry into any confined space cannot proceed unless all other options have been ruled out and the area has been tested for safety.

All affected personnel, including a stand-by person, should be competent and issued with a permit.

5. _______________: Lift utilizing cranes, hoists, or other mechanical lifting devices will not commence unless the assessment of the lift has been completed. The equipment must be certified for use and examined before each lift. The operators must be trained, and the rigging of the load must be done by a competent person.

6. _________________: Work arising from temporary and permanent changes to organization, personnel, system, process, procedures, equipment, products, materials or substances, and laws and regulations cannot proceed unless a Management of change process is completed. This should include a risk assessment conducted by all affected by the changes, authorization of the changes and a clear work plan for the changes.

8. _________________: All categories of vehicle, including self-propelled mobile plant, must not be operated unless the vehicle has been inspected and is in good working order, and safety equipment (such as helmets ans seat belts) is used. Drivers must be trained and certiofied, should not use radios or hand-held phones and should not be under influence of drugs and alcohol.

9. _________________: Work that involves a manmade cut, cavity, trench or depression in the Earth's surface formed by earth removal cannot proceed unless a hazard assessment is completed and all underground hazards have been identified and isolated where necessary.

14. A. Listen to Bob describing an incident. Think of questions you would like to ask about it.

B. Listen to Ahmed asking Bob about the incident. Were his questions the same as yours?

C. Work with a partner. Ask each other questions about the incident. One person plays the role of Bob and one person plays the role of Ahmed.

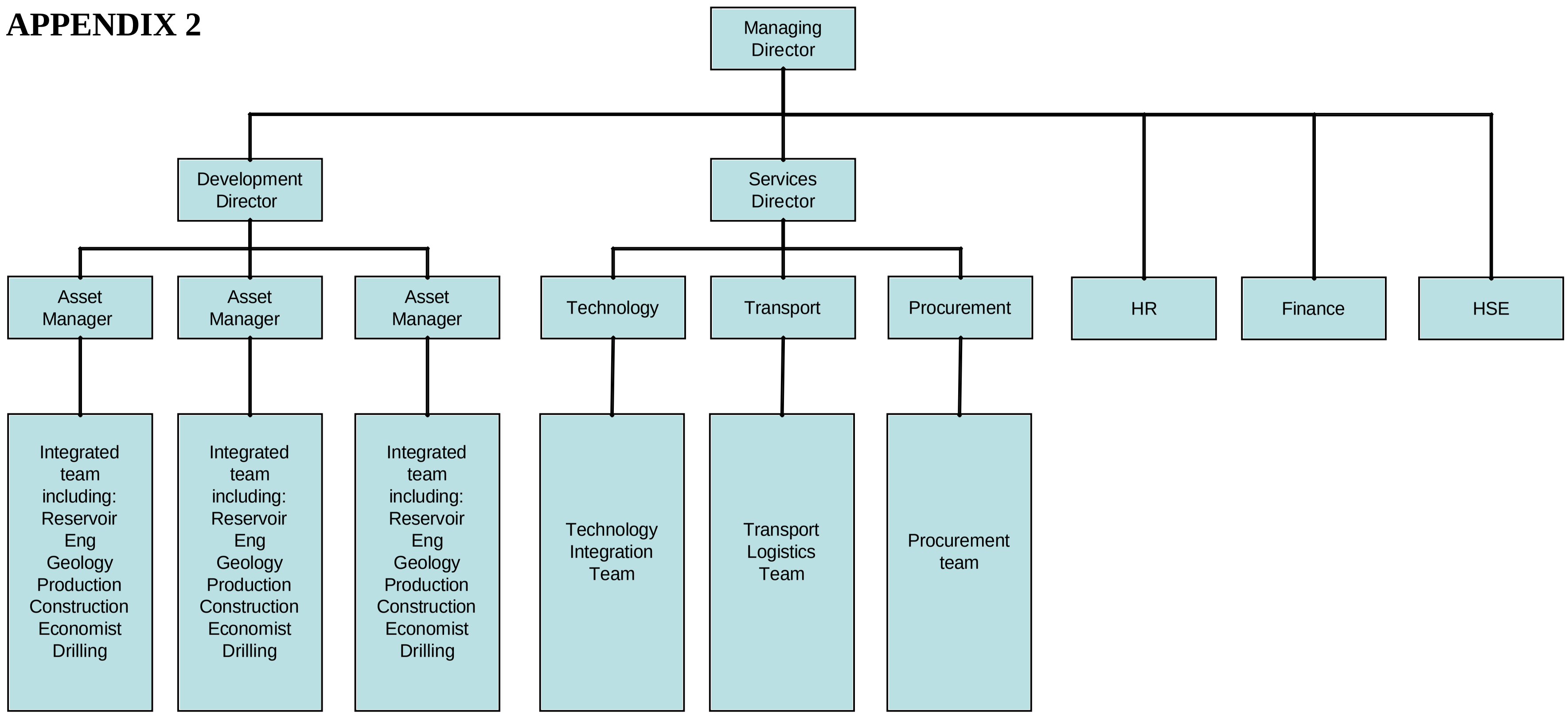
15. Describe some incident really happened in oil, gas and petrochemical industries. Report it to the group, answer possible questions.

(Levrai P. English for the Energy Industries. Oil, Gas and Petrochemicals. Garnet, 2009)

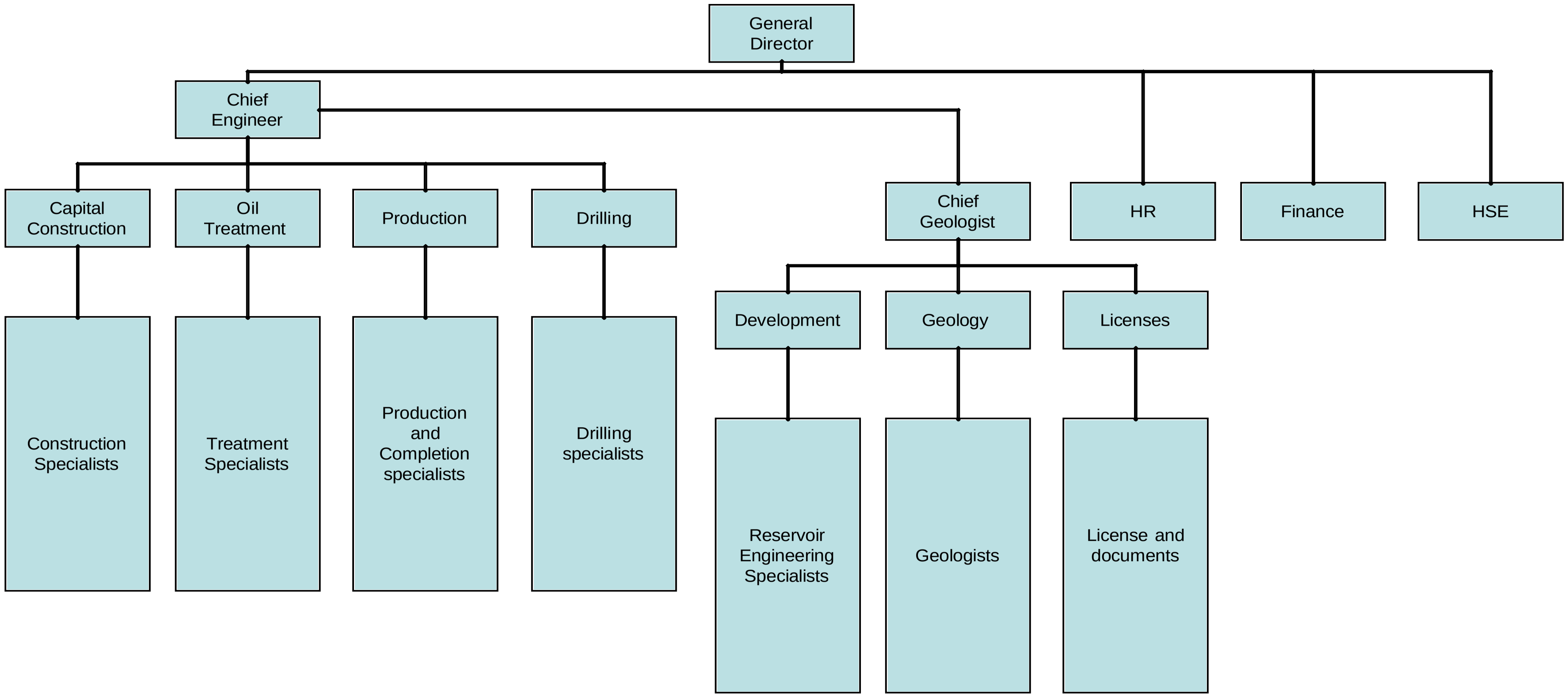
APPENDIX 1
UNIT 2
COMPANY STRUCTURE

1	Accountant Department	department responsible for administrating a company's financial affairs
2	A.G.M. (UK)	Annual General Meeting of a company's shareholders
3	Board of Directors	group of people chosen to establish policy for a control of a company
4	Chairman (UK)	person who head a Board
5	Director	a member of the board of directors
6	Executive Officer (UK)	person managing the affairs of a corporation – **chief executive**
7	Headquarters	a company's principal or main office or centre of control
8	Manager	person responsible for day-to-day running of a department; executive officer
9	Managing Director (UK)	senior director after the chairman responsible for day-to-day direction
10	Marketing Department	department that puts goods on market, including packaging, advertising, etc.
11	Organization Chart	a table or plan showing a company's structure graphically
12	Personnel Department	department responsible for recruitment and welfare of staff or employees
13	President (US)	the highest executive officer of a company; head of a company
14	Production Department	department responsible for physical creation of product
15	Purchasing Department	department responsible for finding and buying everything for a company
16	R & D Department	department responsible for Research and Development of (new) products
17	Reception	the place where visitors and clients report on arrival at a company
18	Sales Department	department responsible for finding customers and making sales
19	Shareholder	person who holds or owns shares in or a part of a company or corporation
20	Vice President (US)	any of several executive officers, each responsible for a separate division

APPENDIX 2



Integrated Asset Based Organisation



Functional Based Organsation

APPENDIX 3

UNIT 4

HEALTH, SAFETY AND ENVIRONMENT

Action Plan план мероприятий	A schedule of actions required to develop, implement and maintain the HSE Management System.
HSE Meeting заседание (собрание) по вопросам охраны труда и окружающей среды	Any meeting whose agenda comprises solely of HSE topics.
Accident авария	An accident is an unplanned event that results in harm to people, loss of process, or damage to property or the environment.
Incident происшествие	An incident is an unplanned event not resulting in loss which, under slightly different circumstances, could have resulted in harm to people, loss of process, damage to property, the environment, or the business interests of the Company.
Fatal Accident авария со смертельным (летальным исходом)	Where a person(s) is involved in an accident from which they sustain injuries which cause death within 24 hours of the accident.
Serious Accident серьезная авария	Disabling injuries and occupational illnesses causing subsequent death, permanent injury or incapacity from work estimated to exceed 3 months, or property damage and loss exceeding $10,000.
Lost Time Accident авария, связанная с потерей рабочего времени (простоем)	An accident causing injury or occupational illness such that the person concerned is unable to resume normal duties the next day or shift (irrespective of field breaks, leave or holidays).
Minor Accident незначительная авария	First aid, non disabling injury or occupational illnesses which, following treatment, do not result in lost time, or property damage and loss in excess of $10,000.
Serious Incident серьезное происшествие	An incident which under slightly different circumstances could have resulted in a fatal or serious accident.

Minor Incident незначительное происшествие	An incident which under slightly different circumstances could have resulted in a minor accident.
Security Incident происшествие, создающее угрозу безопасности	An incident in which a criminal or negligent action has resulted in harm to people, loss of process, or damage to property, the environment, or the business interests of the Company.
While at Work во время работы (выполняя работу)	Includes being on Company premises, on Company business, and while travelling on Company business, and being on a location not owned by the Company where all or nearly all of the work is being performed for the Company and the Company has a full-time representative on site.
Toolbox Talk специальный инструктаж	A meeting on an operational site which takes place prior to an activity which is especially hazardous or which is unfamiliar to the workers. All of the relevant personnel attend.
	Equipment which is designed to protect the person against the consequences of workplace hazards, for example hard hat, boots, respirator, etc.

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UPSTREAM AND DOWNSTREAM

Chapter 1

GEOPHYSICS

D.A Terre, A.S. Klimentieva

UNIT 1

GEOPHYSICS. GENERAL INFORMATION

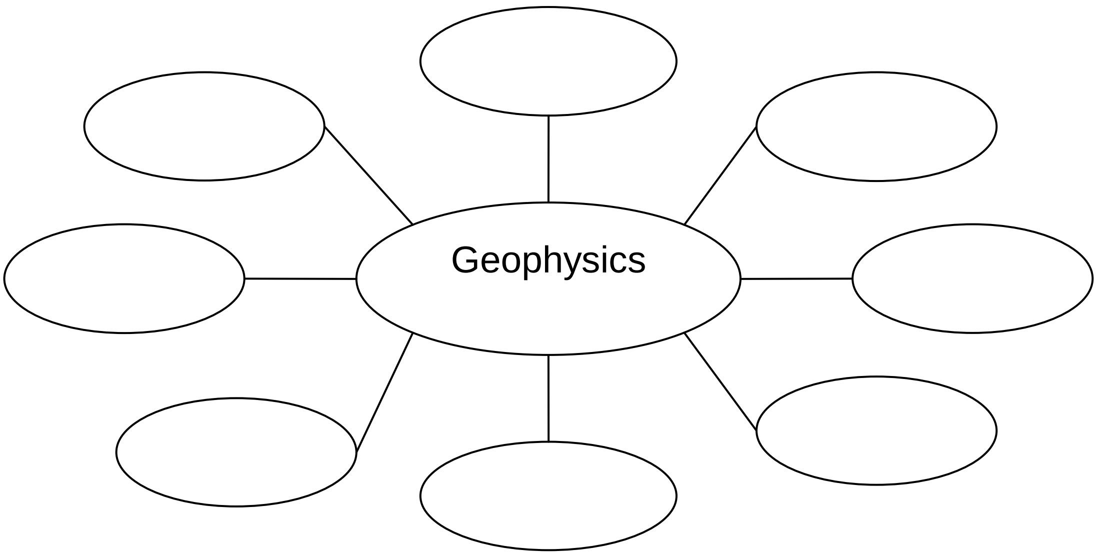
Geophysics, a branch of earth sciences, is the non-invasive study of the Earth by quantitative physical methods, especially by seismic, electromagnetic, and radioactivity methods. The theories and techniques of geophysics are employed extensively in the planetary sciences in general.

Exploration geophysics is the use of seismic, gravity, magnetic, electrical, electromagnetic, etc., methods in the search for oil, gas, minerals, water, etc., with the objective of economic exploitation.

(Robert E. Sheriff's Encyclopedic Dictionary of Applied Geophysics)

Lead-in

Fill in the spidergram with the words associated with Geophysics.



Explain your associations.

Terms and Vocabulary

accuracy	точность
airborne magnetics	воздушная магниторазведка
anticline	антиклиналь
bedrock	коренная порода
density	плотность
detection	обнаружение, выявление
dimensions	размеры
elasticity	эластичность, упругость
electrical conductivity	электропроводимость
electrical survey	электроразведка
exploratory drilling	разведочное\колонковое бурение
gravitational survey	гравиразведка
indication	показание, отчет, признак
magnetic survey	магниторазведка
magnetic susceptibility	магнитная восприимчивость
physical properties	физические свойства
prospecting for oil	нефтеразведка
quantitative interpretation	количественная интерпретация
remanence	остаточная намагниченность
seismic shooting	взрывная сейсмология, сейсмические исследования
seismic survey	сейсморазведка
Site	место проведения работ (установки буровой скважины)
survey	разведка, съемка, изыскания
borehole	буровая скважина
homogeneity	однородность
force	сила
determine	определять, устанавливать
particular	определенный, конкретный, особенный
consider	рассматривать, принимать во внимание, учитывать
utilize	использовать, употреблять
necessitate	делать необходимым, неизбежно влечь за собой
dispense with	обходиться без
same	такой же, одинаковый, тот же самый
civil engineering	гражданское строительство
decide	решать, определять, выбирать
essential	существенный, важный

substantial	значительный, значимый, достаточный
emphasis is on …	акцент делается на ч.-л., особое внимание уделяется ч.-л
on a large scale	в большом масштабе
make use of	использовать
in many instances	во многих случаях
feature	особенность, черта
because of	из-за, благодаря
on the one hand\ on the other hand	с одной стороны\с другой стороны
to a lesser\ greater extent	в большей\меньшей степени
both … and …	как …. так и …..

1. Pay attention to the pronunciation of the following word formations.

seismic-seismology	dense-density
technical-technique	susceptible-susceptibility
emphasize-emphasis	remanent-remanence
elastic-elasticity	gravity-gravitation-gravitational
measure-measurable	apply-applicable-application
homogeneous-homogeneity	polar-polarize-polarizable- polarizability
necessary-necessitate	value-valuable
accurate-inaccurate-inaccuracy	particular-particularly

2. Define the meaning of the words in bold on the basis of their similarity with the Russian ones.

Objects of geophysical survey; because of the **association** of oil with particular feature such as **anticline**; make precise **interpretation** difficult; **variations** in bedrock depth; degree of **radioactivity**; **contrasting** properties of subsurface rocks; when **gravity** fields are **utilized**; **concentrations** of **uneconomic** minerals; **final** decision; electrical **polarizability**; **indicators** of valuable metallic ores.

3. Read the text and do the exercises.

Objects of Geophysical Surveys

The objects of geophysical **survey** are to locate subsurface geological structures or bodies and where possible to measure their **dimensions** and relevant **physical properties**. In **oil prospecting** structural information is sought because of the association of oil with **particular features** such as **anticlines** in sedimentary rocks. In mining geophysics the **emphasis is** on **detection** and determination of **physical properties**. Though mineral ore bodies give distinctive and measurable geophysical **indications** they are often of irregular shape and occur in rocks of complex structure, making precise **quantitative interpretation** difficult or impossible. In **site** investigation engineers may be interested in **both** structure **and physical properties**. Variations in **bedrock** depth are often needed on major construction **sites** and the mechanical properties of the overburden may be important when heavy loads have to be sustained.

A geophysical survey consists of a set of measurements, usually collected to a systematic pattern over the earth's surface by land, sea or air, or vertically in a **borehole**. In choosing the geophysical technique to be used to study a problem the contrasting properties of the subsurface rocks and their **homogeneity** within a **particular** formation are important factors to be **considered**.

The properties of rocks of which most use is made in geophysical prospecting are **elasticity**, **electrical conductivity**, **density**, **magnetic susceptibility** and **remanence** and **electrical polarizability**. **To a lesser extent** other properties such as degree of radioactivity are also **utilized**.

Gravitational and **magnetic surveys make use of** natural fields of force. Most **seismic** and **electrical** (including electromagnetic) methods, which involve the elastic and electrical properties of rocks, **necessitate** introducing energy into ground. Since the source is under control the source to detector distance can be varied. This makes it possible when gravity and magnetic fields are being **utilized**.

Many factors – geological, economic, logistic and what we might call geophysical govern the choice of method for **particular** survey. **In many instances** more than one method will be used to **survey** the same ground. The search for oil may start with gravity and **airborne magnetic** work as a preliminary to **seismic shooting** in localities determined by interpretation of the earlier surveys. Combining electromagnetic, magnetic and gravity data may make it possible to **decide** whether certain **indications** are of valuable metallic ores or merely of concentrations of uneconomic minerals.

Remote sensing aircraft

The final decision to be taken in prospecting and **site** investigation is whether or when to drill. In **civil engineering** where depths of investigation are small and high **accuracy** is required it may pay to **dispense with** geophysics and drill from the outset. As depths or distances to be covered increase, particularly if the geology is simple, geophysics will be increasingly used. In **prospecting for oil** the structures to be discovered lie at great depth, making **exploratory drilling on a large scale** prior geophysical survey out of question.

Generally, **both** economic **and** scientific factors have to be **considered** in **deciding** a drilling programme. The cost of drilling to map accurately the undulating surface of the bedrock on a **site** may be very high relative to the cost of using geophysics but if the economic penalties of inaccuracy are **substantial** it may be cheaper to drill. **On the other hand**, where a large area must be covered in detail but high accuracy is not **essential**, geophysics can be the obvious answer.

(*D.H. Griffiths, R.F. King Applied Geophysics for Geologists and Engineers. The Elements of Geophysical Prospecting. Oxford, 1981*)

4. Form adjectives from the following words.

Example: elasticity – elastic

seismology	~~elasticity~~	remanence
homogeneity	density	accuracy
detection	quantity	prospecting
physics	magnetics	exploration

5. Match the words from the left column with their synonyms from the right one.

Example: 2. penalty – E. punishment

1. essential	A. beginning, start
~~2. penalty~~	B. weigh down
3. dimension	C. uphold, support
4. shooting	D. make use
5. overburden	~~E. punishment~~
6. dispense with	F. measurement
7. outset	G. do without
8. sustain	H. substantial
9. utilize	I. explosion

6. ***Match the verb with the noun to form collocations. Add a preposition where necessary.***

Example: locate bodies

locate		indication
measure		irregular shape
consist		bodies
necessitate	of	introduction
decide		depth/distance
determine		factors
consider		dimensions
utilize		measurements
survey		properties
cover		drilling programme
give		ground
be		natural fields of force

7. Fill in the gaps with the terms from the text.

1. One of the objects of geophysical survey is ____________ ____________ of subsurface geological structures.
2. Oil is commonly associated with _________ _________ such as anticlines in the sedimentary rocks.
3. In mining geophysics the emphasis is made on _________and ________of _______________.

4. In __________ investigations engineers are interested in ______ structural and physical properties.
5. A _____________consists of a set of measurements usually collected to a systematic pattern over the earth's surface by land, sea or air.
6. Such factors as ___________ and _________ govern the choice of method for particular survey.
7. The most useful properties of rocks in geophysical prospecting are _______.
8. Other rock properties such as _____________are also utilized in geophysical prospecting.

8. Make up sentences using the following words.

1. govern/ many/ for/ the choice/ factors/ method/ survey/ geophysical/ of/ particular.
2. can be/ in/ oil prospecting/ seismic/ for/ magnetic/ a preliminary/ survey/ shooting/ stage.
3. programme/ in/ economic/ are considered/ deciding/ and scientific/ drilling/ factors.
4. ores/ to detect/ a combination/ concentrations/ of magnetic/ of/ metallic/ help/ and gravity data/ valuable.
5. civil engineering/ is/ small/ with/ geophysics/ not necessary/ for / deals/ depths/ which.
6. requires/ exploratory/ on/ money/ scale/ drilling/ a large/ much.

9. Give English equivalents of the given Russian words.

1. In the field investigations engineers make use (как) structural (так и) physical properties.
2. The remote site location (делает необходимым) participation of a large corporation in the project.
3. Variations in (глубине залегания коренной породы) are often needed on major construction (места).
4. Every (конкретное) formation can be characterized by some degree of (однородности).
5. (Остаточная намагниченность) is a property which is (в большей степени определяется) by the structure of a rock.
6. High (электропроводимость) is an indirect (показатель, признак) of oil and gas presence.
7. (С другой стороны) if the economic penalties of (неточности) are (значительны) it may be cheaper (провести разведочное бурение).

8. (Сейсмические изыскания) are of the (той же самой) importance in (разведке, поиске) for underground waters in (гражданском строительстве).

10. Replace the underlined words or word-combinations with their synonyms from your active vocabulary. In some instances you have to change the structure of the sentence.

1. The fact that measurements are precise is very important for surveys.
2. Some subsurface rocks are characterized as materials that let the energy go easily through.
3. The factor that consists in the fact that a formation contains rocks of the same character determines the choice of geophysical method.
4. One more method of seismic survey is used when prospectors apply explosives.
5. Geophysical exploration utilizes phenomena which can be interpreted through the fundamental laws of physics.
6. Great depth and simple geology of the formation make it necessary to apply geophysical survey.
7. Employment of more than one survey method in oil prospecting helps to find signs of valuable metallic ores.
8. Irregular shape of rock of complex structure makes it difficult to carry out analysis of measurements of a particular structure.

11. Fill in the gaps with the given words.

necessitate make use decide prospecting particular
substantial electrical conductivity essential
seismic survey quantitative interpretation civil engineering

1. Exploration geophysics represents the use of seismic, gravity, magnetic methods in ………. for oil, gas with the objective of economic exploitation.
2. The process of field development can be divided into three stages, each of them ……. carrying out a number of investigations.
3. Both economic and scientific factors must be considered in ……….. a drilling programme.
4. Geophysical exploration ………….. of phenomena which can be interpreted through the laws of physics.
5. The knowledge of geologic conditions is …………. in some industrial fields.

6. The electrical survey is based on the difference in …………….. of rocks.
7. Results of …………….. of geophysical data make it possible for a drilling company to choose a site.
8. In ………….. where depths are small and high accuracy is required, it is possible to dispense with geophysics.
9. The chance of success of seismic operations is ……………. enough to cover costs for …………………. .
10. As a rule, seismic operations are completed long before getting ……….. answers to the questions to be considered.

12. Translate into English.

свидетельствовать о	be evidence of
забуривать поисково-разведочные скважины	spud wildcats
хотя	although
позволять	allow
непосредственно	directly
окупить затраты на	cover expenses for
потребуется ли	whether you will need
карстовые полости	caverns
заброшенные выработки	abandoned mines
разрез	profile
разрывные нарушения	disjunctive interruptions
граница	boundary

1. Обширное применение сейсмических работ свидетельствует об их важной роли в разведке на нефть. 2. При выборе мест для забуривания поисково-разведочных скважин почти все нефтяные компании пользуются результатами интерпретации сейсморазведочных данных. 3. Хотя во многих случаях результаты сейсморазведочных работ позволяют обнаружить геологические структуры, а не непосредственно найти нефть, вероятность успеха достаточно значительна, чтобы окупить затраты на сейсморазведку. 4. Сейсмические изыскания имеют такую же важность в поисках грунтовых вод в гражданском строительстве. 5. С их помощью можно измерить глубину залегания коренных пород, знание которой необходимо при строительстве крупных зданий, шоссейных дорог и портовых сооружений. 6. Они также позволяют определить, потребуются ли взрывные работы при строительстве дорог, если под выбранными площадками могут встретиться такие потенциальные опасности, как карстовые полости

или заброшенные выработки. 7. В ходе таких работ специалисты устанавливают, есть ли в разрезе разрывные нарушения, которые могут быть опасными для атомных электростанций. 8. С другой стороны, сейсмические методы находят небольшое применение при прямых поисках полезных ископаемых, так как они не могут получить достаточно надежные результаты, когда границы между породами сильно нерегулярны.

(В.С. Белоусов. Нефтегазовая промышленность. Основные процессы и англо-русская терминология. Москва, 2006.)

13. Comment on each sentence.

1. Geophysical survey is essential for oil production.
2. Geophysicists should take a lot of measurements.
3. There exist different kinds of geophysical survey.
4. There are a lot of rock properties substantial for geophysical works.
5. We should think a lot before doing a geophysical survey.

14. Answer the following questions.

1. What is the object of geophysical survey?
2. Why is structural information essential in oil prospecting?
3. Why are both structural and physical properties of mineral bodies important for the exploration?
4. What does the kind of geophysical survey depend on?
5. Which rock properties are essential for geophysical prospecting?
6. What do gravitational and magnetic surveys have in common?
7. What is the common feature of seismic and electrical methods?
8. What is the use of applying more than one survey method in oil prospecting?

15. State which words the following nouns are formed of.

seismology, volcanology, meteorology, oceanology, measurement, composition, difference, determination, formation.

16. Form adjectives from the following nouns.

Example: ***electricity – electrical***

Gas	elasticity	geophysics
density	seismology	conductivity
gravitation	atmosphere	application
magnetism	detection	physics
essence	volcano	significance
subsurface	ocean	suit

17. Study the words. Then read the text and separate the sentences by means of full stops.

applicable in	применимый в
exposed	обнаженный
gaseous (liquid) envelope	газовая (жидкая) оболочка
geophysical measurements	геофизические измерения
embrace (v)	охватывать
verify (v)	проверять, подтверждать
phenomenon – phenomena	феномен – феномены
terrestrial magnetism	земной магнетизм
entail for (v)	определять, иметь следствием
exhibit (v)	показывать, демонстрировать, проявлять
advisable	целесообразный

Significance of Geophysical Exploration

geophysical exploration may be defined as prospecting for mineral deposits and geologic structure by surface measurement of physical quantities geophysical exploration (GE) makes use of **phenomena** which can be interpreted fully through the fundamental laws of physics, measured, and **verified** by anyone as long as suitable instruments are used geophysical exploration may be considered an application of the principles of geophysics to geological exploration derived from the Greek the word Geophysics means “physics” or “nature” of the earth it deals with the composition and physical phenomena of the earth and its **liquid** and **gaseous envelopes** it **embraces** the study of **terrestrial magnetism**, atmospheric electricity, and gravity; and it includes seismology, volcanology, oceanology, meteorology, and related sciences experience has demonstrated that most subsurface structures and mineral deposits can be located, provided that detectable differences in physical properties exist the main properties **exhibited** by the more common rocks and formations are: density, magnetism, elasticity, and electrical conductivity this **entails for** major geophysical methods: gravitational, magnetic, seismic, and electrical since GE is the determination of subsurface geologic structure by means of surface physical measurements, it is applicable in industrial fields where knowledge of geologic conditions is essential it is understood that such applications are **advisable** only where structures and ore bodies are not **exposed,** as most **geophysical measurements** are more expensive than surface geological surveying

18. You are going to listen to an interview with Steve Holbrook, Professor of University of Wyoming (UW), Geology Geophysics Department. The notes on the information from the interview are given below. For gaps (1-10) you should fill in words that are missing. No more than two words can be used.

Steve Holbrook does (1) ________ _________ seismology.
There are seismologists who listen to the sounds which the (2) ______ _________.
The second type of seismologists make their own sounds and listen for the (3)_____ that comes back.
The students of the department are very (4) ______ and that brings a lot of energy to the place.
Professor Holbrook's recent research is connected with (5) ________ ________ .
This gas might have played a role in the (6) ______ ________ .
The project which is conducted in Costa Rico involves analysis of magma (7) _____ and magma flux.
The very exciting research area that Professor Holbrook's group has just taken is seismic (8) ___________ .
The seismic survey in the ocean is used to (9) _____ the Earth.
There are a lot of (10) ____ ______ and _______ events at the university.

19. Use the information from the text and words. Make up a dialogue based on the situation.

STUDENT A: You are a school leaver (абитуриент). You don't know which department – geophysics or geology and oil-gas field development – to choose. You come to the entrance examination office (приемная

комисия) and ask questions to know more information about specializations.
STUDENT B: You are a person at the entrance examination office. There is a shortage of students at geophysics department. Persuade (убедите) the school leaver to enter this department and specialization. Talk about:

- advantages of the specialization;
- its prospects for future jobs;
- conditions of studies there;
- courses or subjects, famous teachers, skills you can get there;
- some bonuses in studies and future jobs connected with the specialization.

20. Tell about geophysical survey according to the given plan using words in brackets.

1. Aims of geophysical survey and necessary factors to be considered.
(dimensions, anticlines, emphasis is on …, irregular shape, structural and physical properties)
2. Essence (суть) of geophysical survey and the choice of necessary method.
(measurements, systematically, homogeneity, contrasting properties)
3. Properties used in geophysical survey.
(most use, to a lesser extent, natural fields of force, necessitate)
4. Combined approach to geophysical survey.
(many factors, in combination, preliminary, valuable ore deposit)
5. The proven (оправданное) usage of geophysical survey.
(civil engineering, high accuracy, depth, geology, cost of drilling, relative to, penalties of inaccuracy, cheaper to drill)

21. Read the text «Significance of Geophysical Exploration» and answer the following questions.

1. How can geophysical exploration be defined?
2. What is the origin of the word «geophysics»?
3. What sciences related to geophysics do you know?
4. Which four physical properties of minerals are most essential for their location?
5. When is geophysical exploration applied?
6. What field is the greatest use of geophysical prospecting made in?

Significance of Geophysical Exploration

Geophysical exploration may be defined as prospecting for mineral deposits and geologic structure by surface measurement of physical quantities.


Aircraft for remote sensing

Geophysical exploration (GE) makes use of phenomena which can be interpreted fully through the fundamental laws of physics, measured, and verified by anyone as long as suitable instruments are used. GE may be considered an application of the principles of geophysics to geological exploration. Derived from the Greek the word «geophysics» means «physics» or «nature» of the earth. It deals with the composition and physical phenomena of the earth and its liquid and gaseous envelopes; it embraces the study of terrestrial magnetism, atmospheric electricity, and gravity; and it includes seismology, volcanology, oceanology, meteorology, and related sciences.

Experience has demonstrated that most subsurface structures and mineral deposits can be located, provided that detectable differences in physical properties exist. The main properties exhibited by the more common rocks and formations are: density, magnetism, elasticity, and electrical conductivity. This entails for major geophysical methods: gravitational, magnetic, seismic, and electrical.

Since GE is the determination of subsurface geologic structure by means of surface physical measurements, it is applicable in industrial fields where knowledge of geologic conditions is essential. It is understood that such applications are advisable only where structures and ore bodies are not exposed, as most geophysical measurements are more expensive than surface geological surveying.

(C.A. Heiland. Geophysical Exploration. New York, 1940)

22. Discuss the following statement. Explain each benefit of geophysics with your own words.

*Geophysics is a **comprehensive**, **non-destructive**, **cost-effective**, **efficient**, and **proven** method of exploration.*

Terms and Vocabulary

appropriate to	присвоенный, соответствующий
CGS (centimetre-gram(me)-second system)	система СГС, сантиметр-грамм-секунда
conceive	полагать, представлять
conventions	условные обозначения
conversion	преобразование, переход
conversion factor	коэффициент преобразования; переводной коэффициент
dimensionless ratio	безразмерное соотношение
EMU (Electromagnetic units)	единицы электромагнитной системы
= equals	равняется
factor (2 and 5 are factors of 10)	множитель
F	поле, сила
gauss	гаусс (единица измерения магнитной индукции)
gravity unit	единица ускорения свободного падения
m_1 (m sub one)	*м* первое
magnetizing field	намагничивающее поле
magnetic induction	магнитная индукция
Mho	мо (единица проводимости)
x (multiply by)	умножить на
numerical value	численное значение
π (pi)	пи
10^{-2} (raise 10 to minus second power)	десять в минус второй степени
rationalization	освобождение от иррациональностей
rationalized unit	единица рационализованной системы
reciprocal	аналог, эквивалент; обратная величина, дробь
resistivity	удельное сопротивление
seismic velocity	скорость сейсмической волны
siemens	сименс (единица электропроводимости)
SI (Système International)	международная система единиц
tesla	тесла (единица измерения магнитной индукции)
unrationalized	нерационализованный

23. Read the words paying attention to the pronunciation of the following words.

reciprocal
conversion
rationalized unit
numerical value
rationalization
gauss
ampere

m_1
equals
multiply by
resistivity
dimensionless ratio
tesla
gal

24. Read the text, do the exercises.

Units in Geophysics

The **SI** (Système International) units used in this book have come into common use, but older units are still to be found, and a note on **conversions** may be of some value.

Electrical units

These are the least affected by the introduction of SI, which uses the same units (volt, ampere, ohm etc.) as the "practical" version of the **EMU** System. The only real change is that **resistivity** is now measured in ohm-meters (Ωm) rather than in ohm-cm or ohm-ft.

1 ohm-cm = 10^{-2} Ωm

1 ohm-ft ≈ 0.3 Ωm

Use of this latter **conversion factor** (more precisely 0.305) rather than its **reciprocal** in all conversions involving feet and metres makes for easy mental conversions to better than 2 per cent accuracy.

Conductivity is of course measured in **mho** m^{-1} or **siemens** (S).

Seismic velocity

The SI unit is the metre per second (m s^{-1}) but seismologists commonly use the kilometre per second (km s^{-1}), a unit which is conveniently also thought of as the metre per millisecond (m ms^{-1}) in applied seismology.

Gravity

If a gravitational field is conceived as an acceleration, its SI unit will be the m s^{-2}; if as a force per unit mass it will be measured in Newtons per kilogram (N kg^{-1}), the same unit by a different name. The **"gravity unit"** is the μm s^{-2} (or μN kg^{-1}) so that

1 g.u. ≡ 10^{-6} ms^{-2} ≡ 10^{-6} N kg^{-1} ≡ 10^{-1} mGal

since the old "milligal" (mGal) unit was defined as

10^{-3} cm s^{-2} = 10^{-} ms^{-2}.

The SI unit of density is the kg m^{-3}: the density if water is 1000 kg m^{-3}, and to avoid the use of large numbers it is convenient to express densities in tonnes per cubic metre (t m^{-3}) so that they have the same **numerical value** as in the old units of g cm^{-3}, since 1 tonne = 1000 kg.

Magnetism

There has been some confusion in the application of the SI to magnetic units, particularly in geophysics, since at least three slightly differing **conventions** have been in use. All these conventions are based on **"rationalized" units**, in which the force between two magnetic poles m_1, m_2 *in vacuo* becomes $m_1 m_2/4\pi\mu_0 r^2$ *rather than* $m_1 m_2/\mu_0 r^2$. The constant μ_0 units, known as the permeability of free space, has the value $4\pi\cdot10^{-7}$ in SI units and unity in the old **c.g.s.** electromagnetic units. The **factor** of 4π introduced by **rationalization** means that although magnetic susceptibility is a **dimensionless ratio** its value in SI units will be a factor of 4π larger than that **appropriate to** the (**unrationalized**) c.g.s. e.m.u. system.

In the particular (Sommerfeld) convention used in magnetizing field **F** and intensity of magnetization **J** are both measured in amperes per meter (A m^{-1}) and are related to the **magnetic induction** B in a magnetized medium, which is measure in **teslas** (**T**), through $B= \mu_0 (F-J)$. The geomagnetic "field" and its anomalies are taken to be fields of the induction B rather than of F; thus outside magnetic material the normal geomagnetic field $B_g= \mu_0 F_g$. The intensity of magnetization J produced in a body of susceptibility k will be $k F_g$, but we work only with the quantity $\mu_0 J= k\mu_0 F_g = kB_g$ and calculate from it the "B" field produced by a magnetic body. Magnetic anomaly fields are then conveniently measured in nanoteslas (nT), a unit which is the same as gamma (γ) used in the c.g.s. system, since $1\gamma = 10^{-5}$ **gauss** and 1 *tesla* $= 10^4$ gauss, the gauss being the unit of magnetic induction in the e.m.u. system.

(*D.H. Griffiths and R.F. King "Applied Geophysics for Geologists and Engineers. The Elements of Geophysical Prospecting". Oxford, 1981*)

25. Read the following expressions and equations.

$$S_v = 6f(1-Kn)\sum \frac{p_i}{d_i}$$

10^{-7}–10^{-4} m 10^{-9}–10^{-7} m

$P_g > P_j$ $\sigma_{water} = 1{,}05 \cdot 10^3$ kg/m^3

$\sigma_{oil} = 0{,}755 \cdot 10^3$ kg/m^3

$$S_v = 2f \cdot Kn \sum \frac{p_i}{r_i}$$

WORDLIST

ENGLISH	RUSSIAN
accuracy	точность
airborne magnetics	воздушная магнитная съемка
anticline	антиклиналь
applicable in	применимый в
bedrock	коренная порода
be employed in	использоваться в
borehole	скважина
civil engineering	гражданское строительство
comprehensive	всесторонний, полный
consider	рассматривать, принимать во внимание
cost-effective	прибыльный, рентабельный
decide	решать, определять, выбирать
density	плотность
detection	обнаружение
determination	определение
dimensions	размеры
dispense with	обходиться без
efficient	действенный, эффективный
electrical conductivity	электропроводимость
electric survey	электроразведка
elasticity	эластичность
emphasis is on …	акцент делается на ч.-л., особое внимание уделяется ч.-л
entail smth for smth / sb	влечь за собой
essential	существенный, важный
exploratory drilling	разведочное \ колонковое бурение
exposed	обнаженный
extensively	в значительной степени
gaseous envelope	газовая оболочка
geophysical measurements	геофизические измерения

gradient	градиент, угол наклона
gravity	сила тяжести, тяготение
gravity survey	гравиразведка
homogeneity	однородность
indication	показание, отчет, признак
liquid envelope	жидкая оболочка
magnetic susceptibility	магнитная восприимчивость
magnetic survey	магниторазведка
make use of	использовать
necessitate	делать необходимым, неизбежно влечь за собой
non-destructive	неразрушающий
on a large scale	в большом масштабе
outset	устье шахты
overburden	перекрывающие породы, вскрыша
particular	особенный, определенный, конкретный
phenomenon, phenomena	феномен, -ы
physical properties	физические свойства
prospecting for oil	нефтеразведка
proven	проверенный, доказанный
provided that	при условии если
quantitative	количественный
quantitative interpretation	количественная интерпретация
remanence	остаточная намагниченность
same	такой же, одинаковый, тот же самый
seismic shooting	сейсмические исследования
seismic survey	сейсморазведка
Site	место (проведения работ)
substantial	значительный, значимый, большой
survey	разведка, обзор, съемка, изыскания
sustain a load	выдерживать нагрузку
technique	способ, метод, технология
terrestrial magnetism	земной магнетизм
undulating surface	волнистая поверхность
utilize	использовать, употреблять

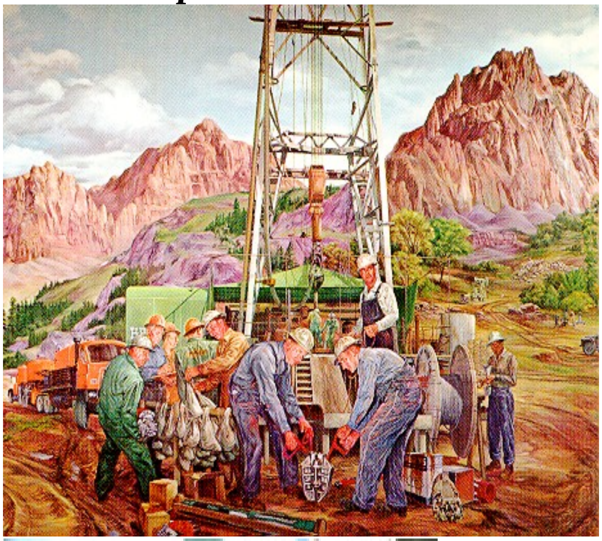
UNIT 2

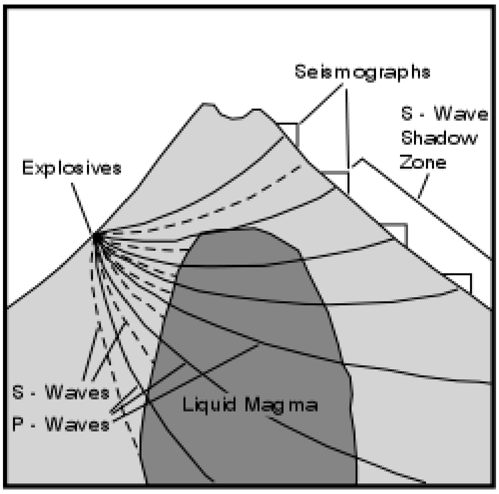
GEOPHYSICAL METHODS IN PETROLEUM EXPLORATION

Hydrocarbon exploration (or oil and gas exploration) is the search by petroleum geologists for hydrocarbon deposits beneath the Earth's surface, such as oil and gas. Oil and gas exploration are grouped under the science of petroleum geology.

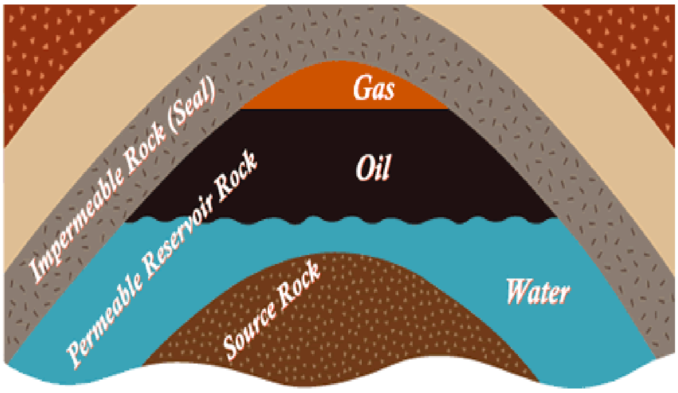
Lead-in

Look at the pictures and describe some operations or processes associated with Oil Exploration.





After Murck et al., 1996



Name other activities, equipment that are necessary for oil exploration. Name occupations that are involved into petroleum exploration.

Terms and Vocabulary

anomaly	аномалия
array	ряд, группа, расстановка
air gun array	расстановка пневмопушек
depth value	значение глубины
downward propagation	нисходящее распространение
gravitational attraction	гравитационное притяжение
land survey	наземная съемка
marine survey	морская съемка
penetrate (v)	проникать (внутрь)
pull of gravity	величина тяготения
reflection seismology	сейсморазведка методом отраженных волн
refraction seismology	сейсморазведка методом преломленных волн
source energy	энергия источника
structural uplift	структурный подъем
thumping device	устройство падающего груза
predetermined	заранее установленный
actuate (v)	приводить в действие; запускать; включать
interface	граница раздела двух сред; поверхность контакта
embed (v)	закладывать, встраивать
trail (v)	прокладывать путь
streamer	морская коса (сейсморазведоч-ный кабель)
yield	давать (определенный резуль-тат), выдавать, производить
due to	благодаря, из-за, вследствие
generate	порождать, производить
carry out	выполнять, осуществлять, проводить
reflect (v)	отражать
refract (v)	преломлять
arrival time	время вступления волны
event	волна (на сейсмограмме)

explosion	взрыв
receive (v)	получать
subsequent	последующий
recording unit	регистрирующее устройство
digitize (v)	представлять в цифровом виде, оцифровывать
pick up (v)	собирать, регистрировать
device	устройство
transmit	передавать

1. Read the words paying attention to the pronunciation.

[ʌ] thumping, fundamental, subsequently
[i:] streamer, receive, yield, sea
[ju:] due to, actuate
[ou] prospecting, processing, explosion
[ɛə] air, various, aeromagnetics
[ʒ] measure, measurement, explosion
[ai] arrival, divide, digitize, vibrating, widely
[ei] data, same, basically, arrays, cable, basin

2. Pay attention to the stress in the following words.

a'nomaly	seis'mology
'analog	'penetrate
meta'morphic	'subsequent
'yield	'downward
a'nalysis	ma'rine
e'vent	ma'chine
ar'rival	

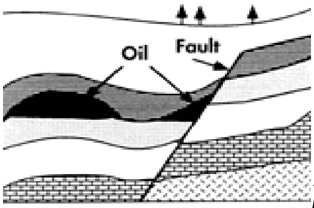
3. Read the following word-combinations and give their translations.

Due to changes of structure or magnetic susceptibility of the rocks; interpretation of the recorded anomalies; to yield the maximum depth value for a sedimentary basin; variations in the pull of gravity; to have greater gravitational attraction; to appear as an anomaly on the gravity map; to carry out in the air on helicopter; to be divided into the branches of reflection and refraction seismology; arrival times of events reflected from the subsurface; seismic energy which penetrates the earth’s surface; concept is the same for both land and marine surveys; to be generated by arrays of small chemical explosions or thumping devices; to result from the downward propagation of the source energy; to digitize the analog signals; to record for subsequent analysis; array of air guns is actuated; move over a predetermined course; detectors embedded in a streamer; to transmit to a central recording unit.

4. Read the text and do the exercises.

Geophysical Prospecting for Oil

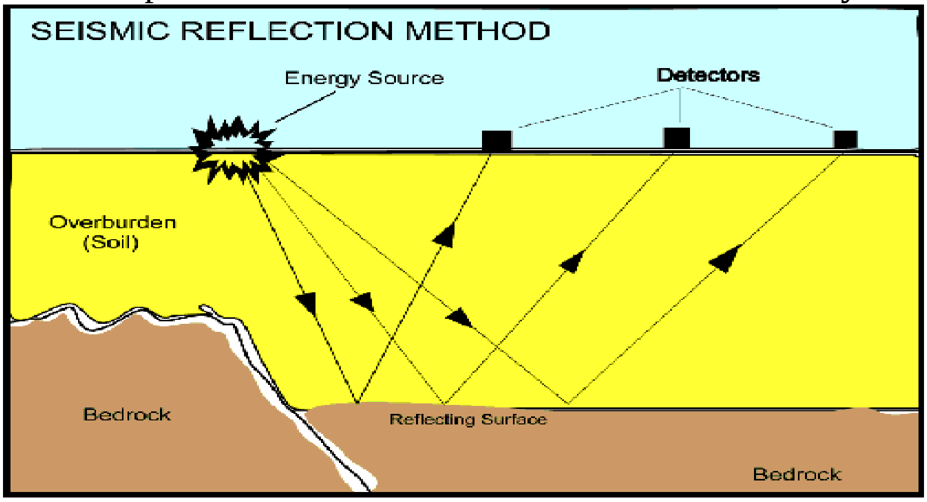
At present the greatest use of geophysical prospecting is made in oil exploration. The three principle geophysical methods used in petroleum exploration are seismic, magnetic, and gravity. The magnetic method is the oldest geophysical method, and is based on the measurement of variations in the magnetic field **due to** changes of structure or magnetic susceptibility of the rocks. Sedimentary rocks generally have a smaller susceptibility than igneous or metamorphic rocks, so an interpretation of the recorded **anomalies** can **yield** the maximum **depth value** for a sedimentary basin. Today, magnetic surveys for hydrocarbon exploration are usually **carried out** from the air (aeromagnetics) or from a ship. The gravity method is based on the measurements of the variations in the **pull of gravity** from the rocks in the upper layers of the earth's surface. Denser rocks have greater **gravitational attraction** than less dense rocks. For example, a **structural uplift** of denser rock will appear as an anomaly on the gravity map. Gravity surveys for hydrocarbons are carried out on land, in the air on helicopters, and at sea on ships.



Petroleum deposits near fault


Vibroseis trucks

The most widely used geophysical method is the seismic method. Exploration seismology is divided into the branches of **reflection seismology** and **refraction seismology**. Most petroleum exploration is done by the reflection seismic method. Reflection seismology is a method of mapping the subsurface sedimentary rock layers from measurements of the **arrival times** of **events** reflected from the subsurface layers. The technology of collecting and processing reflection seismic data is based on a fundamental concept by generating seismic energy which **penetrates** the earth's surface. Basically, the concept is the same for both **land** and **marine surveys**.



On land, seismic energy is generated at or near the earth's surface by **arrays** of small chemical explosions, or vibrating machines, or **thumping devices**. The seismic waves resulting from the **downward propagation** of this **source energy** are reflected from the various **interfaces** and received by the detectors. A central recording unit then digitizes the analog signals and records them for subsequent analysis. At sea, a source such as an **array of air guns** is **actuated** every few seconds as the ship moves over a **predetermined** course. The seismic waves are picked up by detectors **embedded in** a cable (called a **streamer**) **trailing** the ship. As in land surveys, the data are transmitted to a central recording unit and recorded in digital form.

(M. T. Sylvia, E.A. Robinson. Deconvolution of Geophysical Time Series in the Exploration for Oil and Natural Gas. Amsterdam-Oxford-New York, 1979)

5. Form all possible nouns from the following words, using the following suffixes: *-ity, -or, -er, -ment, -ion, -sion, -tion, -ive.*

Example: explore – exploration, explorer

generate	record	~~explore~~	susceptible
transmit	reflect	measure	penetrate
detect	refract	dense	interpret
attract	digitize	act	explode

6. Complete the sentences using correct prepositions where necessary.

1. Most petroleum exploration is done ___ the reflection seismic method.
2. This method is based ___ the measurement ___ variations ___ the magnetic field due ___ changes ___ structure or magnetic susceptibility ___ the rocks.
3. Exploration seismology is divided ___ two branches.
4. Magnetic surveys are usually carried ___ from the air or ___ a ship.
5. The seismic waves are picked up ___ detectors.
6. The concept is the same ___ both surveys.
7. The seismic waves result ___ the downward propagation.
8. The three basic methods are used ___ petroleum exploration.
9. Gravity surveys are carried out ___ land, ___ the air ___ helicopters, and ___ sea ___ ships.

7. Fill in the gaps using the terms from the text.

1. The three principle geophysical methods used in petroleum exploration are _____________and _______________.
2. The _____________ method is the oldest one.
3. Today, magnetic surveys for hydrocarbon exploration are usually carried out from ___________or from _______________.
4. Exploration seismology is divided into the branches of __________ and _______________.
5. A central recording unit digitizes the __________ ___________.

8. Fill in the gaps with words which are derived from the word given at the end of each line.

1. …… method is not so popular in exploration seismology as reflection method.	REFRACT
2. The gravity method is concerned with measurements of gravitational ………. of rock of upper layers.	ATTRACT
3. He hurt her and the ……… decision was to break up.	SEQENCE
4. In spite of bad weather the exploration team worked according to a ……………… timetable.	DETERMINE
5. The outside …….. into the thoughts of a man is still impossible.	PENETRATE
6. The developed device was ……. after several years of experiments.	ACT
7. The speed of wave ………….. depends on the density of	PROPAGATE

the medium.
8. Pickups are …….. of analog signals applied in seismic exploration. RECEIVE
9. The base of seismic operations is ……… of seismic waves and measurements of their travel time. GENERATE
10. Shooter actuates ………. at the predetermined time and cleans the well area after the explosion EXPLODE

9. Give English equivalents to the following sentences.

1. Более плотные породы имеют большее гравитационное притяжение, чем менее плотные породы.
2. Разведка месторождений ценных полезных ископаемых осуществляется на земле.
3. Осадочные породы имеют меньшую восприимчивость, чем изверженные.
4. Нисходящее распространение звуковой волны способствовало установлению местонахождения корабля.
5. Пневматический источник сейсмических сигналов порождает сейсмические волны, которые отражаются от поверхности контакта.
6. Современная технология сбора и обработки данных требует их записи в цифровом виде.
7. Сейсмические волны могут проникать глубоко в недра Земли и, как следствие, давать информацию о ее внутреннем строении.
8. Пусковое устройство, вмонтированное во взрывчатку, было приведено в действие в полночь.
9. Величина тяготения определяется массой тела.
10. Устройство падающего груза произвело энергию необходимой мощности.

10. State whether the following sentences are true or false; correct the false ones.

1. Less dense rocks have greater gravitational attraction than denser rocks.
2. Reflection seismic method is the oldest one.
3. Gravity method is based on the measurement of magnetic field due to changes of structure and gravitational susceptibility of the rocks.
4. The technology of collecting and processing reflection seismic data is based on the concept, that seismic energy generates and penetrates the earth's surface.

5. At sea, seismic energy is generated at or near the earth's surface by arrays of small chemical explosions.
6. Magnetic surveys are usually carried out from a ship and from the air.

11. Reconstruct the jumbled sentences.

1) unit\ are\to\ the data\ transmitted\ central\ a\ recording.
2) defined\ gravitational\ is\ the density\ by\ of\ attraction\ rocks.
3) array \ in \of \ marine\ is actuated\ survey\ air guns.
4) the seismic\ propagation\ are\ energy\ of downward\ waves\ result\ of the source.
5) is based on\ seismology\ subsurface \of arrival times\ reflection\ measurements/ reflected from\ of events\ interfaces.
6) digitizes\ a central \ subsequent\ and\ analog\ records\ unit\ them\ for\ recording\ analysis\ signals.
7) denser rocks\ as an anomaly\ map\ uplift of\ will be shown\ a structural\ on gravity.
8) energy\ devices\ arrays of\ can be\ chemical\ seismic\ generated\ explosion\ by\ thumping\ or.

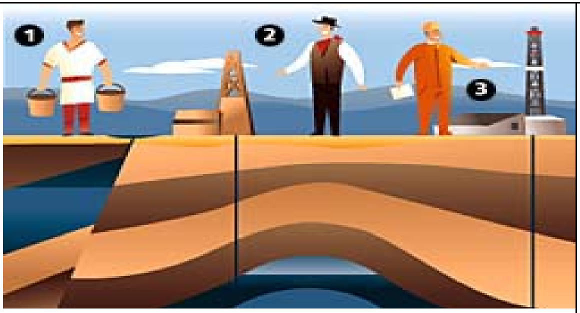
12. Answer the following questions.

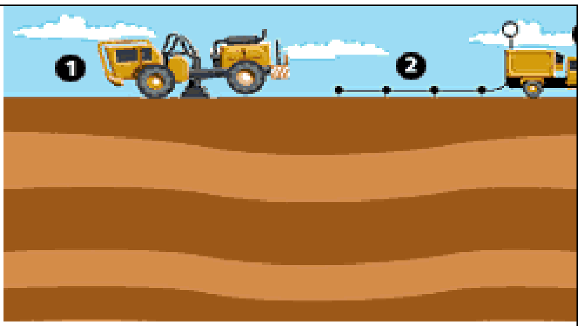
1. What are three geophysical methods mostly used in oil exploration?
2. Which of the methods is based on the measurement of variations in the magnetic field due to changes of structure?
3. Which of the three methods is the oldest one?
4. Which of the methods is used everywhere: on land, in the air and on ships?
5. Which of the three methods is most widely used?
6. What is gravity method based on?
7. What two branches of exploration seismology do you know?
8. Which of the methods is most frequently used for petroleum exploration?
9. How does reflection seismology work?
10. What fundamental concept is reflection seismic method based on?
11. What are the differences and features in common for land and marine reflection seismic method?

13. Listen to Khoi Pham who works for Geophysical Service Incorporated (GSI). He tells about his position as a crew manager in marine survey. Answer the questions given below.

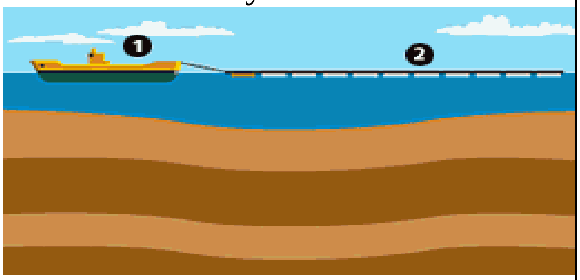
1. What are his responsibilities in this position?
2. What opportunities are there for the promotion?
3. What does the job of an observer include?
4. What skills should an observer have?
5. Why does he like the job?
6. What is his schedule like?
7. How does he spend his free time?
8. What are his personal accomplishments connected with the job?

14. Tell about prospecting for oil using the following pictures.

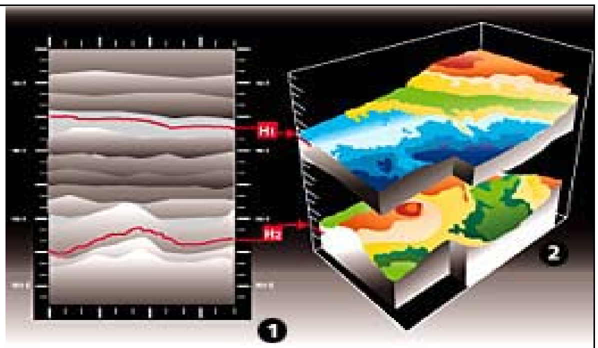
 1. In ancient times 2. In the 19th century 3. Today	 1. Map 2. Hammer 3. Acids 4. Magnifying glass 5. Logbook
 1. Aerial shot. 2. Satellite shot	



1. Vibrator truck
2. Receivers
3. Laboratory truck

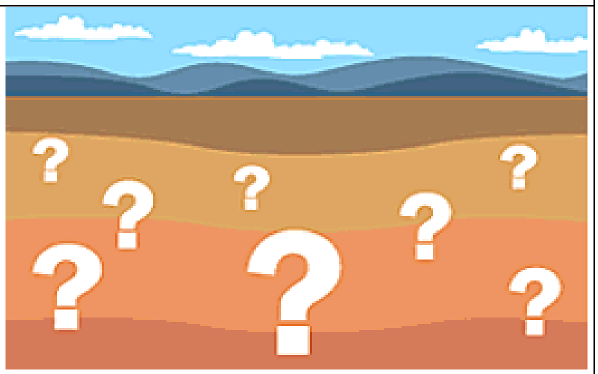


1. Seismic vessel
2. Receivers

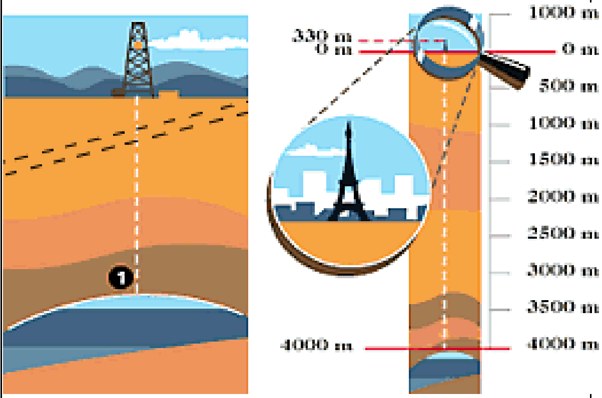


1. Isochrons
2. 3D seismic Maps

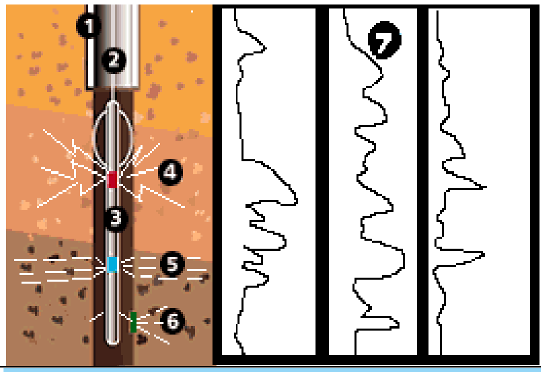
1. Geophysicist
2. Geologist



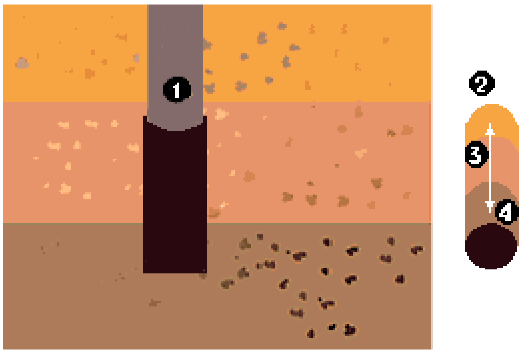
1. Drilling location



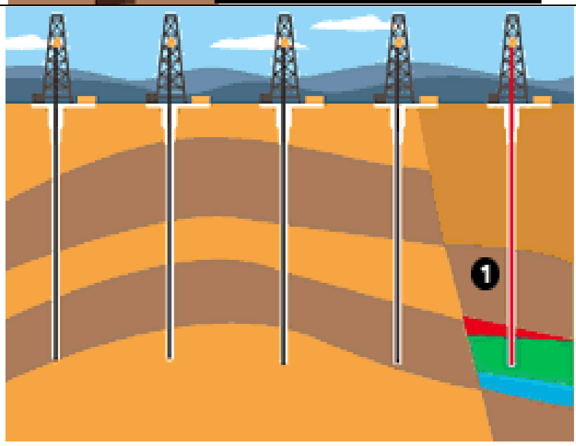
1. Well casing
2. Cable retaining the downhole probe
3. Downhole Probe
4. First probe sensor
5. Second probe sensor
6. Third probe sensor
7. Measurements obtained by the sensors



1. Coring tool
2. Core sample
3. Indications concerning height of beds



4. Clues concerning type of rock



1. One hole in five struck oil

1. Economic data
2. Choice of operating methods
3. Geological data

***ELF Aquitaine* Geophysical Prospecting: How to find oil!**
http://www.mssu.edu/SEG-VM/introduction_to_geophysical_prospecting.html

Terms and Vocabulary

astatizing	астатизированный
Bar	брусок, плитка
beam	балка, коромысло
curvature	выгиб, изгиб, искривление
discrepancy	разница, расхождение
gravimeter	гравиметр
helical spring	винтовая пружина
hinged beam	шарнирно-опертая балка
inverted position	перевернутая позиция
latitude	широта
mount	устанавливать
observation time	время наблюдения
pendulum	маятник, отвес
plausible assumption	правдоподобное допущение
qualitative	качественный
quantitative	количественный
quantity	количество, величина
restoring force	возвращающаяся сила
Rod	стержень, рейка
salt dome	соляной купол
spring force	жесткость пружины, сила сжатия пружины
stratified	слоистый
suspension wire	несущий трос
taut	тугонатянутый
terrain	топография, физические особенности местности
torsion balance	крутильный динамометр, весы
torsion	кручение; скручивание
labilizing(force)	активирующая сила
value	величина; значение
arrangement	классификация; группировка; расположение, размещение
give preference to\over	отдавать предпочтение ч-л. над ч-л.

resolve	вращаться, перемещаться; раскладывать (на компоненты)
coincide with	совпадать, совмещать
supersede	заменять, заместить
suspend from	подвешивать на
compare	сравнивать, сопоставлять
reduce	снижать, сокращать, уменьшать

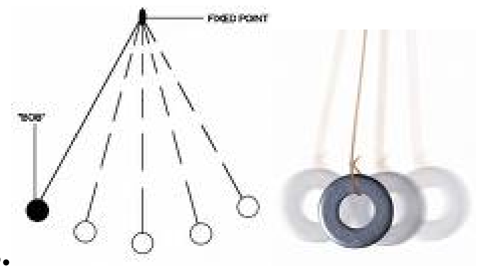
15. Pay attention to the pronunciation of the following word formations and words.

pendulum	quality-qualitative
discrepancy	curved-curvature
gravimeter	quantity-quantitative
plausible	suspend-suspense-suspension
terrain	torsion-torsionless
astatizing	balance-unbalance
chronometer	suit-suitable
hinged beam	coincide-coincidence
effect	sensitive-sensitivity
component	contrary-contrarily
assumption	short-shorten
since	correct-correction
contrast	supersede-supersession

16. Read the text, do the exercises.

Gravity Method

Variations in the gravitational field may be mapped by the **pendulum**, gravimeter, and **torsion balance**. The pendulum and **gravimeter** measure relative gravity, whereas with the torsion balance, the variations of gravity forces per unit horizontal distance, also known as «**gradients»** of gravity are determined. Since gravitational effects of geologic bodies are proportional to the contrast in density between them and their surroundings, gravity methods are particularly suitable for location of structures in **stratified** formations.



Pendulum methods.

Pendulum may be used to determine not only time but gravity as well. Gravity pendulums are kept as contrast as possible in length so that variations in period indicate changes in gravity only. The most common method for securing the necessary accuracy in pendulum observations is the «**coincidence»** or beat method whereby the gravity is compared with a chronometer or another pendulum of nearly equal period.

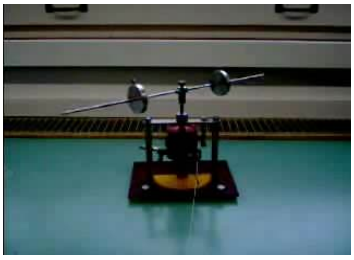
Gravimeters.

Pendulum, or «dynamic» methods of measuring gravity have been **superseded** recently by "static" or "gravimeter" methods in which gravity is compared with an elastic **spring force**. Mechanically simplest are the Threlfall and Pollock instrument (in which a thin horizontal quartz bar is **suspended from** a horizontal torsion wire), the Hartley gravimeter (containing a horizontal, **hinged beam** suspended from two **helical springs**), the Lindblad-Malmquist and the Askania gravimeters in which the masses are suspended directly from springs, with **arrangements** for electrical or similar sensitivity may be attained by providing "astatizing" mechanisms which involve the application of a **labilizing force** nearly equal and opposite to elastic **restoring force**. For example, the Ising gravimeter, in which a vertical quartz **rod** is suspended in inverted position from a **taut** horizontal quartz fiber.

Corrections on gravity values observed with pendulums and gravimeters.

The following corrections must be applied on relative gravity values: (1) a correction for normal variations of gravity (planetary effect); (2) terrain correction; (3) free-air and Bouguer (elevation) correction. The planetary correction is due to the variation of gravity with latitude. The effect of **terrain** is calculated from elevations along radial lines and concentric circles around the station. Elevation is allowed for by a reduction to sea level (free air correction) to which the influence of the rocks between station and sea level is added (Bouguer reduction).

Torsion balance.



Contrarily to the beam in an ordinary balance, the **beam** in a torsion balance **resolves** in a horizontal plane and is reflected from a position corresponding to the torsionless condition of the **suspension wire** by the unbalance of horizontal forces acting on it.

The beam with two weights attached to its ends at different levels is most frequently used in practice. The gradients and **curvature values** may be **resolved** into their north and east components. Hence the torsion balance beam is affected by four unknown quantities, to which is added a fifth, the zero or torsionless position of the beam. And the detection of the beam depends on its azimuth, the action of gravity forces on it may be changed by rotating the entire instrument in a different direction. To determine the five unknown quantities, five azimuths are therefore required. To shorten the **observations time** (20 to 30 minutes in each position), two beams are mounted side by side in antiparallel arrangements. The second beam adds its torsionless position as sixth unknown, so that three positions separated by angles 120° are required to determine all quantities.

Torsion balance interpretation may be **qualitative** and **quantitative**. In the former, gradients are given preference over **curvature values**. The largest gradients occur above such portions of subsurface geologic features as are characterized by the greatest horizontal variation of density, for example, on flanks of anticlines, edges of **salt domes,** igneous intrusions. Quantitative interpretation is usually of an indirect nature; geologically **plausible assumptions** are made about subsurface mass dispositions; their gravity anomalies are calculated and compared with the field findings. **Discrepancies** between the two are **reduced** step by step by modifying the assumptions regarding depth, shape, and density of the subsurface bodies.

(C.A. Heiland. Geophysical Exploration. New York, 1940)

17. Complete the sentences with your own ideas. Use words from your vocabulary.

1. The hinged beam in this device ……………… .
2. Latitude determines ……………………………….. .
3. The astatizing mechanism …………………………… .
4. The pendulum …………………………………. .
5. The assumptions should be modified because ……… .
6. Discrepancies between two quantities ……………….. .
7. In our work we give preference to ……………… .
8. A helical spring is suspended from …………………… .

18. Replace the underlined words or word-combinations with their synonyms from your active vocabulary. In some instances you have to change the structure of the sentence.

1. The planetary correction occurs <u>because of</u> variations of gravity with latitude.
2. <u>The method making use of events reflected from the subsurface</u> is commonly applied in petroleum exploration.
3. Magnetic surveys are usually <u>performed</u> from the air or from a ship.
4. <u>Some devices utilizing the air</u> are necessary to produce a source energy for seismic <u>survey at sea.</u>
5. An anomaly can indicate <u>a fault with one block which is moved up along the other.</u>
6. Different rocks <u>produce</u> local variations in Earth's magnetic field and so <u>give</u> different readings from a magnetometer.
7. A recording truck <u>registers</u> the data that are transmitted by receivers.
8. The gravity method is based on the measurements of the variations in the <u>pull of gravity</u> of the rocks of different density.

19. Fill in the gaps with correct prepositions.

1. The planetary correction is due ___ the variation ____ gravity ____ latitude.
2. Pendulum methods have been superseded ___ gravimeter methods.
3. Several corrections must be applied ___ relative gravity values.
4. Detection of the beam depends ___ its azimuth.
5. To shorten the observations time two beams are mounted side ___ side ___ antiparallel arrangements.
6. Quantitative interpretation is usually ___ an indirect nature.
7. Discrepancies _____ the two are reduced step ____ step.

20. Translate the following sentences into English.

1. Статические, гравиметрические методы заместили динамические методы маятника.
2. Гравитационные методы особенно подходят для локализации структур в слоистых образованиях.
3. Топографическая поправка высчитывается по подъему вдоль лучевых линий и концентрическим кругам вокруг станции.
4. Количественная интерпретация имеет непрямую природу.
5. Маятник определяет не только время, но и силу тяжести.
6. Крутильный гравиметр измеряет гравитационные силы на единицу горизонтальной дистанции.

21. State whether the following sentences are true or false; correct the false ones.

1. Pendulum method in geophysics is used to measure time.
2. “Coincidence” method is the least frequent method used among other pendulum methods.
3. Static methods have superseded dynamic methods recently.
4. Threlfall gravimeter is the one in which a vertical quartz rod is suspended in inverted position from a tout horizontal quartz fiber.
5. Terrain correction is due to the variation of gravity with latitude.
6. The gradients and curvature values may be resolved into their south and west components.
7. Five azimuths are required to determine the five unknown quantities.
8. The largest gradients occur on the edges of salt domes and igneous intrusions.

22. Match the parts of the sentences.

1. Since the gravitational effects of geologic bodies are proportional to contrast in density between them and the surroundings	**a** from elevations along radial lines and concentric circles around the station.
2. The pendulum and gravimeter measure relative gravity	**b** gravity methods are applied for location of structures in stratified formations.
3. Gravity pendulums are kept as contrast as possible in length so that	**c** is suspended in inverted position from a taut horizontal quartz fiber.
4. The necessary accuracy in pendulum	**d** the variation of gravity with

measurements is secured	latitude.
5. In "gravimeter" methods the gravity is compared with	**e** a thin horizontal quartz bar is suspended from a horizontal torsion wire.
6.In Threlfall and Pollock instruments	**f** whereas torsion balance measures variations of gravity force per unit of horizontal distance.
7. The Hartley gravimeter contains	**g** an elastic spring force.
8. In Ising gravimeter a vertical quartz rod	**h** variations in period indicate changes in gravity only.
9. The planetary correction is due to	**i** a horizontal, hinged beam suspended from two helical springs.
10. The effect of terrain is calculated	**j** by the coincidence or beat method.

23. Answer the following questions.

1. What methods measure relative gravity?
2. Why are gravity methods particularly suitable for the location of structures in stratified formations?
3. What gravity method superseded dynamic pendulum method?
4. What is the difference between Pollock and Hartley gravimeters?
5. How can terrain correction be calculated?
6. What is the difference between ordinary balance and the torsion balance?
7. What kind of beam is most frequently used in practice?
8. How many quantities influence the torsion balance?
9. What is the qualitative torsion balance interpretation?
10. What is the nature of quantitative torsion balance interpretation?

24. Give definitions to the following terms.

terrain correction	gravimeter
torsion balance	pendulum method

25. Remember some facts about pendulums and gravimeters. Determine their common features and differences.

	PENDULUM	**GRAVIMETER**
Common		
Different		

26. Listen to the report on new equipment for geophysical survey. You will hear the text twice. For questions 1 – 10, choose the correct answer (A, B or C).

1. The company ARKEX is located in
(A) Houston, Texas
(B) Cambridge, England
(C) Houston and Cambridge

2. The core business of the company «ARKEX» is
(A) to prove production equipment
(B) to develop new methodology for geological survey
(C) to do geophysical survey

3. What is «BLUE QUBE»?
(A) a tool that images subsurface geology
(B) a system that makes seismic unnecessary
(C) a new tool that is mostly employed by subsurface engineers

4. «BLUE QUBE» is useful for
(A) observers
(B) shooters
(C) exploration managers

5. «BLUE QUBE» method includes
(A) a system that makes electromagnetics necessary
(B) gravity instrumentation and acquisition
(C) gravity gradient imaging, magnetics, video and ladar

6. What is NOT true about «BLUE QUBE» measurements?
(A) it can help to survey large and deeply buried features in details
(B) it has higher signal-to noise ratio than other gravity systems
(C) it measures change of rock density

7. The disadvantage of 2D seismic is that
(A) it shows a vertical section into the ground
(B) it is not cost effective
(C) it gives no lateral coverage

8. In contrast with «BLUE QUBE» 3D seismic
(A) is more complex
(B) requires much more time
(C) does not destroy the ground

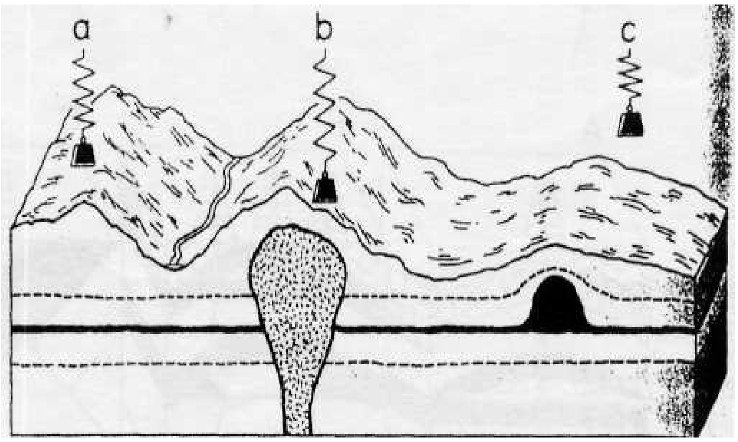
9. «BLUE QUBE» is airborne which:
(A) makes the survey expensive
(B) produces no impact on the environment
(C) does not give high resolution of measurements

10. Combining 2D seismic data with gravity gradient measurements helps
(A) to locate 3D seismic
(B) to win lease
(C) to determine the aspects of drilling process

27. Listen to the report on new satellite GOCE for measuring gravity field of the Earth and state if the sentences are true (T) or false (F).

1. The gravity gives us the sense of vertical and horizontal __
2. The flattening of the Earth is due to variations in the gravity field. __
3. Mountains, ocean trenches can affect the gravity. __
4. Large buildings can influence the gravity as well. __
5. The gravity field of the Earth can best be measured by studying the composition of the planet. __
6. The trip of the satellite will continue for more than two years. __
7. Torsion balance is the instrument which will contribute to the success of the mission. __
8. The new satellite will fly in high orbit because atmosphere in low orbits will cause challenges for its design. __

28. Using the diagram describe the general principle of gravity survey.



a. Normal gravimetric reading.

b. High gravimetric reading from dense igneous rock near the surface.

c. Low gravimetric reading from low density salt dome.

Discussion

29. Work in groups and answer the questions given below. Give your explanations.

1. Could we survive without gravity?
2. What would happen if there were no gravity on Earth?
3. What would happen if gravity were to suddenly double?
4. How much does planet Earth weigh? How is it possible to measure this?
5. How can tracking the movement of two orbiting satellites help in mapping differences in gravity?

30. Work in groups and enumerate all the possible solutions to the problem. Discuss and give the explanations.

For more than 40 years, scientists have tried to figure out what's causing large parts of Canada, particularly the Hudson Bay region, to be «missing» gravity. In other words, gravity in the Hudson Bay area and surrounding regions is lower than it is in other parts of the world, a phenomenon first identified in the 1960s when the Earth's global gravity fields were being charted. Why can parts of Canada be «missing» gravity?

31. Comment on the following statements.

1. «Gravity is a contributing factor in nearly 73 percent of all accidents involving falling objects.» Dave Barry
2. «Love is metaphysical gravity.» R. Buckminster Fuller

3. «Opinion is like a pendulum and obeys the same law. If it goes past the centre of gravity on one side, it must go a like distance on the other; and it is only after a certain time that it finds the true point at which it can remain at rest.» Arthur Schopenhauer
4. «From birth, man carries the weight of gravity on his shoulders. He is bolted to earth. But man has only to sink beneath the surface and he is free.» Jacques Yves Cousteau
5. «Not believing in force is the same as not believing in gravity.» Leon Trotsky
6. «It has been said that arguing against globalization is like arguing against the laws of gravity.» Kofi Annan
7. «I've been noticing gravity since I was very young.» Cameron Diaz
8. «Driving a motorcycle is like flying. All your senses are alive. When I ride through Beverly Hills in the early morning, and all the sprinklers have turned off, the scents that wash over me are just heavenly. Being House is like flying, too. You're free of the gravity of what people think.» Hugh Laurie
9. «To hear some men talk of the government, you would suppose that Congress was the law of gravitation, and kept the planets in their places.» Wendell Phillips

Terms and Vocabulary

assume	допускать, предполагать
base station	опорный пункт
be superimposed upon	быть наложенным на
bipolar	двухполюсный, биполярный
closure	герметизация; купол
disintegration	расщепление, распад; разделение на части
eliminate	аннулировать, устранять
fence	забор, изгородь
handicap	помеха
magnetic doublet	магнитный диполь
mechanical stress	механическое напряжение
remanent	остаточный, реманентный
supplement (v)	дополнять
strike	простирание (пласта)
be subject to (v)	подвергаться (чему-л.)
strength	сила; интенсивность прочность; предел прочности
alter	менять, изменять
arise from	проистекать, являться результатом

affect	воздействовать, влиять
intensity	интенсивность, сила, напряжение
resolve	раскладывать, разлагаться на
induce	вызывать, являться причиной, приводить к ч.-л.
require	требовать
curve	кривая, график, диаграмма
coincide with	совпадать с
disposition	расположение, нахождение
spontaneous	стихийный, неконтролируемый, самопроизвольный
owe	быть обязанным
fall into	делиться на

32. Pay attention to the pronunciation of the following words.

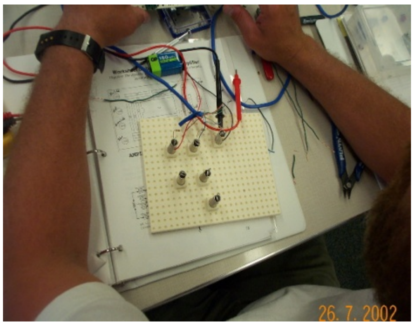
exhibit
lightning
metamorphism
magnetometer
approximate
terrestrial
planetary
doublet
bipolar
magnetic content

33. Pay attention to the suffixes and prefixes of the following words and translate them into Russian.

complete-completeness
require-requirement
vary-variation
assume-assumption
calculate-calculation-calculator
reason-reasonable
compose-composition-component
magnet-magnetic-magnetism-magnetization
compare-comparative
depend-dependent
apply-applicable
agree-disagree-agreement
occasion-occasional-occasionally
direct-directly-indirectly
interpret-interpretation-interpreter

34. Read the text, do the exercises.

Magnetic Methods



Magnetometer

Magnetic gradiometer survey

In common with gravitational methods, magnetic prospecting utilizes a natural and **spontaneous** field of force, with fields of geologic bodies **superimposed upon** a normal terrestrial field. The gravitational fields of geologic bodies do not depend on the earth's gravitational field, whereas magnetic bodies frequently **owe** their magnetization to the magnetic field of the earth. For this reason, magnetic anomalies are often **subject to** change with latitude. Moreover, rocks may have magnetism of their own whose direction may or may not **coincide** with that **induced** by the terrestrial magnetic field. An important factor in the interpretation of magnetic methods is that rock magnetism, contrary to rock density, is of a **bipolar** nature.

In gravity methods, total field vector and the horizontal gradients of the vector or of its horizontal components, are observed. In magnetic prospecting, measuring of the total vector are the exception rather than the rule; it is usually **resolved** into its horizontal and vertical components. Experience has shown that the vertical component exhibits the clearest relation between magnetic anomalies and **disposition** of geologic clearest bodies, at least in northern and intermediate magnetic latitudes. Therefore, measurements of the magnetic vertical **intensity** are preferred and are **supplemented** occasionally by horizontal intensity observations for greater completeness in the evaluation of the anomalies.

Magnetic fields are generally expressed in gauss (simplest definition is lines per square centimeter – in air); in magnetic exploration it is more convenient to use 1/100,000 part of this unit, called the gamma (γ). The accuracy requirements in magnetic prospecting are less than gravity work; it is a comparatively easy matter to design instruments suitable for magnetic exploration.

The magnetic anomalies of geologic bodies are dependent on their magnetic «susceptibility» and «**remanent»** magnetism, properties which vary much more widely than their densities. Rocks and formations fall into two natural groups: igneous rocks and iron ores are strongly magnetic whereas sedimentary rocks are generally weak in magnetization. The magnetic characteristics of rocks are **affected** by numerous factors such as: magnetic content, grain size, lightning, heat, contact metamorphism, mechanical stresses, **disintegration** and concentration, and also by structural forces which may alter the **disposition** of magnetic formations in the course of geologic periods.

Most widely used in magnetic prospecting are the Schmidt magnetometers. There can be Schmidt vertical intensity magnetometer and Schmidt horizontal magnetometer. These instruments provide the high degree of accuracy **required** in oil exploration.

The following corrections are required in magnetic exploration: (1) correction for temperature of instrument, **arising from** the fact that the magnets used for comparison with the earth's magnetic field lose their **strength** with an increase in temperature; (2) a «base» correction which allows for errors of **closure** when checking back to a **base station;** (3) a correction for daily variation which may be determined by visual observation or recording of a second magnetometer; (4) a planetary correction, which **eliminates** the normal variations of the earth's magnetic field with latitude.

Fences, bridges, pipe lines, derricks, well casings, and the like, are a serious **handicap** to magnetic exploration and must be kept at sufficient distance, as it is difficult to correct for them.

Magnetic results are generally represented in the form of lines of equal magnetic anomaly («isanomalic» lines – the name «isogams» as applied to magnetic lines is a misnomer) or in the form of **curves** for profiles at right angles to the angles to the assumed **strike**. Interpretation of magnetic anomalies is usually qualitative. In the interpretation of magnetic data in oil exploration, magnetic anomalies ranging from fifty to several hundred gammas may be **assumed** to result from variations in topography and composition of igneous rocks or from igneous intrusions.

In quantitative interpretation magnetic effects of **assumed** bodies are calculated, compared with the field curves, and assumptions changed until a geologically reasonable agreement is obtained. Direct methods of interpretation are applicable when the magnetic anomaly is simple and arises from one geologic body only; in that case, approximate calculations of depth may be made directly from the anomaly curves by assuming that the magnetic bodies are equivalent to single poles, **magnetic doublets**, single magnetized lines, and line doublets.

(C.A. Heiland. Geophysical Exploration. New York, 1940)

35. Which words from your active vocabulary are given here?

_ _ I _ _ I _ _
_ _ _ N _ A _ _ _ __ _
_ _ _ U _ _
_ _ I _ E _ _ _ _
_ _ P _ _ _ _ E_ _
_ _ _ _ _ S _ _ I _ _
_ _ _ _I _ A _ _
_ _ P _ _ _ _ _O _ _ _

36. Choose the suitable word from the given variants.

1. Magnetometers provide the high degree of accuracy which *is required\ arise from\ supplemented* in oil exploration.
2. The scientists *subject to\ assume\ resolve* that the earth's mantle falls into upper and lower part.
3. The magnetic anomalies from fifty to several hundred gammas *eliminate\ arise from\ affect* variations in topography and composition of igneous rocks or igneous intrusions.
4. Sometimes measurements of magnetic vertical intensity are *coincide\ supplemented by\ alter* the horizontal intensity investigations.
5. External forces such as water, wind and glaciers *owe to\ eliminate\ affect* the formation of sedimentary rocks.
6. Everything and everybody *are subject to\ induce\ is superimposed upon* the laws of nature.
7. The principles are subject to change or elimination as new scientific facts *handicap\ assume\ supplement* our knowledge.
8. The *intensity\ closure\ mechanical stress* of a match was not enough to light the room.
9. The voice of the singer was *resolved\ altered\ superimposed upon* the tune.
10. The terrestrial magnetic field may *eliminate\induce\fall into* the magnetization of a magnetic body.

37. Make up sentences, add words if necessary.

1. rocks/ magnetic content/ heat/ mechanical stresses/ disintegration/ numerous factors/ are/ affect/ which/ magnetic characteristics.
2. may/ structural forces/ magnetic formations/ disposition/ alter.
3. temperature/ correction/ arises from/ magnets/ instrument/ fact/ lose/ increase in temperature/ strength.
4. represented/ generally/ form/ lines/ magnetic exploration/ results/ curves.

38. Translate the following sentences into English.

1. Одна стотысячная гаусса называется гамма.
2. Такие помехи, как заборы, мосты и трубопроводы должны находиться на существенном расстоянии во время магнитной разведки.
3. Прямой метод интерпретации применяется, когда магнитная аномалия проистекает только из геологического тела.
4. В магнитной разведке измерение полного вектора, скорее исключение, чем правило.
5. Изверженные породы и железные руды сильно намагничены, в то время как осадочные породы слабо намагничены.
6. На магнитные характеристики пород воздействуют следующие факторы: магнитная доля, размер зерен, молния, теплота и т.д.
7. Планетарная поправка устраняет нормальные колебания магнитного поля земли в зависимости от широты.

39. Change the sentence using the given word. The meaning of a new sentence should be approximately the same.

Example: *Igneous rocks and iron ores are strongly magnetic. (magnetization) →<u>Igneous rocks and iron ores are characterized by high degree of **magnetization**.</u>*

1/ An important factor in the interpretation of magnetic methods is that rock magnetism is of bipolar nature.
(interpret)___________________________________
2/ Fields of geologic bodies are superimposed upon a normal terrestrial field.
(Earth) ____
3/ The accuracy requirements in magnetic prospecting are less.
(accurate)_____________________________________
4/ Magnetic fields are generally expressed in gauss.

(expression)________________________________
5/ The vertical component exhibits the clearest relation between magnetic anomaly and disposition of a geologic body.
(locate) ____________________________________
6/ Measurements of the magnetic vertical intensity are preferred in magnetic prospecting.
(measure)___________________________________
7/ Magnetic anomalies of geologic bodies are dependent on their magnetic susceptibility and remanent magnetism.
(depend) ___________________________________
8/ Magnetic characteristics of rocks are affected by such factors as: magnetic content, grain size, mechanical stress and others.
(determine\ influence) ___________________________________

40. Complete the given sentences.

1. Both gravitational and magnetic methods …………………………… .
2. Magnetic field of the earth induces magnetization to ………………. .
3. Magnetic anomalies are subject to ………………………………… .
4. In comparison with rock density, rock magnetism …………………. .
5. In magnetic methods the total field vector is resolved ……………. .
6. In magnetic measurements the special emphasis is on …………… .
7. Magnetic fields are commonly measured in ………………………. .
8. Gamma represents …………………………………………………. .
9. The accuracy required in magnetic prospecting is …………………. .
10. According to the magnetic characteristics there exist two groups of rocks and formations such as …………………………. .

41. Place the sentences according to the order of their appearance in the text.

__ Magnetic content, mechanical stress, lightning and contact metamorphism affect the magnetic characteristics of rocks.
__ Observations of horizontal intensity are sometimes utilized for completeness of anomaly evaluation.
__ Fields of geologic bodies are superimposed upon a normal terrestrial field.
__ Rock magnetism is of bipolar nature.
__ For convenience in practice the scientists use 1\100 000 of this unit.
__ The vertical component of the field vector relates magnetic anomaly with the disposition of geologic body.

__ Magnetic susceptibility and remanent magnetism affect the magnetic anomalies of geologic bodies.
__ The direction of rock magnetic field may not coincide with the direction of the terrestrial magnetic field.
__ Magnetic survey is based on measurements of magnetic vertical intensity.
__ Magnetic anomalies alter with latitude.
__ For measuring magnetic fields such unit as gauss is utilized.
__ Sedimentary rocks are generally weak in magnetization.

42. State whether these sentences are true or false. Correct the false sentences. Give additional information on the subject.

1. The scientists use gravimeters in magnetic survey.
2. Magnetic survey requires no accuracy.
3. Planetary correction arises from the fact that magnets lose their strength when temperature increases.
4. We can carry out magnetic survey on any area and at any place.
5. Results of magnetic survey are registered through images.
6. The scientists always give quantitative interpretation of magnetic anomalies.

43. Answer the following questions.

1. What is in common between gravity and magnetic methods?
2. What is the difference between gravity and magnetic methods?
3. Why are magnetic anomalies subject to change with latitude?
4. What is the unit magnetic field generally expressed in?
5. What is gamma?
6. What do magnetic anomalies depend on?
7. What are the two natural groups of rocks according to their magnetization?
8. What factors influence the magnetic characteristics of rocks?
9. What instruments are used in oil exploration and why?
10. What does the correction for temperature of instrument arise from?
11. What are extra handicaps that must be kept at sufficient distance from the field of magnetic exploration?
12. What forms can represent the magnetic results?
13. What are the two kinds of magnetic anomalies interpretation?

44. Listen to the interview with Chris Leech, geophysicist and director of Geomatrix Earth Sciences Ltd, who is talking about archeological geophysics. Answer the following questions by saying whether each of the following statements are 1 – True (T) or 2 – False (F).

		1	**2**
1.	According to Chris Leech, geophysics is an interdisciplinary field that uses complex techniques to study interior of the Earth.		
2.	Geophysical survey in archeological investigations requires much time to determine the area for further research.		
3.	In archeological geophysics the technique of ground penetrating radar is widely used.		
4.	The equipment used in the survey represents a vertical pole with two horizontal poles attached at each side.		
5.	The vertical pole in the described equipment is actually a magnetometer.		
6.	Each of the tubes in a magnetometer contains three sensors.		
7.	The sensors measure the magnetic field in horizontal component.		
8.	The distance between each sensor is 1 meter.		
9.	The described device measures the vertical gradient of the Earth's magnetic field in two places at the same time.		
10.	To detect small changes in the Earth's magnetic field the measurements must be made with sufficient resolution and accuracy.		

45. Listen to the interview with Dr. Michio Kaku, Professor of Theoretical Physics, telling about leaks in the Earth's magnetosphere. Choose the correct answer to the given questions.

1. Holes in the magnetic field could
   a) threat a global warming
   b) make some protective shield
   c) put a lot of functions at risk

2. What causes the phenomenon of leaks in the magnetic field?
   a) a shock wave
   b) the Sun activity
   c) the peak of the sunspot cycle

3. How often does this phenomenon happen?
   a) once in 11 years
   b) once in 20 years
   c) once in 12 years

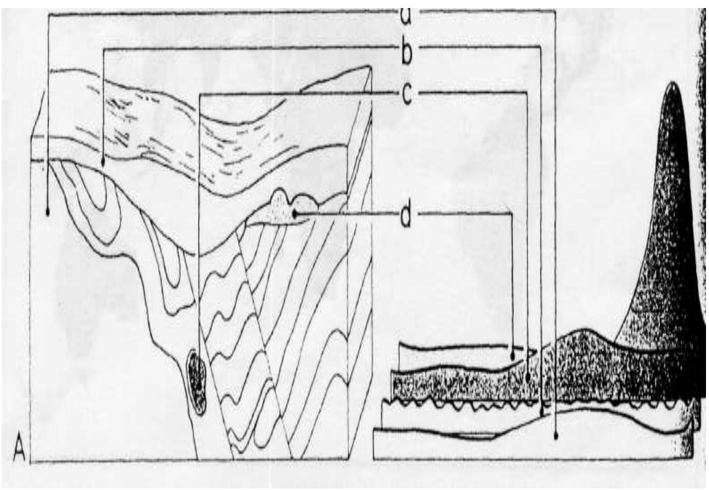
4. Why is there such a regularity in the phenomenon manifestation?
   a) because there is a kind of a clock cycle that we have to wind up
   b) this time is necessary for the magnetic field of the Sun to build up enough intensity
   c) because the solar shield gets ruined

5. The consequence of the leaks in the Earth's magnetic field functioning is that
   a) we could do nothing with them on the Earth
   b) we should reinforce satellites and construct redundant systems
   c) we should make some protective shield

6. The scientists could have made a mistake because
   a) they were not attentive
   b) they assumed that the next peak will be more serious
   c) they did not have enough space satellites in the past

46. Tell about the stages of magnetic survey.
What is it necessary to have and to do for magnetic prospecting?

47. Give the explanation to the following diagram.



***a**. Country rock producing regional magnetism*

***b.** Topsoil producing background magnetism*

***c.** Deeply buried ores*

***d.** Ores just below the surface*

48. Make a presentation on the topic MAGNETIC EXPLORATION. Use the following plan.

A. Title page
B. Content page
C. General overview of magnetic field and magnetism (magnetic methods, magnetic field, magnetism)
D. Magnetic measurements (accuracy, instruments, corrections)
E. Magnetic survey result interpretation (results presentation, types of interpretation)
F. Conclusion

Answer all the possible questions concerning magnetic exploration.

49. Work in groups. Think over, give your idea and justify your opinion.

1. Is the Earth a magnet?
2. How does the core of the Earth generate a magnetic field?
3. Why do models and chart of a geomagnetic field need to be periodically updated?
4. Is it true that the magnetic field occasionally reverses its polarity? What causes the magnetic field to reverse its polarity?
5. Could magnetic reversals be caused by meteorite or cometary impacts? Could reversals be caused by melting of the polar ice caps or some sort of planetary alignment?
6. The strength of the magnetic field has been decreasing lately, does this mean that we are about to have a reversal?
7. Could the mass extinctions observed in the paleontological record be correlated with magnetic reversals?
8. Are variations in the geomagnetic field somehow associated with earthquakes or vice versa?
9. Does the Earth's magnetic field affect human health?
10. Do animals use the magnetic field for orientation?
11. What is a magnetic storm? What are the hazardous effects of magnetic storms? What are Auroras?
12. Why do we measure the magnetic field at the Earth's surface? Wouldn't satellites be better suited for space-weather studies?

50. Comment on the following statements.

1. «Magnetism, as you recall from physics class, is a powerful force that causes certain items to be attracted to refrigerators.» Dave Barry
2. «The essential element in personal magnetism is a consuming sincerity – an overwhelming faith in the importance of the work one has to do.» Bruce Barton
3. «To speak, therefore, of an electric current in the nerves, is to use quite as symbolic an expression as if we compared the action of the nervous principle with light or magnetism.» Johannes P. Muller
4. «We have people who are healers and those who posses a certain animal magnetism.» Julian May

Terms and Vocabulary

alternating current	переменный ток
direct current	постоянный ток
furnish (v)	доставлять
self-potential method	метод естественного электрического поля
distinguish	различать, выделять
surface potential method	метод поверхностного потенциала
galvanic	гальванический
inductive	индукционный, индуктивный, побуждающий
frequency band	полоса частот
audio-frequency	низкочастотный
radio frequency	высокая радио частота
refraction method	метод преломлённых волн, МПВ
reflection method	метод отражённых волн, МОВ
potential-drop-ratio method	метод отношения градиентов потенциала
resistivity method	каротаж методом сопротивления
resolving power	разрешающая способность
placer	прииск, россыпное месторождение
formation boundary	граница пласта
formation waters	пластовые воды
solution pressure	упругость растворения
wet cell	наливной элемент
equipotential line	эквипотенциальная линия
potential profile	профиль распределения потенциала, потенциальный рельеф

milliammeter	миллиамперметр
unpolarizable	неполяризованный
distortion	искажение
stationary	постоянный, стабильный,
flux line/line of flux	линия (магнитной) индукции, линия потока
current generator	генератор тока
steeply dipping	крутопадающий
dipping formation	наклонное образование
primary circuit	первичная цепь
potential difference	разность потенциалов
electrode spacing	расстояние между электродами
external circuit	цепь внешней нагрузки
potential drop	падение напряжения; разность потенциалов
stake	веха, подпорка, столб, электрод
fault	разлом
ground current	ток в земле
supply (v)	доставлять, подавать
insulated loop	замкнутый профиль
strike	зд. пласт
point electrode	точечный электрод
inductive coupling	индуктивная связь
induce (v)	вызывать
emission characteristic	эмиссионная характеристика
transmitter	отправитель, передатчик
field intensity	напряженность поля
radiate (v)	распространяться

51. Define the meaning of the words in bold on the basis of their similarity to the Russian ones.

On the basis of their **reaction** to electrical field; **spontaneous electrochemical phenomena;** to be supplied to the ground by **contact** or by **induction**; be subdivided into **galvanic electromagnetic** and **inductive electromagnetic** methods; from 100 **kilocycles** to several **megacycles**; produced by **corrosion** of pipelines; different **ion concentrations**; **equipotential** lines; two unpolarizable **electrodes**; lines of equal **potential**; from an alternating current **generator**; in resistivity **procedures**; **effect** of subsurface conductors on **emission characteristics**; **variatio**ns of field **intensity**; in the **category** of radio methods.

52. Pay attention to the pronunciation of the following words and word formations.

spontaneous	current-currently
circuit	steep-steeply
galvanic	distinguish-distinction
supply	solve-solution
fault	resolve-resolution
occur	limit-limitation
feature	emit-emission
external	potential-equipotential
straight	differ-different-difference
kilocycle-	compare-comparable-comparison
megacycle	alter-alternating-alternative-alternation
owing to	induce-inductive-induction
vice versa	insulate-insulation-insulator
milliammeter	conduct-conductive-conductivity-conductor
furnish	combine-combination-combinability
alternating current	resist-resistance-resistivity
distinguish	polarize-polarizable-unpolarizable
stationary	energy-energize-energetic

53. Read the following word-combinations and translate them into Russian.

To be produced by direct or alternating current; bodies furnish their electrical field; to be supplied to the ground by contact or by induction four frequency bands may be used; the audio-frequency range of from 200 to 1000 cycles; methods are usually subdivided into galvanic-electromagnetic and inductive-electromagnetic; radio-frequency range is used in the radio methods of electromagnetic prospecting; owing to the lack of depth penetration; resistivity and potential-drop-ratio methods are comparable to refraction methods; inductive methods are applied to the mapping of horizontal beds; spontaneous electrochemical phenomena occur on placers; to be produced on formation boundaries; difference in the conductivity of drilling fluid and formation waters; materials of different solution pressure; act as wet cells; survey equipotential lines or potential profiles.

54. Which word-combination is out of place in each line? And why?

a) alternating current, electrode spacing, direct current
b) supply, furnish, provide, induce
c) self-potential, surface potential, refraction, electromagnetic
d) compare, formation boundaries, comparable, comparison
e) pressure solution, low frequencies, high frequencies, radio frequencies
f) fault, inductive, external circuit, ground current
g) milliammeter, transmitter, current generator, field intensity
h) resistivity, flux line, potential-drop-ratio, self-potential, surface potential

55. Make up word combinations using the given words.

survey	equipotential lines or potential profiles
produce	inductive methods and refraction methods
supply	formation boundaries
apply	alternating current
induce	high radio frequency
radiate	potential difference
furnish	frequency bands
observe	point electrodes
compare	emission characteristics
detect	potential drop

56. Read the text, do the exercises.

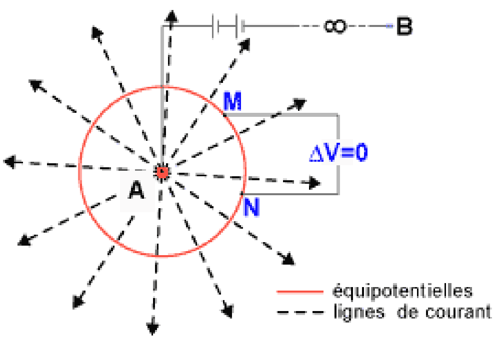
Electrical Methods

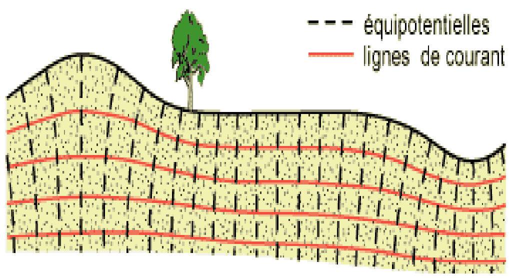
Mineral deposits and geologic structures may be mapped by their reaction to electrical and electromagnetic fields. These are produced by either direct or **alternating current**, except where ore bodies spontaneously **furnish** their own electrical field (**self-potential methods**). Electrical energy may be supplied to the ground by contact or by induction. Three main groups of electrical methods may be distinguished: (1) self-potential, (2) surface-potential, and (3) electromagnetic methods. Frequently the first two groups are combined into one group of potential methods; the electromagnetic methods are usually subdivided into galvanic-electromagnetic and inductive-electromagnetic.

Four **frequency bands** may be used in connection with alternating current electrical prospecting: (1) low frequencies of from 5 to about 100 cycles; (2) the **audio-frequency** range of from 200 to 1000 cycles; (3) high frequencies of from 10 to 80 kilocycles; and (4) **radio frequency** of from 100 kilocycles to several megacycles. The low frequency range is applied in most potential methods; the audio-frequency range is used in some potential and most electromagnetic methods; the high-frequency range in the high-frequency electromagnetic methods; and radio-frequency in the radio methods of electromagnetic prospecting. The application of high radio frequencies is limited owing to their lack of depth penetration; of greatest importance are the audio frequencies and the low frequencies. In a number of respects, electrical methods are similar to seismic methods; comparable to **refraction methods** are **resistivity** and the **potential-drop-ratio methods**; **inductive** methods as applied to the mapping of horizontal beds are comparable to **reflection methods** but lack their resolving power.

Self-potential method. The **self-potential method** is the only electrical method in which a natural field is observed; its causes are spontaneous electrochemical phenomena. These phenomena occur on ore bodies and on metallic minerals and **placers**; they are produced by corrosion of pipe lines and on **formation boundaries** in wells by differences in the conductivity of drilling fluid and **formation waters**. Ore bodies whose ends are composed of materials of different **solution pressure** and are in contact with solutions of different ion concentration, act **as wet cells** and produce an electrical field which can be detected by surveying **equipotential lines** or **potential profiles**. For the mapping of equipotential lines, a high-resistance milliammeter connected to two **unpolarizable** electrodes is used. One is kept **stationary** and the other is moved until the current vanishes. At that point the electrodes are on an equipotential line.

Equipotential-line and potential-profile methods.

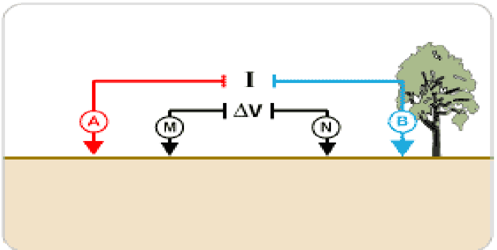




Equi potential lines of the current

When a source of electrical energy is grounded at two points, an electrical field is produced. **Distortions** of this field result from the presence of bodies of different conductivity; good conductors will attract the **lines of flux**, and vice versa. As it is difficult to survey these lines of flux, lines of equal potential, that is, lines along which no current flows, are mapped instead. In practice power is supplied to two grounded electrodes from an alternating **current generator**.

Resistivity methods. Equipotential-line methods, while useful for the mapping of vertical or **steeply dipping** geologic bodies, are not suited to the investigation of horizontally stratified ground. Conversely, **resistivity methods** are applicable to depth determinations of horizontal strata and the mapping of **dipping formations.**



In resistivity procedures not only the potential difference between two points but also the current in the **primary circuit** is observed. The ratio of **potential difference** and current, multiplied by a factor depending on electrode **spacing**, gives the resistivity of the ground.

Potential-drop-ratio methods. The essential feature of the resistivity methods is a determination of the potential difference between two points at the surface and a measurement of the current in the **external circuit**. In **potential-drop-ratio** methods current measurements in the external circuit are not made and the potential drops in two successive ground intervals (represented by three **stakes** arranged in a straight line, **radiating from** one of the power electrodes) are compared. The potential-drop-ratio method is best suited for the location of vertical formation boundaries (faults, dikes, veins, and the like).

Electromagnetic-galvanic methods. Electromagnetic methods of electrical prospecting differ from potential methods in that the electromagnetic field of **ground currents** and not their surface potential (electric field) is measured. They fall into two major groups: (1) electromagnetic-**"galvanic"** methods in which the primary energy is **supplied by** contact as in the potential methods; (2) electromagnetic-"inductive" methods in which the ground is energized by **inductive coupling** (with **insulated loops**). **To supply** electrical energy to the ground by contact, line electrodes are laid out at right angles to the **strike**, **point electrodes** parallel with the strike.

Electromagnetic-inductive methods. In inductive procedures power is supplied to the ground by insulated loops which will cause induction currents to flow in subsurface conductive bodies. An advantage of inductive methods is the ease with which power may be transferred into the ground when the surface formations are poor conductors. Since currents **induced** in the subsurface conductors are dependent on frequency, interpretative advantages may be gained by regulating the frequency.

Radio methods. Since radio methods employ frequencies still higher than the high-frequency-inductive methods, they are subject to the same limitations. In one group of radio methods the effect of subsurface conductors on the **emission characteristics** of a **transmitter** is observed. In a second group a receiving arrangement is employed in addition to the transmitter, and the variation of **field intensity** with location is measured. In the category of radio methods belong the so-called «treasure-finders.» These are portable instruments for the location of shallow metallic objects, pipe lines, and the like.

(C.A. Heiland. Geophysical Exploration. New York, 1940)

57. ***Fill in the gaps with correct prepositions.***

1. Electrical energy may be supplied __ the ground __ contact or __ induction.
2. Frequently the first two groups are combined ___ one group __ potential methods; the electromagnetic methods are usually subdivided ___ galvanic-electromagnetic and inductive-electromagnetic.
3. Four frequency bands may be used __ connection ___ alternating current electrical prospecting.
4. The application __ high radio frequencies is limited owing __ their lack __ depth penetration; __ greatest importance are the audio frequencies and the low frequencies.
5. One unpolarizable electrode is moved ____ the current vanishes.
6. The potential-drop-ratio method is best suited ___ the location __ vertical formation boundaries.
7. To supply electrical energy __ the ground __ contact, line electrodes are laid out __ right angles __ the strike, point electrodes parallel ___ the strike.

58. Fill in the gaps with the terms from the text.

1. In _______ procedures power is supplied to the ground by insulated loops which will cause induction currents to flow in subsurface conductive bodies.
2. ___________________ are portable instruments for the location of shallow metallic objects, pipe lines, and the like.
3. The essential feature of the _____________ methods is a determination of the potential difference between two points at the surface and a measurement of the current in the external circuit.
4. _____________ methods are applicable to depth determinations of horizontal strata and the mapping of dipping formations.
5. Distortions of __________ field result from the presence of bodies of different conductivity; good conductors will attract the lines of flux, and vice versa.
6. The _______________ method is the only electrical method in which a natural field is observed.
7. _______ methods employ frequencies still higher than the high-frequency-inductive methods.
8. An advantage of _____________ methods is the ease with which power may be transferred into the ground when the surface formations are poor conductors.

59. State whether the following sentences are true or false; correct the false ones.

1. Two main groups of electrical methods can be distinguished.
2. The application of high-frequencies are limited owing to the lack of their resolving power.
3. Comparable to seismic refraction methods are self-potential and electromagnetic galvanic ones.
4. Comparable to seismic reflection methods are inductive ones.
5. Equipotential-line methods are suited to the investigation of horizontally stratified ground.
6. Resistivity methods are applicable to the mapping of vertical or steeply dipping geologic bodies.
7. Electromagnetic methods of electrical prospecting differ from potential methods in that the electromagnetic field of ground currents and not their surface potential (electric field) is measured.
8. To supply electrical energy to the ground by contact, line electrodes are laid out at right angles to the strike, point electrodes vertical to the strike.

60. Give definitions to the following terms.

spontaneous electrochemical phenomena
ion concentration
high-resistance milliammeter
horizontally stratified ground
dipping formations
external circuit

61. Answer the following questions.

1. What is the source of electrical and electromagnetic fields?
2. What are the two ways of supplying electrical energy to the ground?
3. What electrical methods are considered potential ones?
4. What frequency bands are distinguished in electrical prospecting?
5. What frequencies are applied in potential, electromagnetic methods, and radio methods?
6. What are the causes of a natural electric field?
7. What kinds of rocks produce electric field?
8. What is called an equipotential line? And line of flux?
9. When is resistivity method applied?
10. How can the resistivity of the ground be determined?
11. What is the difference between resistivity methods and drop-ratio ones?
12. Define the difference between electromagnetic methods and potential ones.
13. What is an interpretative advantage in electromagnetic-inductive methods?
14. What are the so-called «treasure-finders» and what group of electric methods do they belong to?

62. Read the text and decide which of the headings (1-6) best summarizes each part (A-D) of the text. There is one extra heading that you do not need to use.

1. Operational principle of DC resistivity technique
2. Processing results
3. Measurement peculiarities
4. Model types
5. The characteristic features of instruments
6. Notion of DC resistivity method

A

DC resistivity techniques, sometimes referred to as electrical resistivity, electrical resistivity imaging or vertical electric sounding, measure earth resistivity by driving a direct current (DC) signal into the ground and measuring the resulting potentials created in the earth. From that data the electrical properties of the earth (the geoelectric section) can be derived and thereby the geologic properties inferred.

B

In DC resistivity method two short metallic stakes (electrodes) are driven about 1 foot into the earth to apply the current to the ground. Two additional electrodes are used to measure the earth voltage (or electrical potential) generated by the current. Depth of investigation is a function of the electrode spacing. The greater the spacing between the outer current electrodes, the deeper the electrical currents will flow in the earth, hence the greater the depth of exploration. The depth of investigation is generally 20% to 40% of the outer electrode spacing, depending on the earth resistivity structure.

C

Instrument readings (current and voltage) are generally reduced to «apparent resistivity» values. The apparent resistivity is the resistivity of the homogeneous half-space which would produce the observed instrument response for a given electrode spacing. Apparent resistivity is a weighted average of soil resistivities over the depth of investigation. For soundings a log-log plot of apparent resistivity versus electrode separation is obtained. This is sometimes referred to as the «sounding curve.»

D

The resistivity data is then used to create a hypothetical model of the earth and its resistivity structure (geoelectric sections). Resistivity models are generally not unique; i.e. a large number of earth models can produce the same observed data or sounding curve. In general, resistivity methods determine the «conductance» of a given stratigraphic layer or unit. The conductance is the product of the resistivity and the thickness of a unit. Hence that layer could be thinner and more conductive or thicker and less conductive, and produce essentially the same results. Because of these constraints on the model, borehole data or assumed unit resistivities, can greatly enhance the interpretation.

E

The end product from a DC resistivity survey is generally a «geoelectric» cross section (model) showing thicknesses and resistivities of all the geoelectric units or layers. If borehole data or a conceptual geologic model is available, then a geologic identity can be assigned to the geoelectric units. A two-dimensional geoelectric section may be made up of a series of one-dimensional soundings joined together to form a two-dimensional section, or it may be a continual two-dimensional cross section. The type of section produced depends on the acquisition parameters and the type of processing applied to the data.

63. Listen to the report on the resistivity survey conducted at Sulfurbank Mercury Mine Superfund site and identify the steps of the investigation.

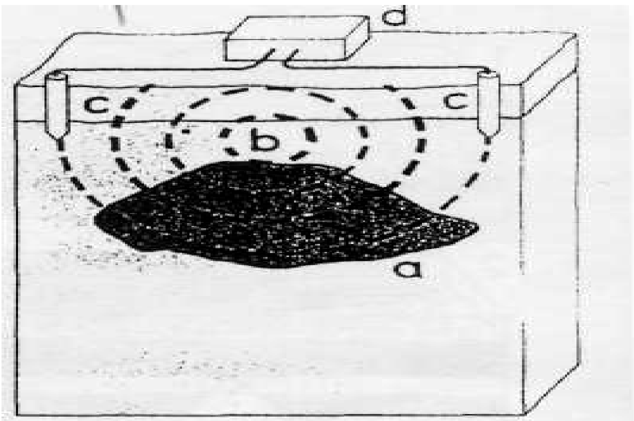
	Activities	**Order of the Step**
A	The near surface areas containing high concentrations of sulfide minerals were identified.	
B	Electromagnetic conductivity survey was carried out over twelve square kilometers area.	
C	One anomaly was chosen for detailed ground electromagnetic conductivity survey.	
D	The samples were taken from every three meters along the constructed lines.	
E	The geophysical survey determined flow paths for mercury rich acid waters.	
F	The conductive zones of probable pathways for ground water flow were detected.	

G	About 1.5 million irregularly spaced samples were obtained.	
H	The wire metric mapping was produced with CTAX software.	
I	Four magnetic and ore-conductive anomalies were identified.	

64. Listen to the presentation on electromagnetic instrumentations and match the comments on slides (1–5) with the images (A–E). One comment is extra.

EM31	
A Top Plot	1. shows results of the most sensitive survey
B Middle Plot	2. shows the limits of landfield containing buried metal
C Bottom Plot	3. excludes from results areas with small metal degree
EM61	4. shows contour shaded in orange and red
D Top Plot	5. shows results of iron ore prospecting
E Bottom Plot	6. gives data on identification of parameter of buried waste in associated leachate

65. Using the diagram describe the general principle of electrical survey.



(a) an ore deposit

(b) natural ground currents

(c) buried electrodes

(d) millivoltmeter

66. You are going to make a short research project. You should spend 5 -15 minutes to examine «*Electrical survey*» from each of the following aspects. The results of your research should be arranged in your report.

- Describe it (What does it look like? What is it?);
- Compare it (What is it similar to? How does it differ from magnetic or gravity survey?);

- Analyze it (What is its principle? What types are there? What components does it include? What devices are necessary?);
- Apply it (What can you do with it? What can you use it for?);
- Argue for or against (Take either positions. Give reasons);
- Associate it (What do you associate it with? What does it remind you of?).

67. Comment on the following statements.

1. «Pain reaches the heart with electrical speed, but truth moves to the heart as slowly as a glacier.» Barbara Kingsolver
2. «All I know about thermal pollution is that if we continue our present rate of growth in electrical energy consumption it will simply take, by the year 2000, all our freshwater streams to cool the generators and reactors.» David R. Brower
3. «The number of electrical injuries cared for in hospitals in the US is estimated at as many as 50,000; the cost of these injuries on the US economy is estimated at over one billion dollars per year.» Richard Neal
4. «I am an expert of electricity. My father occupied the chair of applied electricity at the state prison.» W. C. Fields
5. «People always fear change. People feared electricity when it was invented, didn't they? People feared coal, they feared gas-powered engines. There will always be ignorance, and ignorance leads to fear. But with time, people will come to accept their silicon masters.»
Bill Gates
6. «And God said, 'Let there be light' and there was light, but the Electricity Board said He would have to wait until Thursday to be connected.» Spike Milligan
7. «We believe that electricity exists, because the electric company keeps sending us bills for it, but we cannot figure out how it travels inside wires.» Dave Barry
8. «Electricity can be dangerous. My nephew tried to stick a penny into a plug. Whoever said a penny doesn't go far didn't see him shoot across that floor. I told him he was grounded.» Tim Allen
9. «What is a soul? It's like electricity – we don't really know what it is, but it's a force that can light a room.» Ray Charles

WORDLIST

ENGLISH	RUSSIAN
air gun array	расстановка пневмопушек
alternating current	переменный ток
anomaly	аномалия
array	ряд, серия
assume	допускать, предполагать
astatizing	астатизированный
audio-frequency	низкочастотный
bar	брусок\плитка
base station	опорный пункт
be superimposed upon	быть наложенным на
beam	брус, балка\коромысло
bipolar	двухполюсный, биполярный
closure	герметизация; купол
current generator	генератор тока
curvature	выгиб, изгиб, искривление
depth value	значение глубины
dipping formation	наклонное образование
discrepancy	разница, расхождение
disintegration	расщепление, распад; разделение на части
downward propagation	нисходящее распространение
electrode spacing	расстояние между электродами
eliminate (v)	аннулировать, устранять
emission characteristic	эмиссионная характеристика
equipotential line	эквипотенциальная линия
external circuit	цепь внешней нагрузки
fault	разлом
fence	забор, изгородь
field intensity	напряженность поля
flux line / line pf flux	линия (магнитной) индукции, линия потока
formation boundary	граница пласта

formation waters	пластовые воды
frequency band	полоса частот
galvanic	гальванический
gravimeter	гравиметр
gravitational attraction	гравитационное притяжение
ground current	ток в земле
handicap	помеха
helical spring	винтовая пружина
hinged beam	шарнирно-опертая, балка
induce (v)	вызывать
inductive	индукционный\индуктивный\ побуждающий
inductive coupling	индуктивная связь
insulated loop	замкнутый профиль
inverted position	перевернутая позиция
land survey	наземная съемка
latitude	широта
magnetic doublet	магнитный диполь
marine survey	морская съемка
mechanical stress	механическое напряжение
milliammeter	миллиамперметр
mount (v)	устанавливать
observation time	время наблюдения
oil exploration	нефтеразведка
pendulum	маятник
penetrate (v)	проникать (внутрь)
placer	прииск, россыпное месторождение
plausible assumption	правдоподобное допущение
point electrode	точечный электрод
potential difference	разность потенциалов
potential drop	падение напряжения; разность потенциалов

potential profile	профиль распределения потенциала, потенциальный рельеф
potential-drop-ratio method	метод отношения градиентов потенциала
primary circuit	первичная цепь
pull of gravity	величина тяготения
qualitative	качественный
quantitative	количественный
quantity	количество
radiate	распространяться
radio frequency	высокая\радио частота
reflection seismology	сейсморазведка методом отраженных волн
refraction seismology	сейсморазведка методом преломленных волн
remanent	остаточный, реманентный
resistivity method	каротаж методом сопротивления
restoring force	возвращающаяся сила
rod	стержень\рейка
salt dome	соляной купол
self-potential method	метод естественного электрического поля
solution pressure	упругость растворения
source energy	источник энергии
spring force	жесткость пружины \ сила сжатия пружины
stake	веха, подпорка, столб
steeply dipping	крутопадающий
stratified	слоистый
strike	зд. пласт
structural uplift	структурный подъем
supply	доставлять, подавать
surface potential method	метод поверхностного потенциала
suspension wire	несущий трос
taut	тугонатянутый

terrain	топография\физические особенности местности
thumping device	устройство падающего груза
torsion balance	крутильный динамометр \ весы
transmitter	отправитель, передатчик
unpolarizable	неполяризованный
wet cell	наливной элемент

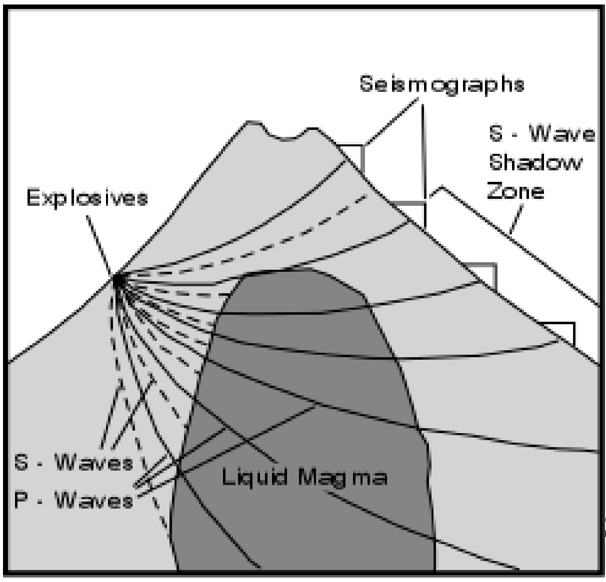
UNIT 3

SEISMOLOGY AND SEISMIC SURVEY

Seismology is the study of earthquakes and seismic waves that move through and around the earth. A seismologist is a scientist who studies earthquakes and seismic waves.

(Wikipedia. The free encyclopedia. http://www.wikipedia.org/)

Lead-in



After Murck et al., 1996

Seismic exploration and monitoring

Listen to the song «Seismic waves» and fill in the gaps with the words from the tape.

Feel a rumble, hang on grumble
What's this (1)…………. you say
Underground there is feeling of earthquake
Building swaying, (2)………….. making
Falling bricks block your way
And at each feet full (3)…….. you think
Seismic waves, seismic waves
They why the (4)…………. is swaying
Aftershocks, faulted rocks
We'll just (5)……. it next year
P and S waves and they always
From the (6)…….. they raise
Through the Earth they can travel a distance

P are (7)……., L are laster
Liquid S speeds no trace,
And the moan of the rumble you fear
Seismic waves, seismic waves
They why the driveway is cracking
(8)……. scale start to wail
We'll just repave it next year.

Is there any difference between seismology and seismic survey?
What is the main aim of seismic survey?
What devices are used for registration of vibrations?
What types of waves do you know?
What is a seismogram?

Terms and Vocabulary

acquisition	регистрация данных
boundary	граница
data set	набор данных
exponentially	в геометрической прогрессии
frequency output	выходная частота
impedance	импеданс; полное сопротивление
incidence	охват, сфера действия
mean	средняя величина
medium – media	среда – среды
plot (v)	наносить на график, строить (график, диаграмму, кривые)
reflection profile	профиль метода отраженных волн
source array	групповой источник
spread correction	поправка на нормальное приращение времени
storage medium	носитель информации, запоминающая среда
terrain	топография
time (v)	измерять время, рассчитывать (по времени)
transition zone	переходная зона
tuned air gun array	ряд настроенных пневмопушек
variable	переменная величина
impact	воздействие, влияние; удар
receptor	приёмник
propagation	распространение
travel time	время распространения (волны); время прохождения (сигнала)

velocity	скорость
equation	уравнение
encounter (v)	сталкиваться; иметь столкновение
output (v)	производить; выпускать, выдавать
generate	порождать, производить
excite	возбуждать, вызывать
transmit	передавать

1. Read the words paying attention to their pronunciation.

[ʌ] thumping, fundamental, subsequently
[i:] receive, sub-sea, feature, medium, impedance
[ə:] interpret, reserves, concern, curve
[ai] arrive, vibroseis, hydrocarbon, hydrophone, profile, excite, multiply, microphone
[au] encounter, amount, boundary
[ou] echolocation, sonar, processed, explosives, profile, prospect, although
[ei] data, array, equation, straight
[ju:] security, issue, tuned
[ɛə] variable, software
[dʒ] geophone, storage, average, generate
[ʃ] exponentially, specialize
[kw] acquire, acquisition, require, frequency, equation

2. Pay attention to the stress in the following words.

'profile	in'terpret
im'pedance	'impact
'incidence	te'rrain
'variable	a'rray
'sonar	pa'rameter
	par'ticular
al'though	en

3. Pay attention to the word formations.

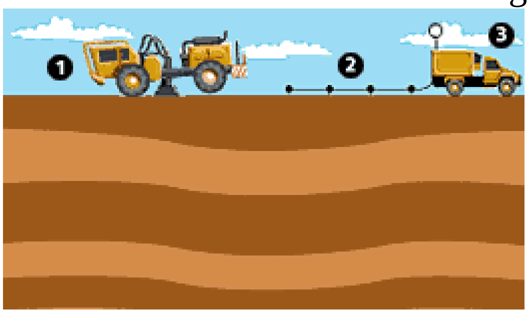
geophysics-geophysicist	deep-depth
determined-predetermined	success-successful-unsuccessful
environment-environmental	explore-exploration-explorer
sign-signify-signification-signature	special-specialist-specialize
acquire-acquisition	common-commonly
act-action-active-activity	explode-explosion-explosive

4. Read the text, do the exercises.

Reflection Seismology

Reflection seismology, or 'seismic' as it is more commonly referred to by the oil industry, is used to map the subsurface structure of rock formations. Seismic technology is used by geologists and geophysicists who interpret the data to map **structural traps** that could potentially contain hydrocarbons. Seismic exploration is the primary method of exploring for hydrocarbon deposits, on land, under the sea and in the **transition zone** (the **interface** area between the sea and land). Although the technology of exploration activities has improved **exponentially** in the past 20 years, the basic principles for acquiring seismic data have remained the same.

In simple terms and for all of the exploration environments, the general principle is to send sound energy waves (using an energy source like dynamite or **Vibroseis**) into the Earth, where the different layers within the Earth's crust reflect back this energy.



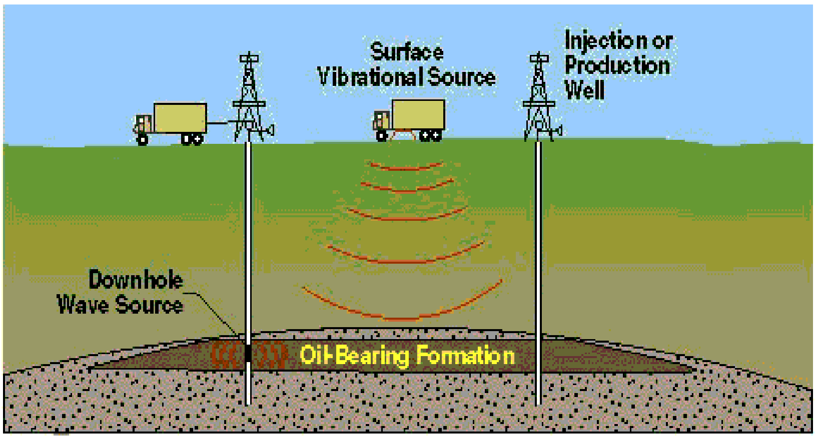
These reflected energy waves are recorded over a **predetermined** time period (called the **record length**) by using hydrophones in water and geophones on land. The reflected signals are **output** onto a **storage medium**, which is usually magnetic tape. The general principle is similar to recording voice data using a microphone onto a tape recorder for a set period of time. Once the data is recorded onto tape, it can then be processed using specialist software which will result in processed seismic profiles being produced.

These profiles or **data sets** can then be interpreted for possible hydrocarbon reserves.

The three primary exploration environments for seismic exploration are land, the **transition zone** and marine (shallow and deep water).

What parameters are used for each **acquisition** project depends on a significant number of **variables** specific to a particular area. For example, in the marine environment the choice of a **tuned air gun array** will depend on the known sub-sea geology, data from previous seismic surveys, the depth at which the main features of geological interest exist within the Earth, the desired **frequency output** of the **source array**, the amount of energy or power required and so on. For the land environment, the source choice is normally between drilled dynamite shot holes or mechanical vibrators. Again, the choice will depend on the specific geology and characteristics of the prospect area but can also be influenced by non geophysical issues, such as **terrain**, security issues especially for explosive use and storage and local environmental **concerns** (such as working in protected areas, working close to buildings and structures or in national parks etc).

Seismic surveys may also have a positive **impact** by reducing the number of unsuccessful wells drilled while exploring for hydrocarbon deposits and by increasing the amount of hydrocarbons produced from existing wells.



Conceptual diagram of how ground vibrations stimulate increased production of oil and gas. The increase is transient but can be produced by surface vibroseis truck or vibration source in a borehole.

Reflection seismology (or seismic reflection) is a method of exploration geophysics that uses the principles of seismology to estimate the properties of the Earth's subsurface from reflected seismic waves. The method requires a controlled seismic source of energy, such as dynamite or a specialized air gun. By noting the time it takes for a reflection to arrive at a receiver, it is possible to estimate the depth of the feature that generated the reflection. In this way, reflection seismology is similar to sonar and echolocation.

Depths are calculated from reflection records by **timing** the reflections for a **mean receptor** distance, and multiplying the time by one-half of the average velocity. This is true for nearly vertical **incidence**. For greater distances a «**spread correction»** is applied. Although reflection rays are curved, it is usually satisfactory to calculate depths on the basis of straight ray **propagation**.

Relative depth determination may be made by **plotting travel time** only. For absolute depth determinations the average velocity must be known. It may be determined by recording reflections from known depths, by shooting in wells, or by surveying a long **reflection profile** at the surface.

Seismic waves are a form of elastic wave that travel in the Earth. Any **medium** that can support wave propagation may be described as having **impedance**. The seismic (or acoustic) impedance Z is defined by the equation $Z= V \rho$, where V is the seismic wave velocity and ρ (Greek rho) is the density of the rock. When a seismic wave **encounters** a boundary between two different materials with different impedances, some of the energy of the wave will be reflected off the boundary, while some of it will be transmitted through the boundary.

(Wikipedia. The free encyclopedia. http://www.wikipedia.org/)

5. Form nouns from the following verbs.

reflect	form	interpret
explore	produce	calculate
determine	require	apply
record	characterize	describe
process	influence	correct

7. Match the words in the right column with their synonyms in the left one.

1. generate	A. power
2. excite	B. convey
3. protect from	C. characteristics
4. estimate	D. border
5. properties	E. stimulate
6. sufficient	F. create
7. boundary	G. evaluate

8. energy	H. satisfactory
9. transmit	I. defend from

7. Match the words in A with the words in B to form collocations.

1. encounter	A. exponentially
2. ray	B. output
3. frequency	C. gun
4. acquisition	D. boundary
5. storage	E. zone
6. transition	F. incidence
7. structural	G. medium
8. improve	H. impact
9. air	I. trap
10. positive	J. project
11. vertical	K. propagation

8. Choose the most suitable word or word-combination.

1. *Spread correction/ travel time/ plotting* is time required for a seismic wave to travel from the source to *storage medium/ sonar/ receptor*.
2. Conclusions on presence or absence of hydrocarbons are usually made on the basis of data from *impedance/ terrain/ reflection profiles*.
3. In reflection method the energy initially *propagates/ outputs/ plots* downward and at some point *times/ encounters / transmits* a boundary which reflects it back.
4. In choosing a *mean/ transition zone/ source array* for a particular *storage medium/ acquisition project/impedance* one must consider a lot of factors.
5. Seismic *data sets/ frequency output/ terrain* may help to measure depth of source rock which is needed for construction of highways and big buildings.
6. The eruption of mount St. Helen’s produced a great *propagation/ impact/ echolocation* on the surrounding environment.
7. The equation contains a number of *timing/ variables/ media*.
8. The natural gas production rates increased *by spread correction/ by incidence/ exponentially* as enhanced oil recovery techniques were applied.
9. Seismic waves have lower velocity in solid *storage medium/ medium /source array*.

10. *Tuned air gun array/ transition zone/ frequency output* is one of the primary environments for seismic exploration.

9. Make up sentences, add words if necessary.

1. use/ interpret/ to map/ seismic/ structural/ technology/ maps/ geophysicists/ to.
2. the/ hydrophones/ used/ to/ record/ reflected/ are/ waves/ energy/ geophones/ and.
3. storage/ environmental concerns/ are/ issues/ non geophysical/ terrain/ explosive use/ and.
4. reduce/ unsuccessful wells/ seismic/ the/ may/ survey/ number/ of.
5. average/ for/ absolute depth/ we/ the/ velocity/ need/ to know/ determination.

10. Reconstruct the order of operations that are performed in seismic survey.

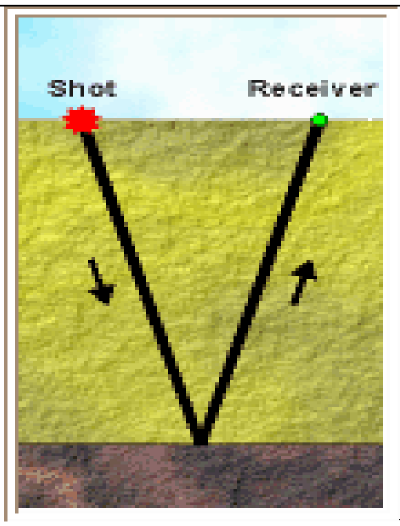
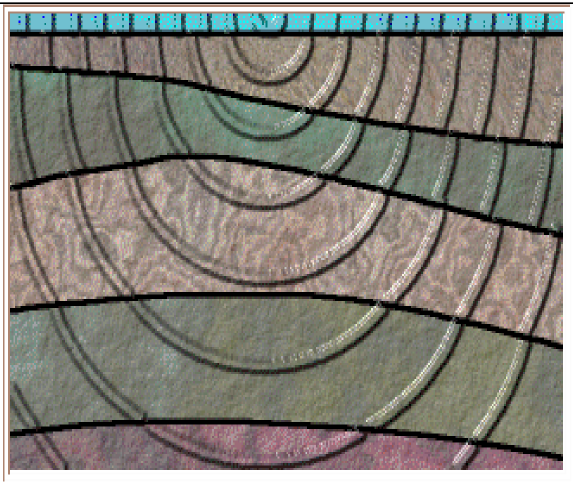
___ The reflected signals are output onto a storage medium.
___ Different rock layers within the Earth's crust reflect back the energy.
___ The recorded data are processed with special software.
___ Hydrophones and geophones record the reflected energy waves over a predetermined set of time.
___ These profiles or data sets are then interpreted for possible hydrocarbon reserves.
___ Sound energy waves are sent into the ground by means of dynamite or Vibroseis.
___ As a result of data analysis seismic profiles are produced.

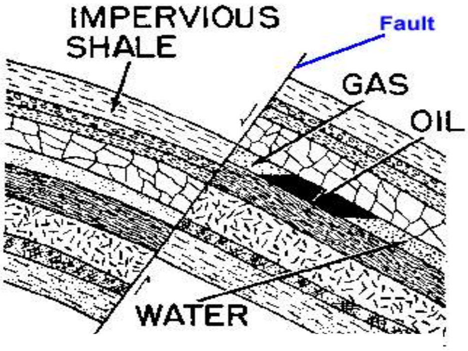
11. State if these sentences are true or false. Add more information if they are true and correct them if they are false.

1. In the oil industry reflection seismology is applied to find oil.
2. The technology of exploration activities has remained the same over the recent time.
3. The general principle of reflection seismology consists in recording voice data using a microphone onto a tape recorder for a set period of time.
4. The three primary exploration environments for seismic exploration are land, the transition zone and marine.
5. Characteristics of a particular area determine the methods for each acquisition project.

6. In the marine environment the choice of air gun array is made between dynamite shot holes or mechanical vibrators.
7. The choice of a tuned air gun array depends on the specific geology, depths of geological feature and desired frequency output of the source array.
8. Terrain, security issues and local environmental concerns make no difference in choosing energy source for the land environment.

12. Match the pictures with the extract for illustration of which they can serve.

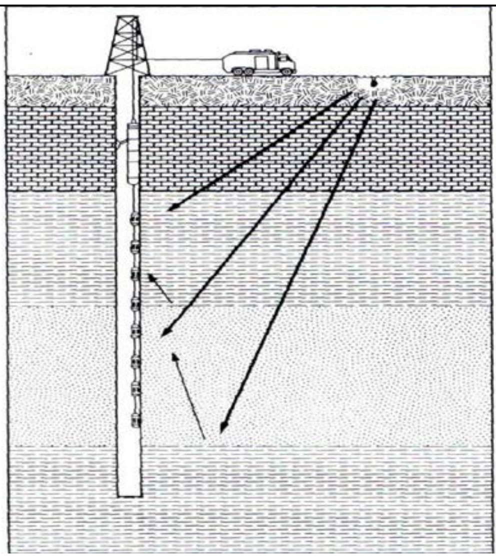
 A	 B
 C	 Photo courtesy of **Horizon Exploration Ltd.** D



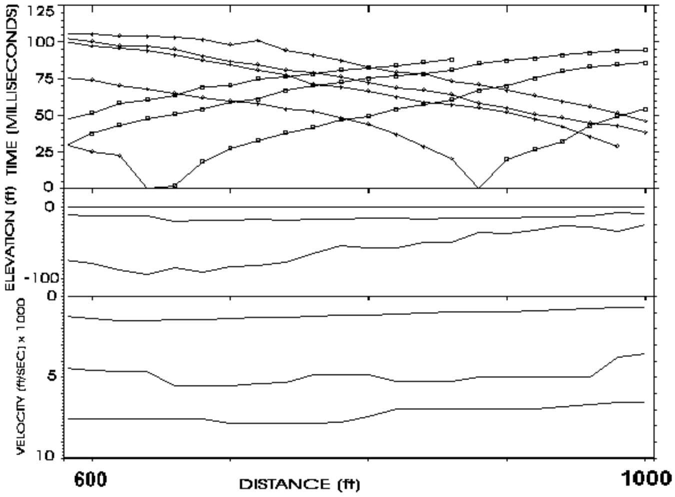
E

$Z=V*\rho$

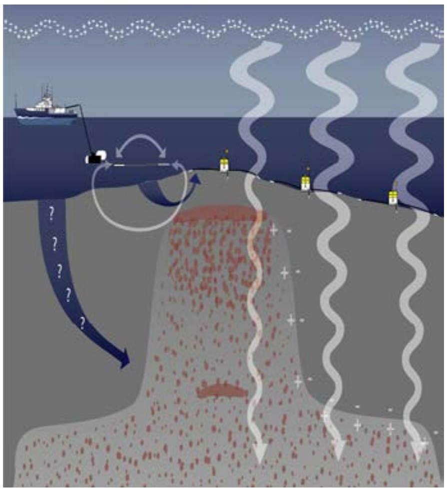
F



G



H



I

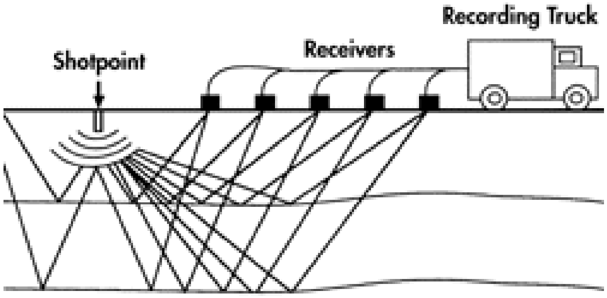
Using these pictures study some facts about reflection seismology.

13. Answer the following questions.

1. What do geophysicists interpret the seismic data for?
2. What are three environments for seismic exploration?
3. What is the general principle of getting seismic data?
4. Which exploration tool is typical for sub-sea survey?
5. What non-geophysical issues may influence the choice of exploration technology?
6. What is the reflection seismic method?
7. What does that mean «reflection seismology is similar to sonar and echolocation»?
8. How are depths of geological structures determined?

9. In what case is a «spread correction» applied?
10. What is impedance?

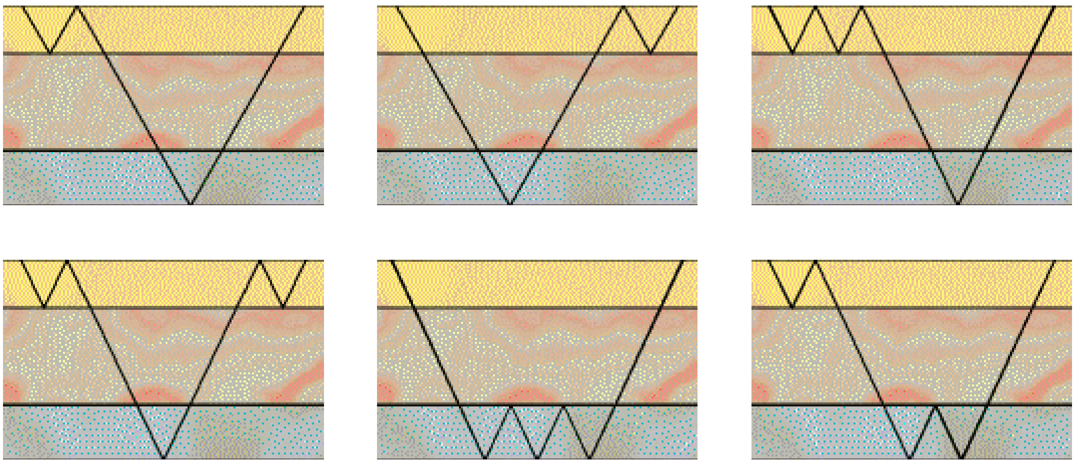
14. Describe the method of geophysical exploration shown in the diagram.



Reflection Seismology

15. Read the following definitions and say in a brief form what the difference is between reflections and refractions.

__Reflection__ – when an incident **compressional wave** strikes a boundary between two media having different velocities of wave propagation, part of the energy is reflected from the boundary. Possible ways of multiple reflections are endless.



__Refraction__ **–** the portion of the incident energy that is not reflected and is transmitted through the boundary and into the second layer. The transmitted ray travels through the second layer with changed direction of propagation.

16. Render the information from the text into English.

расстояние между	***spacing***
пункт взрыва	***shot point***
пункт приема	***receiving point***
превышать	***exceed***
картируемые границы	***mapping limits***
отражающая граница	***reflector***
путь распространения	***propagation path***
под углом	***at an angle***
линия наблюдения	***observation line***
высокоскоростной пласт	***high-velocity layer***
ослабление	***attenuation***
смещение	***displacement***
перпендикулярно	***perpendicular to***

Метод преломленных волн

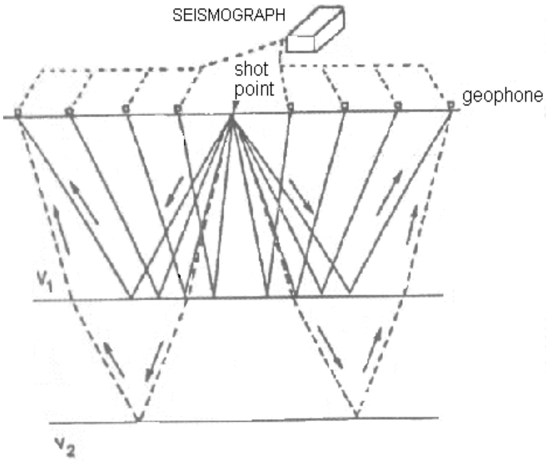
Основное различие между методами отраженных и преломленных волн состоит в том, что при использовании преломленных волн расстояние между пунктом взрыва и сейсмоприемниками превышает глубины картируемых границ, тогда как оно мало или сравнимо по величине с глубинами отражающих границ. Поэтому пути распространения волн при работах методом преломленных волн преимущественно вертикальны. Головные волны или преломленные волны подходят к высокоскоростному пласту и выходят из него под критическим углом. С их помощью можно обнаружить только такой пласт, в котором скорость распространения волн значительно меньше, чем в вышележащих породах. В связи с этим метод преломленных волн имеет более ограниченное применение, чем метод отраженных волн.

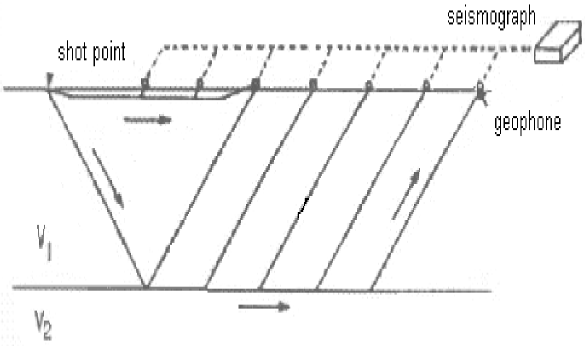
Поскольку преломленные волны обычно регистрируют на больших расстояниях, чем отраженные, в этом методе требуются более мощные источники колебаний. Расположение сейсмоприемников вдоль линии наблюдения ведет к ослаблению головных волн, содержащих горизонтальную компоненту смещения. Поэтому сейсмоприемники группируются либо радиально, либо перпендикулярно линии, соединяющей пункты взрыва и приема.

(Белоусов В.С. Нефтегазовая промышленность. Основные процессы и англо-русская терминология. Москва, 2006)

17. Compare and contrast the methods shown in the pictures. Mention the following aspects:

- ***Wave propagation***
- ***Source energy arrays and receivers***
- ***Application of the methods***





Terms and Vocabulary

advancement	продвижение, усовершенствование, прогресс
application	применение, использование
capability	мощность, производительность, возможность
capture	записать, зафиксировать, отражать
compressional wave	волна сжатия
continuity	непрерывность
development	разработка
engineering survey	инженерная съемка
enhanced oil-recovery	добыча нефти с искусственным поддержанием энергии пласта\ улучшенная нефтедобыча
full-vector wave-field imaging	полновекторное изображение волнового поля
gas chimney	скопления мелкозалегающего газа
geothermal energy	геотермальная энергия
ground-penetrating radar	георадар, радиолокация приповерхностных структур
insensitive	нечувствительный
mapping	картирование

plaque	испещрять, изобиловать, часто встречаться
processing data	обработка данных
production	добыча
reduce uncertainties	сокращать неточности
shallow	неглубокий
shear wave	сдвиговая волна
3D-seismic technology	трехмерная сейсмическая технология
fracture	разлом
frame	границы, пределы; каркас, остов
affect	оказывать влияние, подвергать воздействию
discriminate among	различать, отличать, проводить различие, дифференцировать
execute	осуществлять, выполнять, делать; реализовать
cause	вызывать, являться причиной

18. Pay attention to the pronunciation of the following words and wordformations.

environmental	image-imaging-imagine-imagination
plaque	certain-uncertain-uncertainty
shear	sensitive-insensitive
radar	thermal-geothermal
monitor	continuous-continuity
capture	execute-executive
cause	compress-compression-compressional
discriminate	respect-respective-respectively

19. Read and give Russian translation of the following word-combinations.

Such resources as minerals and geothermal energy; to be used in shallow application for engineering, groundwater and environmental surveying; a method known as ground penetrating radar; to be applied for mapping shallow subsurface; to reduce uncertainties across the entire range of exploration and development; to plan and execute enhanced oil recovery strategies; advancements in data acquisition and processing; to capture rocks properties between wells; full-vector wave-field imaging involves shear and compressional waves; to be insensitive to the type of fluid; gas chimney plaque economically important areas; destroy P-wave continuity.

20. Expand the given sentences in any way you can. Give details, describe the definite situation.

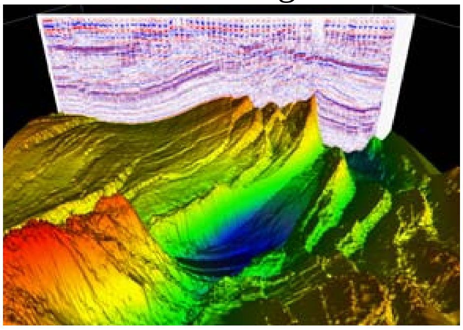
1. The capabilities increased.
2. The device reduces uncertainties.
3. Gas chimneys plaque.
4. The hand becomes insensitive.
5. The event broke continuity.
6. The full-vector wave-field imaging was performed.
7. The ground penetrating radar captured wrong data.
8. 3D seismic technology advanced.

21. Read the text, do the exercises.

Applications of Reflection Seismology

Reflection seismology is extensively used in exploration for hydrocarbons (i.e., petroleum, natural gas) and such other resources as coal, ores, minerals, and **geothermal energy.** Reflection seismology is also used for basic **research** into the nature and origin of the rocks making up the Earth's crust. Reflection Seismology is also used in **shallow** application for **engineering**, **groundwater** and environmental **surveying**. A method similar to reflection seismology which uses electromagnetic instead of elastic waves is known as **Ground-penetrating radar** or GPR. GPR is widely used for **mapping** shallow subsurface (up to a few meters deep). The reflection method is at present the most **accurate** method of determining depths of formations in oil exploration.

Ground Penetrating Radar



3D Seismic technology

Today, **3D-seismic technology** is applied to **solve problems** and **reduce uncertainties** across the **entire range** of **exploration**, **development** and **production operations**. Surveys are used to characterize and model reservoirs, to plan and **execute enhanced-oil-recovery** strategies and to

monitor fluid movement in reservoirs as they are developed and produced. These **capabilities** have been made possible by **advancements** in **data acquisition**, **processing** and interpretation.

Full-Vector Wavefield Imaging which includes **shear** and **compressional waves** (S- and P-waves, respectively) to **capture** rock properties between wells. P-waves are influenced not only by rock **frame** properties but also by the nature of the fluid in the rock pores. S-waves are insensitive to the type of fluid in sediments. Full-vector wavefield imaging makes it possible to "see" through **gas chimneys** that **plague** economically important areas. These chimneys which are caused by free gas in the sediments **destroy** P-wave **continuity** but hardly **affect** S-wave reflections. Combining P- and S-waves **discriminate among** sands and shales and is valuable in helping to **detect** fractures.

(Wikipedia. The free encyclopedia. http://www.wikipedia.org/)

22. Match the words in A with the words in B to make collocations.

1. reflection	A. surveying
2. geothermal	B. method
3. groundwater	C. wave
4. ground-penetrating	D. energy
5. accurate	E. operation
6. solve	F. radar
7. reduce	G. acquisition
8. exploration	H. seismology
9. shear	I. problem
10. data	J. uncertainties

23. Fill in the gaps with correct prepositions.

1. Reflection seismology is used ____ basic research into the nature and origin ____ the rocks.
2. GPR is widely used ____ mapping shallow subsurface ____ ___ a few meters deep.
3. 3D-seismic technology is applied to reduce uncertainties _____ the entire range ____ exploration, development and production operations.
4. These chimneys are caused ____free gas ___ the sediments.
5. Combining P- and S-waves discriminate _____ sands and shales and is valuable ___ helping to detect fractures.

24. Make up sentences, adding words where necessary.

1. reflection/ accurate/ is/ at present/ the most/ seismology/ method.
2. applied/ to/ uncertainties/ 3D-seimic/ technology/ is reduce.
3. includes/ and/ waves/ full-vector wave-field imaging/ shear/ compressional.
4. economically/ gas/ plague/ chimneys/ areas/ important.
5. used/ exploration/ reflection seismology/ for/ extensively/ is/ hydrocarbons/in.

25. Fill in the gaps with words which are derived from the word given at the end of each line.

1. The technology of exploration activities has improved exponentially because of …………. in data processing and interpretation.	ADVANCE
2. ….. in geophysical measurements can cost a lot of money.	CERTAIN
3. Numerous factors such as subsurface geology, terrain, security issues determine parameters for data …………….	ACQUIRE
4. As S-waves can travel only through a solid, they are …….. to the type of a fluid in the rock.	SENSITIVE
5. ….. Vice President refers to a rank in senior management and usually reports directly to the President of the company and could be more than one in different areas (Upstream, Downstream, Oilfield services).	EXECUTE
6. It is difficult to overestimate ………. of 3D seismic technology for hydrocarbon exploration, development and production operations.	CAPABLE
7. Primary waves are ………. waves that travel quicker in dense rock and slower in fluids.	COPMRESS
8. Gold and uranium as well as other ores are ……….. mineral resources.	VALUE
9. Upstream provides a …….. supply of petroleum for consumers downstream.	CONTINUE
10. If the economic penalties of ………. in depth investigations are substantial, it may be cheaper to perform exploratory drilling.	ACCURACY

26. State whether the following sentences are true or false; correct the false ones.

1. Ground-penetrating radar is widely used to reduce uncertainties across the full range of exploration and production operations.
2. Gas chimneys are extremely useful for economically important areas.
3. Reflection seismology is applied in deep groundwater surveying.
4. The least accurate method of determining depths formation is reflection method.
5. Surveys are used to execute oil-recovery strategies and monitor fluid movement in reservoirs.
6. Geophysicists combine refraction and reflection methods to discriminate among sands and shales.
7. GPR is widely used for mapping shallow subsurface.

27. You will hear the report on seismic waves. Match the terms with their descriptions. One of them is extra.

1. Body waves	**a** waves that travel in a circular motion and cause damage by displacing material
2. Secondary waves	**b** waves propagating along the surface and deforming the material vertically
3. Primary wave shadow zone	**c** waves that travel through the interior of the earth
4. Secondary wave shadow zone	**d** waves that are deflected by the Earth's core forming a special area
5. Love waves	**e** waves that travel only through solids thus they do not penetrate the Earth's outer core forming a special zone
6. Rayleigh waves	**f** waves that move sideways at right angles to the direction of travel
	g waves that do not penetrate the earth's interior but follow the surface

28. Answer the following questions.

1. What are the three main applications of reflection seismology?
2. Which method is similar to reflection seismology?
3. When is the GPR method applied?
4. Which method is applied to determine the depths of formations in exploration of petroleum?
5. What are three operations when 3D-seismic technology is applied?
6. What are the capabilities of 3D-seismic technology?
7. What is S-wave?
8. What is P-wave?
9. What does full-vector wave-field imaging help to «see» through gas chimney?
10. When is the combination of P- and S-waves applied?

29. For the gaps 1–5, 6–10, choose one of the words on the right (1–6) that best completes the gap in the text. You can use each word only once. For every 5 gaps, there is one extra word.

Ground Penetrating Radar

The depth range of GPR is limited by the electrical **(1)** ______ of the ground, and the transmitting frequency. As conductivity increases, the penetration depth **(2)** ______. This is because the electromagnetic energy is more quickly dissipated into heat energy, causing a loss in signal **(3)** __________ at depth. Higher frequencies do not **(4)** ________ as far as lower frequencies, but give better resolution. Optimal depth penetration is achieved in dry sandy soils or massive dry materials such as granite, **(5)** ____________, and concrete where the depth of penetration is up to 15 m. In moist and/or clay laden soils and soils with high electrical conductivity, penetration is sometimes only a few centimetres.	**1. limestone** **2. decreases** **3. conductivity** **4. penetrate** **5. positions** **6. strength**
GPR uses transmitting and receiving antennae. The transmitting antenna radiates short pulses of the **(6)** _________ (usually polarized) radio waves into the ground. When the wave **(7)** _________ a buried object or a boundary with different dielectric constants, the receiving antenna records **(8)** __________ in the reflected return signal. The principles involved are similar to **(9)** ____________ seismology, except that electromagnetic energy is used instead of	**1. dimensional** **2.impedances** **3.high-frequency** **4. encounters**

acoustic energy, and reflections appear at boundaries with different dielectric constants instead of acoustic **(10)** ___________ .	**5. variations** **6. reflection**

Terms and Vocabulary

pattern	структура; график
obtain	получать, приобретать, достигать
sequence	последовательность, ряд
Tow	тянуть на буксире, буксировать
echo-sounding	акустическое зондирование
undertake (took, taken)	предпринимать, выполнять, осуществлять
submerge	погружать(ся), покрывать(ся) водой, затоплять, тонуть
burst	подрыв
pass	передавать
echo	отраженный звук, сигнал, отголосок
reach	достигать
ray path	траектория луча
two-way travel time	полное время пробега, время прохождения сигнала в прямом и обратном напраслении
pulse	импульс, вибрация
hemispherical wave front	полусферический волновой фронт, головная часть волны
intercept	улавливать, выделять, перехватывать
space	расставлять, располагать с определенным интервалом
graph	график; диаграмма; кривая; годограф
plot	представлять данные графически; строить (график, диаграмму, кривые)
wiggle	покачивание, отклонение
wiggle trace	трасса, визуализированная способом отклонений
peak	вершина кривой, высшая точка; максимум
trough	прогиб, низшая точка, минимум
magnitude	величина
deflection	отклонение от прямой, прогибание
convention	условное обозначение, договоренность
dual polarity	двойная полярность

display (n,v)	визуальное представление данных, изображение (на экране); показывать, демонстрировать, изображать
wiggle variable area display	изображение, полученное способом отклонений с зачернением положительных амплитуд
variable density display	изображение, полученное способом переменной плотности
variable area data	данные, полученные способом переменной площади
common depth point	общая глубинная точка
vessel	судно
time	выбирать время; рассчитывать (по времени); упорядочивать, синхронизировать во времени
separation	расстояние между ….., интервал
summing	накапливание; накопление
CDP gather	сейсмограмма ОГТ; сейсмограмма общей глубинной точки
hyperbolic curve	гиперболическая кривая
normal move out (NMO)	поправка за нормальное приращение времени
alignment	выравнивание (плоскости, кривой; установка на одном уровне
stack	комплектовать
stacking	суммирование, накапливание трасс
cause	вызывать, заставлять, побуждать
random noise	случайная помеха
cancel out	уничтожаться, взаимно исключаться
seismic section	сейсмический разрез, профиль
seismic line	профиль
time-section	сейсмопрофиль во временах
subtle	трудноуловимый
depth-section	глубинный разрез
traverse	пересекать
convert	преобразовывать
obscure	затемнять, мешать, делать неясным
intrinsic deficiencies	внутренне присущий (естественный) недостаток
multiple	кратноотраженная волна
ringing	реверберация

diffraction	отгибание, дифракционная волна
mimic	имитировать, воспроизводить
arched formations	антиклинально построенные структуры, сводообразная структура
deconvolution	обратная фильтрация, деконволюция
counteract	противодествовать, препятствовать, нейтрализовать
blurring	искажение, нечеткость, затуманивание
spike	импульс, импульсное искажение, отскок
suppression	подавление
incline	наклонять, падать
muting	обнуление части трасс
embody	заключать в себе, содержать
remove	удалять, устранять
collapse	ослаблять, рушить

30. Pay attention to the pronunciation of the following words and word-combinations.

echo-sounding	minute	trough
axis	oil-bearing	amplitude
interpret	cause	intrinsic deficiencies
obscure	arched formation	blurring
counteract	collapse	society
pattern	occur	deconvolution
hyperbolic curve	alignment	traverse
Via	subtle	towards
incline	distortion	submerge

31. Pay attention to the structure of the words and give their Russian equivalents.

bury-burial	slight-slightly
direct-direction	relate-relative-relatively
correct-correction	desire-desirable-undesirable
suppress-suppression	expensive-inexpensive
migrate-migration	vary-variable-invariable-invariably
pulse-pulsation	indicate-indication-indicator
filter-filtering	locate-relocate
polar-polarity	compress-recompress
distort-distortion	move-movement-remove-motion

32. Make up word-combinations.

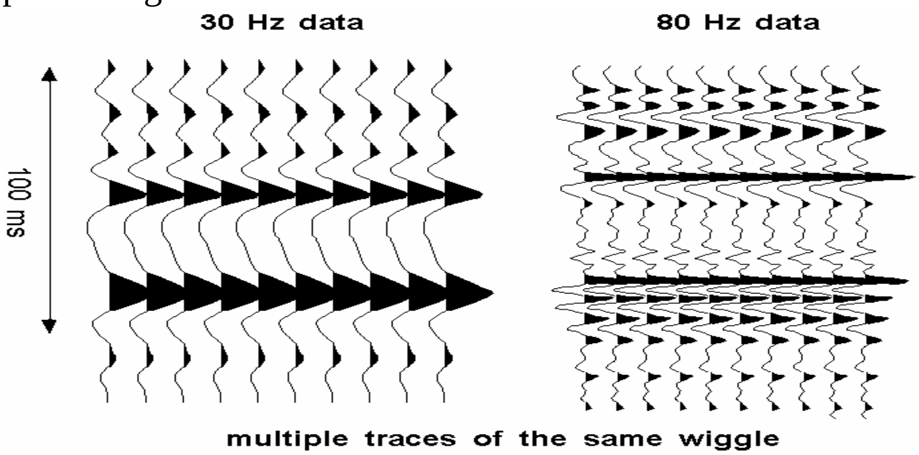
1. tow	a wave front
2. undertake	b ray path
3. submerge	c echo-sounding
4. intercept	d pulse
5. space	e hyperbolic curve
6. plot	f wiggle trace
7. time	g two-way time
8. display	h vessel

33. Read the text and do the exercises.

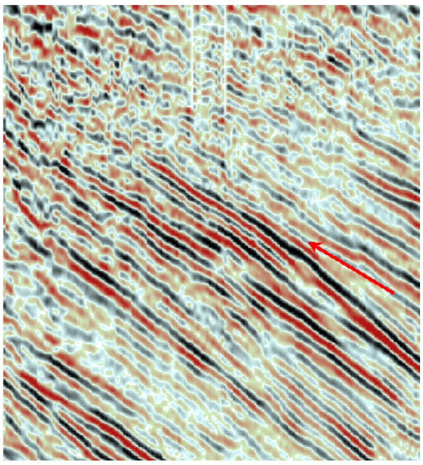
Acquisition

Large-scale geological structures that might hold oil or gas reservoirs are invariably located beneath non-productive rocks, and in addition this is often below the sea. Geophysical methods can penetrate them to produce a picture of the **pattern** of the hidden rocks. Relatively inexpensive gravity and geomagnetic surveys can identify potentially oil-bearing sedimentary basins, but costly seismic surveys are essential to discover oil and gas bearing structures.

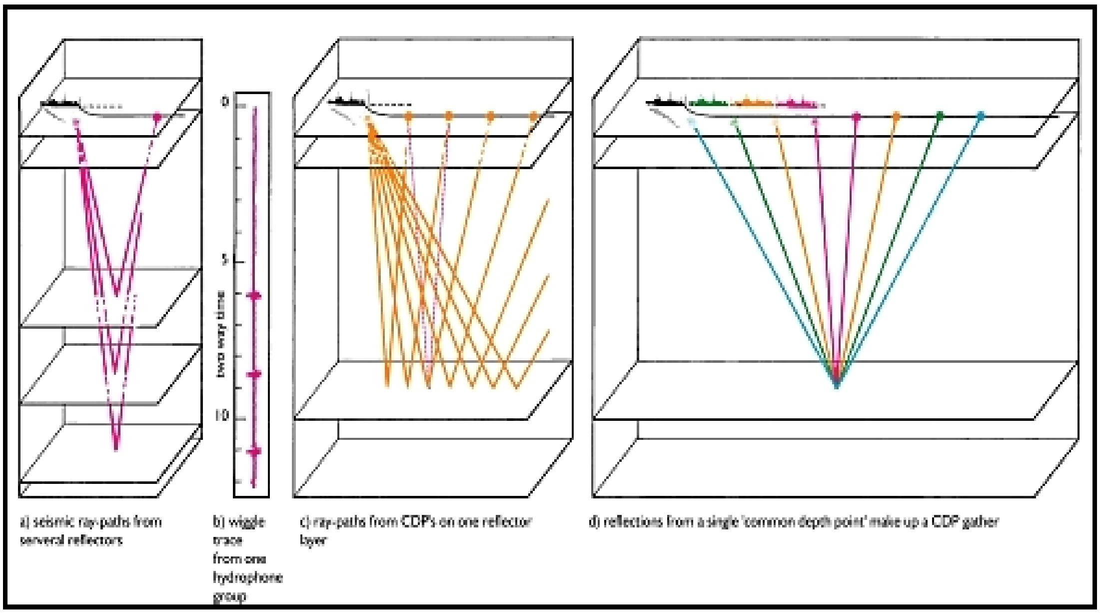
More detailed information about the rock layers within such an area can be **obtained** by deep **echo-sounding** or seismic reflection surveys. In offshore areas these surveys are **undertaken** by a ship **towing** both a **submerged** air or water gun array, to produce short **bursts** of sound energy and a set of streamers of several kilometres length. Each streamer contains a dense array of hydrophone groups that collect and **pass** to recorders **echoes** of sound from reflecting layers. The depths of the reflecting layers are calculated from the time taken for the sound to reach the hydrophones via the reflector; this is known as the **two-way travel time**. The **pulse** of sound from the guns radiates out as a **hemispherical wave front**, a portion of which will be reflected back towards the hydrophones from rock interfaces. The path of the minute portion of the reflected wave-front intercepted by a hydrophone group is called a **ray path.** Hydrophone groups **spaced** along the streamer pick out ray paths that can be spaced to specific points on the reflector surface**.** **Graphs** of the intensity of the recorded sound **plotted** against the two-way time are **displayed** as **wiggle traces**, in which each trace represents a geophone on the surface. **Peaks** and **troughs** on the wiggle represent up and down movements of the geophone, in which the vertical axis of the wiggle is two-way time, and the amplitude of the peak or trough indicates the **magnitude** of geophone movement. Generally, peaks face right and are colored black to make it easier to interpret the line. In **variable density displays**, shades of gray are used to represent amplitude instead of peak/trough **deflection**.



The Society of Economic Geophysicists has a **convention** that troughs represent upward motions of the ground and peaks represent downward motions. However, many companies have their own conventions. At shallow burial depths, troughs (upward expansion) represent low-velocity sands, peaks (downward troughs) are high-velocity shales. With greater burial, sands become faster than shales, and troughs will switch to represent shales.



Today, **dual-polarity displays** of **variable area data** are common, where troughs are colored red to indicate low-velocity sands at shallow depths, peaks are colored black (to indicate high-velocity shales) and transitions between peaks and troughs are not shown at all. The troughs are then reversed, and superimposed on the original traces so that both peaks and troughs face the same direction. Dual polarity displays of variable density are also common.



Seismic recording at sea always uses the common depth point (CDP) method. A **sequence** of regularly spaced seismic shots is made as the survey **vessel** accurately navigates its course. Shots are usually **timed** to occur at distances equal to the **separation** of the hydrophone groups. In this way up to 120 recordings of the echoes from any one of 240 reflecting points can be collected. Each represents sound, which has followed a slightly different ray path, but has all been reflected from the same **common depth point.**

Discovering the Underground Structure
http://www.ukooa.org/education/storyofoil/index.cfm)

34. Choose the necessary word from the given ones.

1. They *intercepted/ timed/undertook* a series of actions but everything was in vain.
2. After collision with the iceberg Titanic *spaced/ submerged/ towed* in several hours.
3. The depths of the reflecting layers are calculated from *the two-way travel time/ peak/vessels.*
4. In wiggle traces *sequence/ burst/trough* indicates the magnitude of geophone movement.
5. Hydrophone groups are *plotted/spaced/ intercepted* along the streamer that picks out ray paths.
6. The Society of young hackers made a *convention/ wiggle variable area display/ graphs* to help each other in any trouble.

7. In variable density displays, shades of gray are used to represent amplitude instead of peak/trough *vessel/deflection/ magnitude*.
8. In offshore surveys air or water gun array is applied to produce short *wave front/bursts/ peaks* of sound energy.

35. Give English equivalents of the words in the brackets.

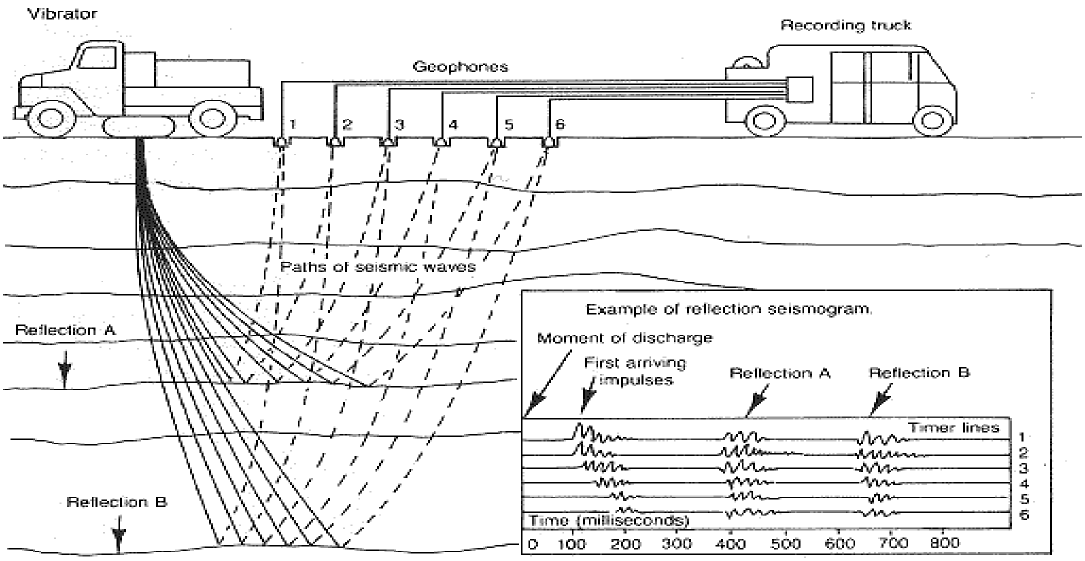
1. Many companies have their own (обозначения) for wiggle trace imaging.
2. At shallow burial depths, (прогиб) represent low-velocity sands, (высшие точки) are high-velocity shales.
3. The path of the minute portion of the reflected wave-front which (улавливается) by a hydrophone group is called a ray path.
4. (последовательность, ряд) of regularly spaced seismic shots is made as the survey (судно) accurately navigates its course.
5. (Подрывы) are usually timed to occur at distances equal to the (расстоянию) of the hydrophone groups.
6. Each echo represents sound, which has followed a slightly different ray path, but has all been reflected from the same (общая глубинная точка).
7. (Акустическое зондирование было предпринято) to identify potentially oil-bearing sedimentary basins.
8. After processing seismic data is (представляются графически).

36. Fill in the gaps using the terms from the text.

1. Massive _______ _______ containing oil or gas reservoirs are commonly hidden beneath non-productive rocks.
2. Cheap _______ and _____ _____ can detect sedimentary basins where there might be oil, but expensive seismic surveys are essential to discover oil and gas bearing structures.
3. _______ _______ can yield more accurate information about the rock layers in areas with complex geology.
4. In offshore areas marine surveys are undertaken by a ship towing an air or water gun array which generates short ______ of sound energy.
5. _____ _____ _____ is known as the time needed for the sound to reach the hydrophones via the reflector which is used for calculation of depths.
6. Hydrophones intercept the path of the minute portion of the reflected wave-front which is called a _______ ______ .

7. Graphs of the intensity of the recorded sound are plotted against the two-way time and as a result ______ ______are displayed.
8. Two-way time represents the vertical axis of the wiggle, and the amplitude of the peak or trough indicates the ______ of ______ ___.
9. For convenience of interpretation, peaks face _____ and are colored _____ .
10. Variable density displays make use of ______ of ______ .

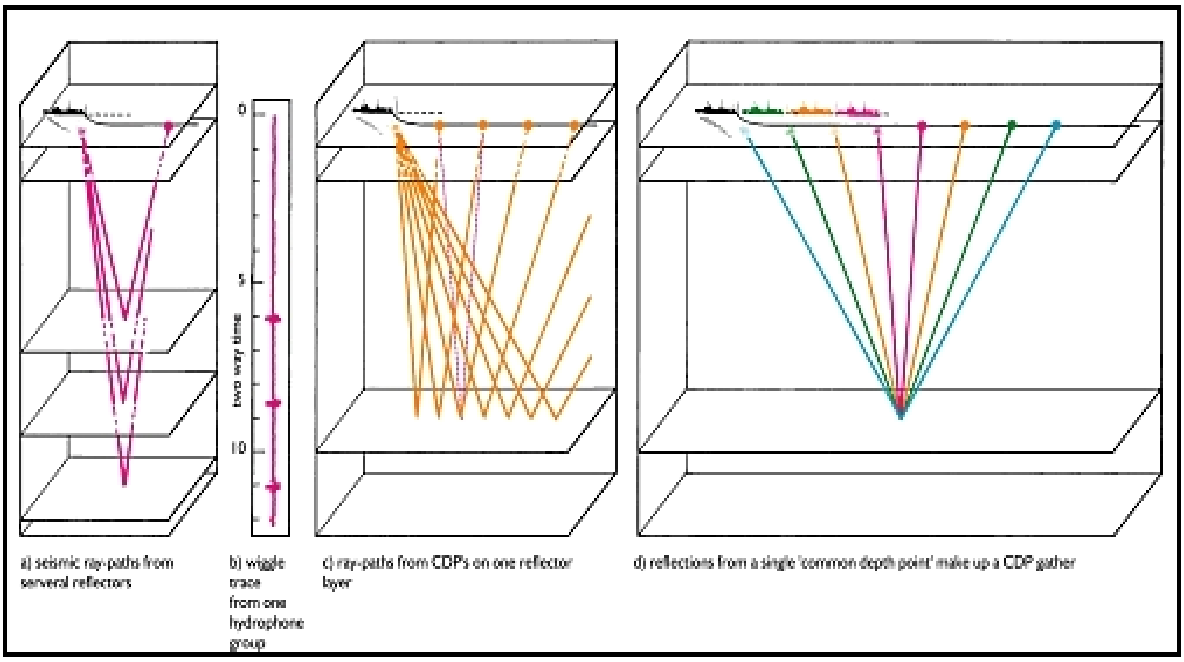
37. Tell about the process of getting wiggle traces using the scheme.



38. Remember and contrast conventions about wiggle traces imaging in the following cases.

Society of Economic Geophysicist convention	other companies conventions	dual-polarity displays convention

39. Study the scheme and define common depth point method.

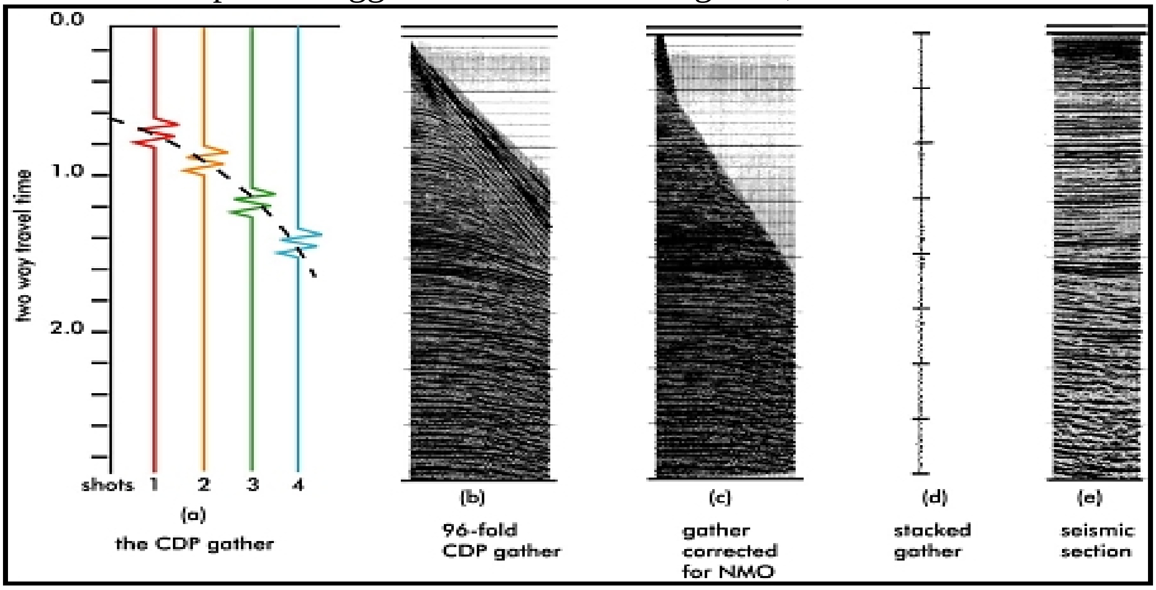


40. Read the text and state if the sentences are true or false.

1. CDP gather is the initial stage of computer summing.
2. Reflections from a reflector form a hemispherical curve on the gather.
3. Normal move out (NMO) is a correction which is needed to bring the pulses to a horizontal alignment.
4. The separation of wiggle traces from one another is called stacking.
5. Stacking helps to exclude random noise.
6. Seismic sections are formed when the stacked and corrected wiggle traces are displayed side by side.
7. Most seismic sections occur as depth sections.
8. Computer processing is designed to improve the quality of the reflections and bring out subtle geological features.
9. For time sections it is necessary to know the velocities of sound in the rock layers before stacking.
10. It is possible to get more accurate information on layer velocity when special velocity surveys in wells are combined with sonic logging.

Processing

Processing recordings involves many stages of signal processing and computer **summing**. Firstly, wiggle traces from a single CDP are collected into groups. Displayed side by side in sequence they form a **CDP gather.** Reflections from any one reflector form a **hyperbolic curve** on the gather because the sound takes longer to travel to the more distant hydrophones. This effect is called **normal move out (NMO).** Correction is needed to bring the pulses to a horizontal **alignment**, as if they all came from vertically below the sound source. The separate wiggle traces are added together, or **stacked**.



Stacking causes true reflection pulses to enhance one another, and hopefully, **random** noise will **cancel out**. This process is repeated for all the CDPs on the survey line. The stacked and corrected wiggle traces are displayed side by side to give a **seismic section**. Most seismic sections used by the oil and gas industry are **time-sections** that have undergone a long sequence of data-processing steps designed to improve the quality of the reflections and bring out **subtle** geological features. For particular purposes, after the principal reflectors have been identified or 'picked', a time-section may be **converted** to a **depth-section**. For this and also for NMO corrections before stacking, the velocities of sound in the rock layers **traversed** by the section need to be known. Computer analysis of traces during NMO corrections yields velocity values, but more accurate data comes from special velocity surveys carried in wells in conjunction with sonic logging.

Data processing lessens the impact of various undesirable effects that **obscure** the reflected signals; it also compensates for some **intrinsic deficiencies** of the CDP method. Undesirable effects include **multiples,** where the sound is reflected repeatedly within a rock formation and, because this takes time, registers as a deeper reflector; reflections between the water surface and the seabed are a similar phenomenon known as **ringing.**

Diffractions are hyperbolic reflections from the broken end of a reflector; they **mimic arched formations.** Random noise, mainly unwanted reflections from within rock layers, horizontally propagated and refracted sound, bubble pulsations from the airguns and other effects also need to be reduced. Stacking reduces multiples and random noise but the main computer processing steps are **deconvolution, muting** and filtering, and migration. Deconvolution ('decon') aims to **counteract the blurring** of reflected sound by 'recompressing' the sound to the clean '**spike'** emitted from the source. The result is clearer reflections and the **suppression** of multiples. Muting cuts out parts of traces **embodying** major defects such as non-reflected signals; filtering **removes** undesirable noise to enhance the best reflections. Finally, migration corrects distortions caused by plotting **inclined** reflectors as if they were horizontal and vertically below the midpoint between shot and receiver; it also **collapses** diffractions. In this process, the seismic energy is relocated to its true subsurface location, ready for interpretation.

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41. Complete the sentence with your own ideas using the words from the vocabulary.

1. There was a subtle noise ………………………………… .
2. The well traversed …………………………….. .
3. The random movement of particles in the cube …………….. .
4. Their attempt to form CDP gather was unsuccessful because ……. .
5. The intrinsic deficiencies of the methods were based on the fact that …… .
6. The latest data canceled out the results of the earlier survey due to the fact that …………………. .
7. When the error was removed we learnt that …………………
8. Arched formations can yield ……………………………… .

42.Match the terms with their definitions.

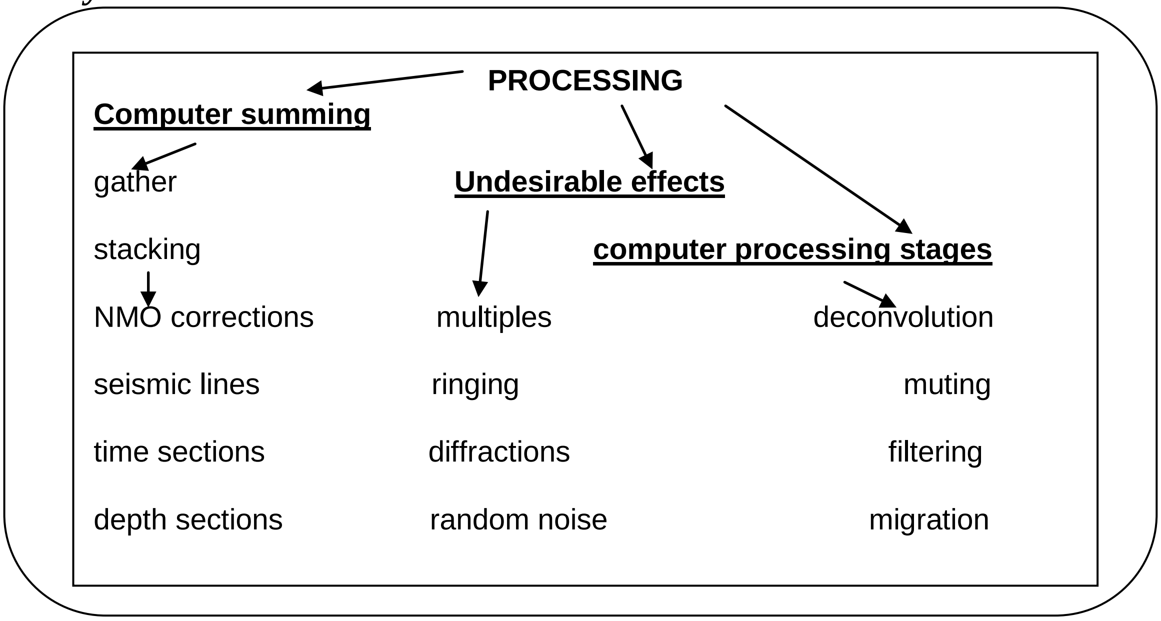
1. diffractions	**a.** correction which is needed to bring the pulses to a horizontal alignment, as if they all came from vertically below the sound source
2. deconvolution	**b.** reflections between the water surface and the seabed
3. muting	**c**. processing step which removes undesirable noise to enhance the best reflections
4. filtering	**d.** unwanted reflections from within rock layers, horizontally propagated and refracted sound, bubble pulsations from the air guns

5. ringing	**e.** wiggle traces from a single CDP collected into groups and displayed side by side in sequence
6. CDP gather	**f.** hyperbolic reflections from the broken end of a reflector which mimic arched formations
7. random noise	**g.** technique that corrects distortions caused by plotting inclined reflectors
8. migration	**h.** a repeated reflection within a rock formation
9. normal move out (NMO)	**i.** processing technique which aims to counteract the blurring of reflected sound by 'recompressing' the sound to the clean 'spike' emitted from the source.
10. multiple	**j.** technique that cuts out parts of traces embodying major defects such as non-reflected signals

***43. Comment of each sentence*.**

1. Several stages are involved into computer summing.
2. There are different types of seismic sections.
3. Various undesirable effects influence the quality of the reflected signals.
4. Main computer processing steps are used to prepare the data for interpretation.

44. Describe the scheme and tell about the processing stage of seismic survey.



45. Answer the questions.

1. How are depths calculated in seismic survey?
2. What do we call a ray path?
3. What are wiggle traces?
4. What conventions are there in wiggle traces imaging?
5. What can you tell about common depth point method?
6. What does the term “CDP gather” mean?
7. Why is the normal move out applied in seismic data processing?
8. What is there specific about depth-sections?
9. What undesirable effects should be removed at the processing stage?
10. What computer techniques are used to prepare the data for interpretation?

Terms and Vocabulary

slantwise	косой, наклонный; наклонно, наоткос
'time-slice'	временной срез
view (n,v)	вид, представление; рассматривать, изучать
interrelationship	взаимосвязанность, соотношение
deduce	проследить, заключать, делать вывод
conspicuously	видимо, ясно, заметно
adjacent	прилежащий, смежный, соседствующий
allow	позволять, разрешать, допускать
stand out	выделяться
noticeably	заметно
flat reflection	отражение плоского участка, структуры
isopach	карты изопахит, карты равных толщин мощностей
intersect	пересекаться, частично перекрываться
contour	оконтуривать, вычерчивать в изолиниях
contour map	карта изолиний
gridding	интерполяция наблюденных значений на равномерную сетку, нанесение координатной сетки
repay	потребовать повторного проведения, возвращать к
warrant	давать основания, полномочия
wildcat drilling	поисково-разведочная скважина
enable	предоставлять возможность, давать право
drain	опустошать, выкачивать
pick	параметрическое значение, выбранное на экране рабочей станции значение
transfer	передавать

capacity	способность
reliable	надежный, достоверный
effort	усилие, попытка
resolution	разрешение, разрешающая способность
deploy	размещать, устанавливать, развертывать
multiple	сложный, комплексный
swath	полоса обзора, широкий профиль; блок
paravane	отклонитель морской косы, устройство для удержания головки морской косы на заданной глубине
steer	направлять, вести
drag	торможение, задержка движения
global positioning system	система спутниковой навигации, глобальная система определения местоположения, координат
sensor	сенсорный датчик, прибор обнаружения
relative to	относительно
behave	вести себя
reveal	обнаруживать, показывать, выявлять
time-lapse seismic	периодические сейсмические наблюдения, сейсмомониторинг
install	устанавливать, помещать
advent	появление
Virtual Reality rooms	комната со средствами виртуальной реальности

46. Pay attention to the pronunciation of the following words and word-combinations.

[a:] target, slantwise
[ɔ:] fault, install, raw
[ɔ] contour, swath, warrant, trough
[ı:] reveal, sequence, peak
[ə:] cursor, overburden, transfer, virtual
[æ] drag, paravane, clarify, transfer, lapse
[ai] identify, clarify, digitize, slantwise, reliable, comprise
[ei] enable, drain, visualization, paravane, adjacent, behave
[ju] simulate, view, conspicuously, deduce
[Ө] synthetic, swath, thickness

47. Pay attention to the stress in the following words.

'slantwise
stra'tigraphy
con'spicuously
ad'jacent
e'xist
'warrant

'cursor
'transfer

'effort
'paravane
'virtual

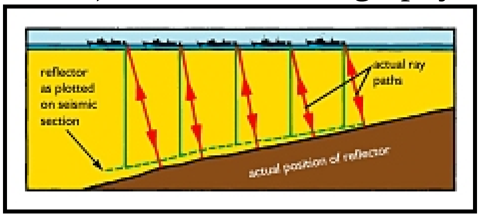
48. Read and give Russian equivalents of the given word-combinations.

To tow the streamer slantwise; divide into time-slices, depositional interrelationships of sedimentary rock; to deduce from an interpretation of seismic data; conspicuously stronger than adjacent portions; a noticeably flat reflection amongst arched reflections; to enter files into a gridding and contouring programs; to warrant wildcat drilling; to drain the reservoir with maximum efficiency; increases in computing capacity; survey vessels deploying multiple streamers; a swath of seismic data; paravanes steer the cables away from each other; the position of the streamers relative to the vessel; to reveal changes in pressure in different parts of the field.

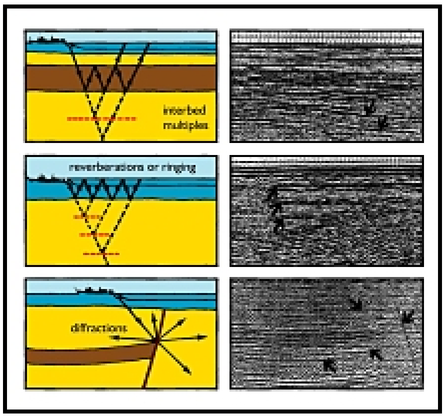
49. Read the text and do the exercises.

Interpretation

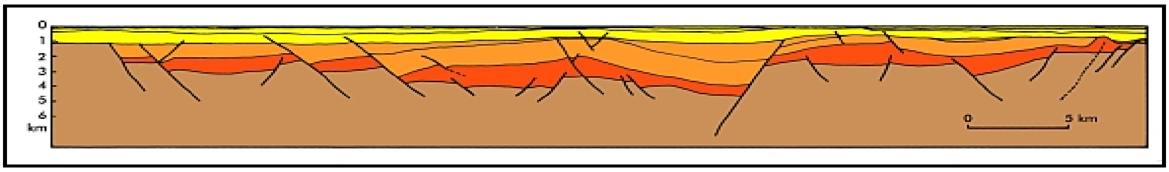
Seismic sections provide 2-dimensional **views** of underground structure. By using special shooting techniques such as spaced air gun arrays or towing the streamer **slantwise**, or by shooting very closely spaced lines, it is possible to produce 3-dimensional (3D) seismic images. These images comprise vertical sections and horizontal sections (**'time-slices'**). Seismic stratigraphy is the study of the depositional **interrelationships** of sedimentary rock as **deduced** from an interpretation of seismic data; it can be used in finding subtle sedimentary traps involving changes in porosity. 'Bright-spots', short lengths of a reflection that are **conspicuously** stronger than **adjacent** portions may indicate gas: the velocity of sound is sharply reduced in gas-bearing rock, producing a strongly



reflective contrast. A gas-water or gas-oil interface may stand out as a **noticeably** flat reflection amongst arched reflections.



The end-products of seismic surveys are interpreted sections showing geological structure down to fine sedimentary details. Maps are used to describe the topology of known rock units and **'isopach' maps** are showing the thickness of these units. For the maps, reflections are 'picked' and their depths at points along parallel and **intersecting** survey lines plotted and **contoured**.



Seismic sections that have been picked by hand are digitised and the digital files entered into a **gridding** and contouring program. **Contour maps** can be plotted or 3D colour and shade enhanced images can be generated to illustrate the subsurface structure. Some rock layers produce wiggles with a distinctive character that can be followed right across a section; others may be identified by comparison with synthetic 'seismograms' made from logging and velocity surveys in existing wells in which the rock sequence is known.
The seismic maps are used to identify structures that would either **repay** more detailed seismic surveying or would **warrant** wildcat drilling. The interpreter studies the maps to identify areas that are shallower and form a dome shape (an anticline) or a shallow area surrounded by faults (a horst block) - within such structures it is possible that migrating oil or gas may have been trapped.

Initially 3D seismic surveys were used over the relatively small areas of the oil and gasfields where a more detailed subsurface picture was needed to help to improve the position of production wells, and so **enable** the fields to be **drained** with maximum efficiency. In the early 1990's, when exploration in the North Sea shifted to smaller and more subtle traps, 3D seismic surveys became more widely used for exploration work. The vast amount of data generated by even a small 3D survey meant that computer workstations were an essential tool for interpreting the data quickly. With a computer an interpreter can map a specific reflector by moving the cursor along it on the screen or, when a reflector is strong and continuous, the computer can 'auto-pick' that horizon through the whole 3D data set. Digital files of reflector **picks** can be **transferred** directly from the interpreter's workstation to mapping software. Visualisation software is an additional tool that **allows** the interpreter to view the whole 3D data set as a cube and rotate or cut it at any angle, allowing a picture of the subsurface geometry to be quickly seen

(Discovering the Underground Structure http://www.ukooa.org/education/storyofoil/index.cfm)

50. Replace the underlined words or word-combinations with synonyms from the vocabulary.

1. 3-dimensional (3D) seismic images can be produced by towing the streamer in inclined position.
2. The successful solution of the problem was made from the interpretation of seismic data.
3. Dykes traverse the surrounding layers.
4. The maps which show the thickness of the rocks are result of seismic surveys.
5. Several receivers can be connected in arrays to enhance the signal and reduce the noise.
6. Due to modern techniques the oil fields are commonly worked out with maximum efficiency.
7. This certificate gives you right to work as an interpreter.
8. As a result of echo-sounding the arched formation was discovered at the depth of several kilometers.
9. The interconnection between the weather and human health has been the subject of many discussions for a long time.
10. A new software was set up and the efficiency of the operations increased severalfold.

51. Reconstruct the jumbled sentences.

1. different \the same area\ enabled \ at \improved resolution \and \ over\ shooting seismic \reduced acquisition time\ time intervals.
2. global\ modern\ that \streamers \positioning sensors\ constantly\ have \record\ multiple\ the position of the streamers\ system.
3. it can be\ beneath \economic\ hydrophones \ an array of\ the seafloor\ to permanently install.

4. reduces\ a powerful \ the paravane\ vessel\ which\ the drag of\ can be sufficient \the streamer array \to stop\.
5. in a short time\ these\ allow\ techniques\ a swath of\ to acquire\ seismic data.
6. reliable\ computing\ increased\ led to\ capacity\ the first\ images seismic.
7. into \a gridding \seismic \the digital\ sections\ and\ files \ are entered\ and contouring program\ are digitised.
8. will clarify \with\ how\ is behaving \changes \the dynamic\ time a field.

52. Match the parts of sentences.

1. Seismic stratigraphy is the study	**A** amongst arched reflections.
2. Short lengths of a reflection that are conspicuously stronger than adjacent portions may	**B** of the depositional interrelationships of sedimentary rock as deduced from an interpretation of seismic data.
3. 3-dimensional seismic images comprise	**C** indicate gas.
4. A gas-water or gas-oil interface may stand out as a noticeably flat reflection	**D** showing geological structure down to fine sedimentary details.
5. By using special shooting techniques such as spaced air gun arrays or towing the streamer slantwise, or by shooting very closely spaced lines,	**E** vertical sections and horizontal sections.
6. The end-products of seismic surveys are interpreted sections	**F** producing a strongly reflective contrast.
7. The velocity of sound is sharply reduced in gas-bearing rock,	**G** it is possible to produce 3-dimensional (3D) seismic images.
8. Maps are used to describe the topology of known rock units	**H** plotted and contoured.
9. For the maps, reflections are 'picked' and their depths at points along parallel and intersecting survey lines	**I** and 'isopach' maps are showing the thickness of these units.

53. Reconstruct the order of the sentences.

__ Initially 3D seismic surveys were used to help to improve the position of production wells, and so enable the fields to be drained with maximum efficiency. (A)
__ Exploration in the North Sea shifted to smaller and more subtle traps in the early 1990's and 3D seismic surveys were used for exploration work. (B)
__ Contour maps can be plotted or 3D colour enhanced images can be generated to illustrate the subsurface structure. (C)
__ Other layers may be identified by comparison with synthetic 'seismograms'. (D)
__ With a computer an interpreter can map a specific reflector by moving the cursor along it on the screen. (E)
__ Some rock layers produce wiggles with a distinctive character that can be followed right across a section. (F)
__ Visualisation software allows the interpreter to view the whole 3D data set as a cube and rotate or cut it at any angle. (G)
__ 3D survey meant that computer workstations were an essential tool for interpreting the data quickly. (H)
__ Seismic sections picked by hand are digitised and the digital files entered into a gridding and contouring program. (I)
__ The interpreter studies the maps to identify areas that are shallower and form an anticline or a shallow area surrounded by faults. (J)

54. Read the text and choose the correct variant.

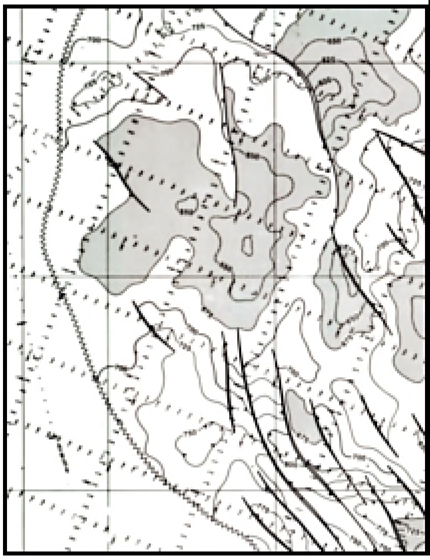
1. Advancement in resolution and data processing made it possible
   a) to detect many changes
   b) to do seismic survey systematically over the same area of the field
   c) for BP to develop the Foinaven field.
2. The so-called 4D or time-lapse seismic allow
   a) to astonish the observers.
   b) to reveal the fourth dimension
   c) to reveal the reservoir dynamics
3. The invention of 4D seismic led to the idea that
   a) shooting can be done with a seismic vessel once a year.
   b) it can be economic to bury cables just beneath the seafloor.
   c) it is useful to permanently install an array of hydrophones on some areas.

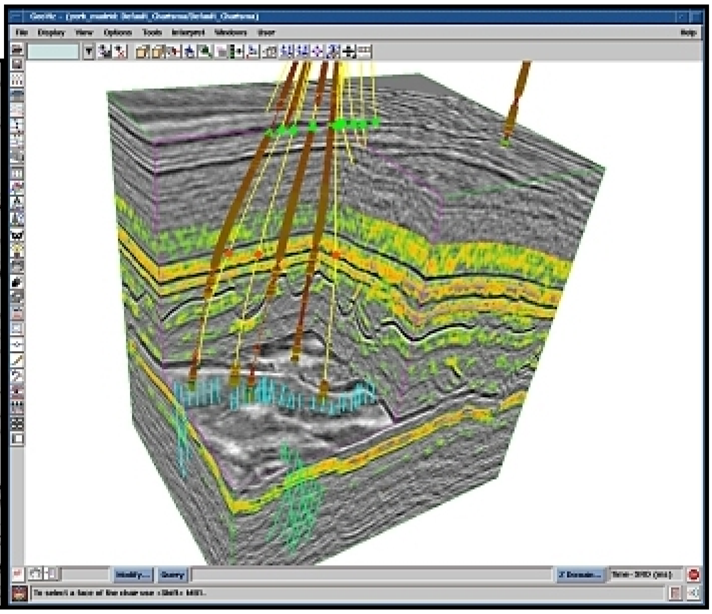
4. Virtual Reality rooms do not allow
   a) to decrease visualization capacity
   b) to display 3d images on a large screen
   c) to view the 3D images from any

5. Virtual Reality rooms
   a) can benefit any company
   b) can simulate the impact of various drilling targets.
   c) is incapable of enhancing communication and understanding when multi-discipline teams meet in such an environment.

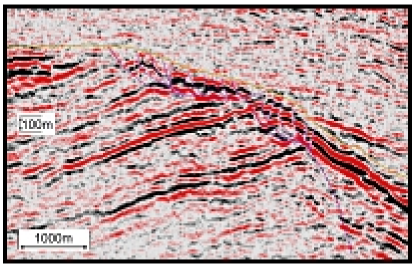
Latest developments

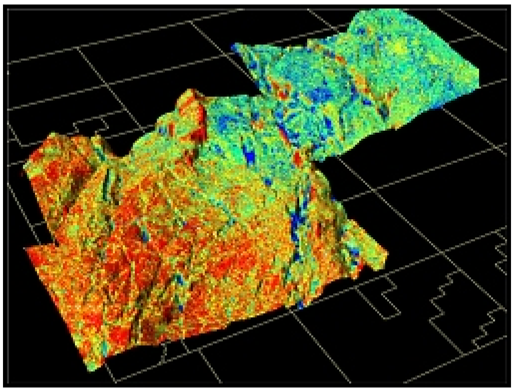
Recent increases in computing **capacity** have enabled the migration process to be applied before stack, i.e. on the vast amounts of data collected in the acquisition phase. This pre-stack depth migration (PSDM) application is critical in areas with complex geological subsurface structures, such as around/below salt domes and other high-velocity layers. This has led to the first **reliable** seismic images of sediments located below such complicated overburden structures.





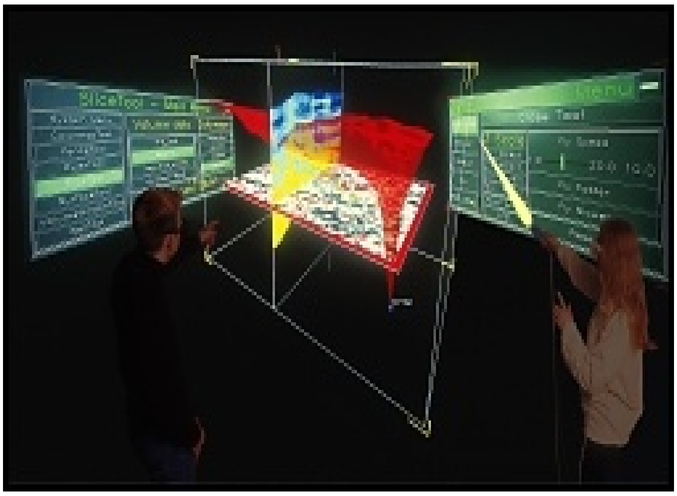
Because of the greatly improved seismic **resolution** of 3D seismic imaging, there has been an **effort** to reduce the cost of 3D data acquisition and shorten the time it takes to acquire and process the large volumes of data acquired. In the past it could take up to 24 months to process the recordings from a 3D survey. Acquisition time has been cut by specially designed survey vessels **deploying** up to ten **multiple** streamers at a time, or by using multiple vessels. These techniques allow a **swath** of seismic data to be acquired in the same time it previously took to record a single 2-dimensional line. Specially designed **paravanes steer** the cables away from each other. Their design reduces the **drag** of the streamer array, which ordinarily would be sufficient to stop even quite a powerful vessel. Modern streamers have multiple **global positioning system** (GPS) **sensors** that constantly record the position of the streamers **relative to** the vessel and the earth.



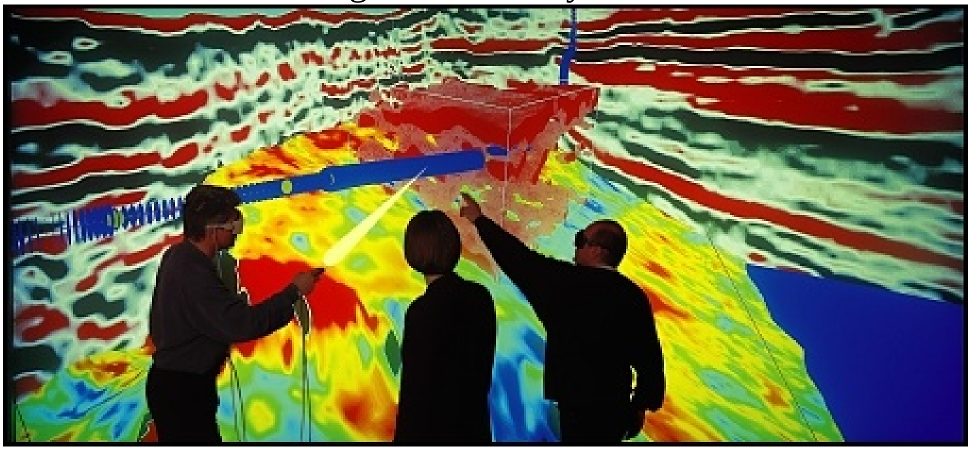


New techniques of data compression are being tried to allow the transmission of the raw seismic records from the acquisition vessel to the shore for immediate processing, in an effort to get the data to the interpreters faster.

Improved resolution and reduced acquisition/processing times have opened up the possibility of shooting seismic at different time intervals over the same area of a producing field, in order to detect changes. These changes with time will clarify how a field is **behaving** by revealing exactly where the fluids are or are not moving, or by **revealing** changes in pressure in different parts of the field, thereby indicating how production might be improved. This is the so-called 4D or **time-lapse seismic**, where time is essentially the "fourth dimension". Results in recent years have been quite astonishing.



If seismic is to be acquired at regular intervals over the same field, then it can be economic to permanently **install** an array of hydrophones on cables buried just beneath the seafloor. BP has done this in the Foinaven field, for example, with the aim of shooting over the array with a seismic vessel once a year.



Another recent development is that visualisation has been taken to a new level with the **advent** of Virtual Reality rooms, allowing 3D subsurface images to be displayed on large screens and to be viewed from almost any angle. Different development options, such as the impact of various drilling targets, can be simulated. Much of the benefit of this approach stems from the fact that communication and understanding are greatly enhanced when multi-discipline teams meet whilst "immersed" in such an environment.

(Discovering the Underground Structure
http://www.ukooa.org/education/storyofoil/index.cfm)

55. Fill in the gaps with the words derived from those at the end of each line.

1. A gas-water or gas-oil interface may be detected as a ……….. flat reflection amongst arched reflections.	NOTICE
2……… files of subsurface formation can be transferred directly from the interpreter's workstation to mapping software.	DIGITIZE
3. Multiple is a repeat propagation of energy within the … .	REFLECT
4. New techniques of data compression …….. the transmission of the raw seismic records from the …….. vessel to the shore for immediate processing.	ABLE ACQUIRE
5. I would not trust him because he is hardly a ………. person.	RELY
6. The cost of drilling on a large scale can be high …….. the cost of using geophysics.	RELATE
7. Map represents a …….. image of the subsurface structure.	DIMENSION

8. Virtual Reality rooms are recent development in the field of …………….. .	VISUALIZE
9. The …………. of the signal greatly depends on the atmospheric conditions.	TRANSMIT

56. Complete the sentences based on the information from the text.

1. Latest advancements in computing capacity allow to …………….. .
2. The greatly improved seismic resolution of 3D seismic imaging makes it possible to …………………………….. .
3. In the past the processing of the recordings from a 3D survey ………..
4. By using multiple seismic vessels we can record 3D seismic data ……………………………. .
5. Specially designed survey vessels deploying up to ten multiple streamers at a time …………………………… .
6. The design of paravanes reduces ………………………………… .
7. Modern streamers have multiple ………………………………………. .
8. New techniques of data compression help to ………………………….

57. Complete the table and describe the latest developments in seismic survey.

Developments	**Significance**
migration before stack	
multiple vessels	
…….	
…….	

58. Answer the questions.

1. What can you tell about 3D seismic images?
2. How can different types of maps help in identification of rock types?
3. Why are computer stations an essential tool for interpretation?
4. What are the results of an increase in computing capacity?
5. What technique made it possible to cut the acquisition time in 3D surveys?
6. What other developments are there in seismic survey?
7. What possibilities did improved resolution and reduced acquisition/processing times open for surveys?
8. What is 4D seismic survey?
9. What is the importance of 4D seismic survey? What does it allow to do?
10. What further advancement does 4D survey make possible?
11. What recent development is there in visualization?
12. What are the advantages of this innovation?

59. Discuss, give your ideas and explanations. Choose from the given selections.

***A* reflection seismology** — ***D* 3D seismic technology**
***B* refraction seismology** — ***E* 2D seismic technology**
***C* ground penetrating radar** — ***F* 4D seismic technology**
***G* full-vector wave-field imaging**

Which method would you apply in the following situations?

1. When you have to distinguish between shales and sands. ___
2. When you are to characterize and give the most accurate model of reservoir fluids. ___
3. If the angle of the formation dip is very low. ___
4. If you plan to detect a tiny object at the depth of up to 20 meters and a device should be extremely portable. ___
5. When we want to capture and follow reservoir dynamics. ___
6. When there is a necessity to determine thickness and subsurface geology as well as to carry out tectonic studies. ___
7. If you need to detect ground water table or to carry out archeological studies. ___
8. When we are concerned with the accurate hydrocarbon exploration. ___

60. Give your ideas.

1. S-waves can only go through solid material. The geologists detected that S-waves cannot get through the Earth's core. What does that suggest?
2. One famous scientist said "You say seismic, I say sequence". What did he mean?
3. "Wireless Internet will be seismic shift for radio" announced some advertisement. What does that mean?

Terms and Vocabulary

acquisition	регистрация
acceleration	ускорение
account for	вычислить
air wave	воздушная волна
offset	расстояние от места взрыва до сейсмоприемников
bounce (v)	отскакивать
coherent	связанный, сцепленный
displacement	смещение
enhance (v)	улучшить, усилить
explosive	взрывчатое вещество
field geometry	геометрия месторождения
frequency	частота
arrival	приход волны, начало сигнала на сейсмограмме
resolution	разрешающая способность
fold coverage	охват кратности перекрытия
geophone	сейсмоприемник
instrumentation	контрольно-измерительные приборы
intrabed	внутренний
linear array	линейная расстановка
near-surface	зона малых скоростей
noise pattern	рисунок шумов, помех
normal movement (NMO)	нормальное приращение (годографа отраженной волны)
positioning	расстановка
receiver	приемник
rotational motion	вращательное движение
sample	образец, проба
section	сечение, срез
multiple	кратный; многократно отраженная сейсмическая волна
reverse	изменять направление на обратное
respond to	отвечать на (воздействие); реагировать на ч.л.
rate	скорость, интенсивность, частота
shallow reflector	отражатель верхней части разреза
shot hole	шпур, взрывная скважина
shot interval	взрывной интервал (расстояние между точками взрыва)

surface wave=ground roll	поверхностная волна
survey configuration	форма съемки
taper	конус; труба с раструбом
trace	трасса
vibrator array	расстановка вибраторов, вибрационных сейсмических источников
weighted / tapered array	утяжеленная, конусообразная расстановка
alias	неоднозначность частотного состава колебания, восстанавливаемого по дискретным данным
aliasing	наложение зеркальных частот
alias filter	фильтр зеркальных частот
amplifier-filter-recorder	усилительно-фильтрующий регистрирующий прибор
alias frequency	побочная низкочастотная составляющая в спектре дискретного сигнала
attenuate (v)	ослаблять
be split (v)	быть разделенным
common depth point	общая глубинная точка
conversion	перевод, преобразование
discrimination	различение, разрешающая способность
end-on shooting	сейсморазведка групповым взрывом; профилирование с фланговой системой наблюдения
gain	увеличение, усиление
gather	выборка записей (компоновка)
input signal	входной сигнал
primary reflection	однократно отраженная волна
pulling the cable	фланговая система с выносом
pushing the cable	фланговая система (односторонняя)
random effect	случайный эффект
ray path	траектория луча
recover (v)	извлекать, получать
sample-and-hold aperture	база данных
signal-to noise ratio	соотношение сигнал-помеха
fold	кратность, указатель кратности
shooting pattern	профилирование

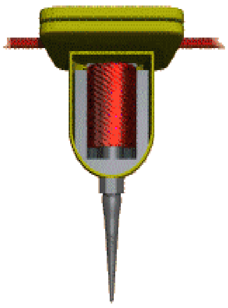
shooting configuration	геометрия системы наблюдений
spread	расстановка, база наблюдений
split spread	симметричная расстановка сейсмоприемников
stacking	наложение, суммирование
termination line	конечная линия
field amplitude	амплитуда поля
straddle shooting	фланговая система (по центру)

61. Pay attention to the pronunciation of the following words and word formations.

coherent	line-linear
bounce	impulse-impulsive
enhance	attenuate-attenuation
amplitude	compose-component
cover-coverage	discriminate-discrimination
pattern	accomplish-accomplishment
multiple	convert-conversion
alias	arrive-arrival
ratio	reflect-reflector
amplifier	derive-derivative
aperture	order-reorder
intrabed	move- movement-motion
weighted/ tapered array	amplify-amplitude-amplifier
straddle shooting	digitize-digital-digitizer
linear array	vary-various-variable-variety

62. Read the text, do the exercises.

Acquisition of Seismic Data



Geophone

Hydrophone

<u>Parameters of data acquisition</u>

Some parameters of a seismic **acquisition** program are:

- maximum **offset**: distance from the source to most remote receiver;
- minimum offset: distance from the source to nearest receiver;
- group interval: distance between **geophone** arrays. Constant for a survey;
- **shot intervals**: distance between holes;
- **fold coverage**: number of times a subsurface point is surveyed by different sources and detectors;
- sample interval: the time interval between digital samples of the signal, which varies from less than 1 to 4 ms. This **sample** rate is chosen not to limit the vertical **resolution** and to record the desired maximum **frequencies**;
- choice of source and geophone **arrays**;
- number of recording channels.

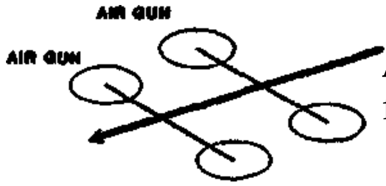
<u>Acquisition of parameters and noise</u>

Fig. 1 below is a schematic seismic **section** showing the major signal and noise features. It has been corrected for **normal movement (NMO)** which is the time correction applied to each **trace** to account for its offset. The first **arrivals** at the top of the record are labeled **P-waves**; these are typically refracted waves from **near-surface** formations. These are followed by two **coherent noise patterns**. The first one, characterized by low frequency and a **velocity** that varies from 3500 to 5500 ft\sec., is the **surface wave (ground roll).** The second one is the **air wave**, which is energy traveling from the source to the detectors through the air having a high-frequency component and low velocity of 1100 ft\sec. The third type of noise is the **multiple**, which is a repeat reflection from the same **interface**. It may be either a simple multiple from one of the **shallow reflectors** or an **intrabed** multiple bounced between two reflectors and back to the surface or one of several other types in which the reflected ray **reverses** direction at some point.

<u>Elements of a data acquisition system</u> are:

1. sources and arrays;
2. detectors and arrays;
3. instrumentation;
4. field geometry or **survey configuration;**
5. surveying, **positioning** and navigation.

Profile



AIR GUN
four-**gun array**

Vibroseis

Five-**vibrator array**

SHOT HOLE
Surface

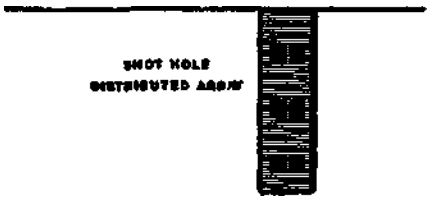


Fig. 1. Source arrays

There is a number of types of

1. Seismic sources used in exploration. They fall within one of the two principal categories:

1. impulsive (**explosives**);
2. distributed or diffuse in nature (vibrators).

2. Seismic detectors. A variety of receiver types are available for detecting seismic waves. On land we use geophones, which respond to either vertical **displacement** or **rotational motion**. Vertical – displacement geophones are commonly used in land seismic data acquisition. They measure the rate of change of displacement or velocity In fact, they can measure derivative of displacement which is **acceleration**.

Multiple **receivers** can be connected in arrays to **enhance** the signal and to reduce noise. Types of arrays used include:

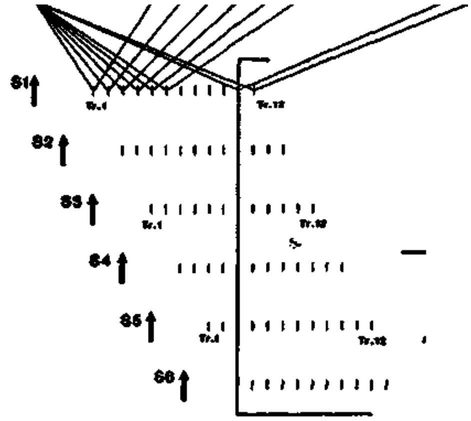
1. **linear array** – a line of single geophones;
2. **weighted\ tapered array** – a line in which the number of geophones at each position varies so that the outer elements have the smallest number of geophones (less weight) and the center element has the greatest number of geophones (most weight). The change in number of geophones from position to position is the **taper** of the array.

3. Instrumentation represents great advancement in the recording of seismic signals without loss of information and with the ability to recover **field amplitudes**.

– **<u>Amplifier – filter – recorder</u>**

– **Alias filter** (assure us that our digital sampling is properly accomplished and that high-frequency noise components do not masquerade as contributions of lower frequency by **aliasing**: is a property of sampling systems in which an **input signal** of one frequency can yield the same values as a signal of another frequency).
Alias filter frequency = 0.6 alias frequency
72 dB + amplitude
Discrimination from 0.6 FA – 1.0 FA
– **Digitizer** (converts the analog electrical signals from the geophones into discrete samples)
– **Gain** ranging and control
– **Sample-and-hold aperture** (in order to accomplish such **conversion**; it is necessary to hold a short portion of the analog signal for conversion to the digital equivalent)
4. Field geometry – common depth point (CDP) gather is a group of seismic traces that represent a single point on a flat reflector. A **common midpoint (CMP) gather** is a group of traces from a dipping reflector. The traces of a common depth point (common **midpoint)** gather are put together in one family. Each trace is from a different source and different receiver, but represents the same subsurface point. This reordering of the traces and **stacking** (summing them together) enhances the **signal-to-noise ratio** by **attenuating random effects** and undesired events, such multiple reflections whose variation with offset offers from that of the **primary reflections**.

SOURCE HI Я2 R3 R* Rn* RECEIVERS



12 End-on pattern channels used for simplicity
Fig. 2. Common depth point field geometry

The diagram (Fig. 2) illustrates the **ray path** geometry for six shots taken and twelve geophones in the line.

By progressively moving the sources and the receivers, traces are obtained for a given subsurface point. These traces use different sources and receivers. The number of traces obtained for a common depth point is called the **fold.** At surface location R4, you can observe that the common depth subsurface point does have six traces. This type of shooting pattern is called **end-on**. If the TRACE 1 is the closest to the source, the shooting configuration is called **pushing the cable**. If TRACE 1 is the farthest from the source it is called **pulling the cable**. Another type of shooting pattern is **split spread** or **straddle shooting**, in which the source is in the middle, the middle spread is symmetrically split and the two banks of the spread are the same length. A technique called shooting through the cable may be used to place depth points as close to the line termination as possible.

(Wikipedia. The free encyclopedia. http://www.wikipedia.org/)

62. Form nouns from the following verbs.
63.

survey	connect	accomplish
vary	characterize	discriminate
limit	travel	digitize
refract	navigate	control
displace	detect	shoot
accelerate	reduce	attenuate
receive	record	convert

64. Fill in the gaps with correct prepositions.

1. Seismic sources are used ____ exploration and fall _____ one of the two principal categories.
2. Minimum offset is the distance _____ source ____ the nearest receiver.
3. Sample interval is the time interval _____ digital samples ___ the signal, which varies ____ less than 1 ms ____ 4 ms.
4. Geophones respond ____ either vertical or rotational motion.
5. The number ___ geophones ___ each position varies.
6. Taper of the array is the change ___ number of geophones ____ position ___ position.

65. Make up sentences.

1. the distance/ the nearest/ receiver/ from/ minimum/ offset/ to/ is/ the source.
2. distances/ short/ intervals/ are/ between/ holes.
3. the/ same/ multiple/ a/ from/ repeat/ reflection/ is/ interface.
4. multiple/ between/ intrabed/ bounces/ two/ reflectors.
5. two/ there/ seismic/ sources/ are/ kinds/ of.
6. vertical/ displacement/ geophones/ to/ rotational/ motion/ and/ respond.
7. acceleration/ displacement/ is/ derivative/ of.
8. to/ enhance/ multiple/ receivers/ the/ signal/ are/ used/ reduce/ noise/ and/ to.

66. Match the terms with their definitions.

1. normal movement	A. number of traces obtained for a common depth point
2. fold coverage	B. noise pattern that has low velocity that varies from 3500 to 5500 ft/sec
3. surface wave	C. a line single geophones
4. air wave	D. property of sampling systems in which an input signal of one frequency can yield the same values as a signal of another frequency
5. multiple	E. energy traveling from the source to the detectors through the air having a high-frequency component and low velocity of 1100 ft/sec
6. linear array	F. tapered array
7. weighted array	G. number of times a subsurface point is surveyed by different sources and detectors
8. aliasing	H. a repeat reflection from the same interface
9. digitizer	I. time correction applied to each trace account for its offset
10. fond	J. device that converts the analog signals from the geophones into discrete samples

67. Give definitions to the following terms.

P-wave	aliasing
air wave	CDP

68. Answer the following questions.

1. Which parameters of data acquisition are connected with distance?
2. Which parameters of data acquisition are connected with time?
3. What is normal movement?
4. What is velocity of surface wave?
5. Which of the waves has higher velocity: surface or air?
6. What three types of noise do you know?
7. What are the two kinds of multiples?
8. There are two types of seismic sources. What are they?
9. What are the functions of geophones?
10. What is the main function of multiple receivers?
11. What is the difference between linear and tapered array?
12. What is the main advantage of instrumentation?
13. What types of instrumentation do you know?
14. What is aliasing?
15. What is the difference between CDP and CMP?
16. What are the positive effects of reordering of the traces and summing them together?
17. What is end-on?
18. Which shooting configuration is called “pushing the cable” – the closest to the source or the farthest from it?
19. Which type of shooting is between pulling and pushing?
20. Which shooting technique allows to place depth points closer to the line termination?

WORDLIST

ENGLISH	RUSSIAN
acceleration	ускорение
account for (v)	вычислить
acquisition	регистрация
acquisition project	проект регистрации данных
advancement	продвижение, усовершенствование
air gun	пневмопушка
air wave	воздушная волна
alias (filter)	неоднозначность частотного состава колебания, восстанавливаемого по дискретным данным
aliasing	появление зеркальных частот
amplifer-filter-recorder	амплитуда-фильтр
application	применение, использование
array	расстановка (сейсмоприемников)
arrival	приход волны, начало сигнала на сейсмограмме
attenuate	ослаблять
be split (v)	быть разделенным
bounce (v)	отскакивать
boundary	граница
capability	мощность, производительность, возможность
capture (v)	записать, зафиксировать, отражать
coherent	связанный, сцепленный
common depth point	общая глубинная точка
compressional wave	волна сжатия
continuity	непрерывность
conversion	перевод
data set	набор данных
development	разработка
discrete	дискретный сигнал, обособленный элемент
discrimination	различение/разрешающая способность
displacement	смещение
echolocation	эхолокация
end-on shooting	сейсморазведка групповым взрывом
enhanced oil-recovery	добыча нефти с искусственным поддержанием энергии пласта/

	улучшенная нефтедобыча
engineering survey	инженерная съемка
enhance (v)	улучшать
environmental survey	съемка окружающей среды
explosive	взрывчатое вещество
exponentially	в геометрической прогрессии
field amplitude	амплитуда поля
field geometry	геометрия месторождения
fold coverage	охват кратности перекрытия
frequency	частота
frequency output	выходная частота
full-vector wave-field imaging	полновекторное изображение волнового поля
gain	увеличение
gas chimney	скопления мелкозалегающего газа
gather	выборка записей (компоновка)
geophone	сейсмоприемник
geothermal energy	геотермальная энергия
ground-penetrating radar	георадар
gun array	расстановка пушек
impedance	импеданс, полное сопротивление
incidence	охват, сфера действия
input signal	входной сигнал
insensitive	нечувствительный
instrumentation	контрольно-измерительные приборы
intrabed	внутри
linear array	линейная расстановка
mapping	картирование
mean	средняя величина
measure (v)	измерять
medium, media	среда, -ы
multiple	многократная волна; кратное отражение
near-surface	зона малых скоростей
noise pattern	рисунок шумов
normal movement (NMO)	нормальное приращение (годографа отраженной волны)
offset	дистанция (расстояние от пункта взрыва до центра ближайшей группы сейсмоприемников)
plaque	испещрять часто встречаться

plotting	нанесение на график, планирование
positioning	расстановка
primary reflection	однократно отраженная волна
processing data	обработка данных
production	добыча
pulling the cable	фланговая система с выносом
pushing the cable	фланговая система (односторонняя)
P-wave	продольная волна
random effect	случайный эффект
ray path	траектория луча
reduce uncertainties	сокращать неточности
reflection	отражение
reflection profile	профиль метода отраженных волн
reflection seismology	сейсморазведка методом отраженных волн
refraction	преломление
rotational motion	вращательное движение
sample	образец, проба
sample-and-hold aperture	база данных
section	сечение, срез
shallow	неглубокий
shallow reflector	отражатель верхней части разреза
shear wave	сдвиговая волна
shot hole	шпур, взрывная скважина
shot interval	взрывной интервал (расстояние между точками взрыва)
signal-to-noise ratio	соотношение сигнал-помеха
sonar	сонар, гидролокатор
source array	группа источников
split spread	симметричная расстановка сейсмоприемников
spread correction	поправка на нормальное приращение времени
stacking	наложение, суммирование
storage medium	носитель информации, запоминающая среда
straddle shooting	фланговая система (по центру)
surface wave=ground roll	поверхностная волна
survey configuration	форма съемки
taper	конус, труба с раструбом

termination line	конечная линия
timing	измерение времени
trace	трасса
tuned air gun array	ряд настроенных пневмопушек
variable	переменная величина
velocity	скорость
vibrator array	расстановка вибраторов / вибрационных сейсмических источников
weighted / tapered array	утяжеленная, конусообразная расстановка
3D-seismic technology	трехмерная сейсмическая технология

APPENDIX. Use the table to tell about the four major geophysical methods used in oil exploration.

SUMMARY OF THE FOUR MAJOR GEOPHYSICAL METHODS

Method				Field	Geologic Application	Action and Control
I. Gravitational		A. Torsion balance		Oil	Anticlinal structures; buried ridges; salt domes; faults; intrusions	Spontaneous Action No depth Control
		B. Pendulum C. Gravimeter			Salt domes; buried ridges; major structural trends	
II. Magnetic				Oil, mining	Anticlinal structures; buried ridges; intrusions; faults; iron ore, pyrhotite, and associated iron ores; gold placers	
III. Electrical	A. Self-potential			Mining	Sulfide ore bodies	
	B. *Galvanic* application of primary energy	1. Potential distribution of secondary field measured	(a) Equipotential, potential profile (b) Resistivity (c) Potential-drop ratio	Mining, civil engineering, oil	General stratigraphic and structural conditions; bedrock depth on dam sites; ground water; oil structures; sulfide ore bodies; highway problems; electrical logging	Reaction to Energizing Fields Control of Depth Penetration
		2. Electromagnetic field measured		Mining	Sulfide ore bodies	
	C. *Inductive* application of primary energy			Oil, mining	Faults; anticlinal, etc., structure; sulfide ore bodies	
IV. Seismic		A. Refraction		Oil, civil engineering	Salt domes; anticlinal etc., structures; faults; foundation & highway problems	
		B. Reflection		Oil	Low-dip structures; buried ridges; faults	

(C.A. Heiland. Geophysical Exploration. NY, 1940)

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Chapter 2

OIL EXPLORATION

T. F. Dolgaya

UNIT 1

OIL EXPLORATION

Oil exploration is the search by petroleum geologists for hydrocarbon deposits beneath the Earth's surface. Oil and gas explorations are grouped under the science of petroleum geology.

Lead-in

What is the name of the activity that deals with the search for hydrocarbon deposits?
What does most of this activity depend on?

LISTING – When listing, write everything that comes to your mind. Write down as many words as you can on the topic ***"Oil Exploration".***

Terms and Vocabulary

oil seep	выход нефти
pockmark	Оспина
hydrocarbon generation	образование углеводородов
deposit	Месторождение
gravity survey	гравиметрическое исследование\работа
magnetic survey	магнитная съёмка, магнитная разведка
scale features	особенности рельефа на карте
subsurface geology	подземная геология
seismic survey	Сейсморазведка
reflected sound wave	отражённая звуковая волна
process of depth conversion	процесс глубинного преобразования
substructure profile	разрез (профиль) пласта
identify (v)	определять, идентифицировать
evaluate (v)	оценивать, рассчитать
determine (v)	измерять, определять
buoyancy	плавучесть
buoyant	лёгкий, плавучий, держащийся на поверхности

caprock	кепрок (вышезалегающая экранирующая порода)
seal (v) – sealed – a seal	придавать непроницаемость – изолированный – изолирующий слой
lead (n)	возможная ловушка углеводородов
matured hydrocarbons	зрелые углеводороды
source rock	нефтематеринская порода
expel (v)	вытеснять
prospect	поиск, разведка, изыскание, перспективный участок
chance of success	перспектива
hydrocarbons in place	углеводороды в пласте
recoverable hydrocarbons	промышленные запасы углеводородов
volumetric equation	уравнение объёма
saturation	насыщенность
shrink (v)	сжиматься
expand (v)	расширяться, увеличиваться в объёме
ratio	соотношение, коэффициент
GRV (gross rock volume)	суммарный объём породы
FVF (formation volume factor)	объёмный коэффициент пласта
burial	захоронение
reservoir	пласт-коллектор; пластовый резервуар (нефти, газа); нефтеносный слой; газоносный пласт; продуктивный пласт; залежь; месторождение (нефти, газа)
precursor	предшественник

1. Pay attention to the pronunciation of the following words. Pay special attention to the letters in bold.

s**ur**vey profi**l**e **i**dentif**y** b**uoy**ancy pro**c**ess substruc**ture** s**our**ce h**y**drocarbons feat**ure** eq**ua**tion ra**tio** de**ter**mine

2. Read the text "Exploration methods" and do the exercises.

Exploration Methods

Visible surface features such as **oil seeps,** natural **gas seeps, pockmarks** (underwater craters caused by escaping gas) provide basic evidence of **hydrocarbon generation** (be it shallow or deep in the Earth). However, most exploration depends on highly sophisticated technology to detect and determine the extent of these **deposits.**

Areas thought to contain hydrocarbons are initially subjected to a **gravity survey** or **magnetic survey** to detect large **scale features** of the **subsurface geology**. Features of interest (known as **leads**) are subjected to more detailed **seismic surveys** which work on the principle of the time it takes for **reflected sound waves** to travel through matter (rock) of varying densities and using the **process of depth conversion** to create a **profile** of the **substructure**. Finally, when a prospect has been **identified** and **evaluated** and passes the oil company's selection criteria, an exploration well is drilled in an attempt to conclusively **determine** the presence or absence of oil or gas.

Oil exploration is an expensive, high-risk operation. Offshore or remote exploration area is generally only undertaken by very large corporations or national governments. Typical Shallow shelf oil wells (e.g. North sea) cost $10–30 Million, while deep water wells can cost up to $100 Million plus. Hundreds of smaller companies search for onshore hydrocarbon deposits worldwide, with some wells costing as little as $500,000 USD.

Elements of a petroleum prospect

A **prospect** is a potential trap which geologists believe may contain hydrocarbons. Five elements have to be present for a prospect to work and if any of them fail, neither oil nor gas will be present.

- **A source rock**. When organic-rich rock such as oil shale or coal is subjected to high pressure and temperature over an extended period of time, hydrocarbons form.
- **Migration**. The Hydrocarbons are **expelled** from **source rock** by three density-related mechanisms: the newly-**matured** hydrocarbons are less dense than their **precursors**, which cause overpressure; the hydrocarbons are lighter medium, and so migrate upwards due to **buoyancy,** and the fluids **expand** as further **burial** causes increased heating. Most hydrocarbons migrate to the surface as oil seeps, but some will get trapped.
- **Trap**. The hydrocarbons are **buoyant** and have to be trapped within a structural (e.g. anticline, fault block) or stratigraphic trap.
- **Seal or cap Rock**. The hydrocarbon trap has to be covered by an impermeable rock known as a **seal or cap-rock** in order to prevent hydrocarbons escaping to the surface.
- **Reservoir**. The hydrocarbons are contained in a reservoir rock. This is a porous sandstone or limestone. The oil collects in the pores within

the rock. The reservoir must also be permeable so that the hydrocarbons will flow to surface during production.

Terms used in petroleum evaluation

- ***Lead*** – a structure which may contain hydrocarbons.
- ***Prospect*** – a lead which has been fully evaluated and is ready to drill.
- ***Chance of Success*** – an estimate of the chance of all the elements (see above) within a prospect working, described as a probability. High risk prospects have a less than 10 % chance of working, medium risk prospects 10–20 %, low risk prospects over 20 %. Typically about 40 % of wells recently drilled find commercial hydrocarbons.
- ***Hydrocarbons in Place*** – amount of hydrocarbons likely to be contained in the prospect. This is calculated using the **volumetric equation** – GRV x N/G x Porosity x Sh x FVF:
  - GRV – **gross rock volume** – amount of rock in the trap above the hydrocarbon water contact;
  - N/G – net/gross **ratio** – percentage of the GRV formed by the reservoir rock (range is 0 to 1);
  - Porosity – percentage of the net reservoir rock occupied by pores (typically 5–35 %);
  - Sh – hydrocarbon **saturation** – some of the pore space is filled with water – this must be discounted;
  - FVF – **formation volume factor** – oil **shrinks** and gas **expands** when brought to the surface. The FVF converts volumes at reservoir conditions (high pressure and high temperature) to storage and sale conditions.
- ***Recoverable hydrocarbons*** – amount of hydrocarbons likely to be recovered during production. This is typically 10–50 % in an oil field and 50–80 % in a gas field.

(http://www.wikipedia.org)

3. Give definitions to the following terms. Learn them.

seep, mature oil, prospect, recoverable oil, lead, migration,
source rock, trap, hydrocarbons in place, seal, reservoir

4. Translate the following Russian sentences into English.

1. Природные проявления нефти и газа указывают на образование углеводородов.

2. Сложная технология помогает обнаружить нефтяные и газовые месторождения и их протяжённость.

3. Первоначально районы возможного содержания углеводородов подвергаются гравиразведке и магнитной разведке.

4. Возможные ловушки подвергаются сейсморазведке, которая создаёт профиль подземной структуры.

5. Разведка нефти и газа – процесс, связанный с большим риском.

6. Чтобы перспективная площадь была результативной, нужны следующие характеристики: материнская порода, миграция, ловушка, покрышка, коллектор.

7. Скважины, имеющие промышленное значение, составляют 40 % от всех недавно пробуренных скважин.

5. Answer the following questions.

1. What is the name of the activity that deals with the search for hydrocarbon deposits?
2. What is “petroleum geology’’?
3. Are there visible features that provide evidence of hydrocarbon generation?
4. Why do we need highly sophisticated technology in oil and gas exploration?
5. What exploration methods can you name?
6. Is the seismic survey different from the other two?
7. When is oil exploration well drilled? What for?
8. Can you prove that oil exploration is a high–risk operation?
9. What do smaller companies search for?
10. When does a prospect work?
11. What elements should be present for the prospect to work?
12. When are hydrocarbons formed?
13. Why are hydrocarbons expelled from the source rock?
14. Could you name 3 density related mechanisms?
15. Why do hydrocarbons migrate upwards?
16. Are all hydrocarbons get trapped?
17. Where are they trapped?
18. Why do hydrocarbons keep staying in traps?
19. Characterize a reservoir rock.
20. What becomes of oil and gas when they are brought to the surface?

Terms and Vocabulary

entrapment	улавливание, захват
interpret	расшифровывать
gravity meter	гравиметр
magnetometer	магнитометр
core samples	образцы керна
sniffer	газоанализатор
seismology	сейсмология
reflect back	отражать
density	плотность
hydrophone	гидрофон
seismometer	сейсмограф
obtain (v)	добывать; приобретать
terrain	местность; территория, район
measure (v)	измерять, мерить; отмерять, отсчитывать
indicate (v)	показывать, указывать
detect (v)	замечать, открывать; обнаруживать

6. Pronounce the following terms. Pay attention to the letters in bold.

int**er**pret magnetom**e**ter s**ei**smology h**y**drophone s**ei**smometer

7. Scan the text "Finding Oil" and answer the after-text questions.

Finding Oil

The task of finding oil is assigned to geologists, whether employed directly by an oil company or under a contract from a private firm. Their task is to find the right conditions for an oil trap – the right source rock, reservoir rock and **entrapment.** Many years ago, geologists **interpreted** surface features, surface rock and soil types, and, perhaps some small **core samples obtained** by shallow drilling. Modern oil geologists also examine surface rocks and **terrain**, with the additional help of satellite images.

However, they also use a variety of methods to find oil. They can use sensitive **gravity meters to measure** tiny changes in the Earth's gravitational field that could **indicate** flowing oil, as well as sensitive **magnetometers** to measure tiny changes in the Earth's magnetic field caused by flowing oil. They can **detect** the smell of hydrocarbons using sensitive electronic noses called **sniffers**. Finally, and most commonly, they use **seismology**, creating shock waves that pass through hidden rock layers and interpreting the waves that are **reflected back** to the surface.

The shock waves travel beneath the surface of the Earth and are reflected back by the various rock layers. The reflections travel at different speeds depending upon the type or density of rock layers through which they must pass. The reflections of the shock waves are detected by sensitive microphones or vibration detectors – **hydrophones** over water, **seismometers** over land. The readings are interpreted by seismologists for signs of oil and gas traps.

(David Lambert "The Field Guide to Geology", Cambridge University Press, 1998)

8. Find the answers to the following questions.

1. What specialists usually find oil?
2. What is their task?
3. What did shallow drilling help the specialists to do?
4. How do modern specialists examine surface rocks?
5. Are there new methods to find oil?
6. What do geologists use them for?
7. What does seismology deal with?
8. What is the aim of shock waves?
9. Do reflections travel at different speeds?
10. What are reflections detected by?
11. Are readings important?

Terms and Vocabulary

drill (v)	бурить
rock sample	образец породы
core	керн
survey (v)	производить съёмку или изыскание
property	свойство, характеристика
seismic survey	сейсморазведка
thickness	мощность
environment	окружающая среда
drill bit	буровая коронка, долото
string of pipes	колонна труб

lubricate (v)	смазывать
mud	буровой раствор
gusher	фонтанирующая скважина
Christmas tree	фонтанная арматура (ёлка)
well head	устье скважины
S-wave	поперечная волна
wildcat well	скважина, заложенная без предварительного геолого-геофизического обоснования
cut down (v)	сокращать, урезать
encounter (v)	наталкиваться; столкнуться
suspended from (v)	висящий, подвешенный

9. Pay attention to the pronunciation of the following words.

lubricate search surface structure microscope chemical geophysicist survey environment fluid

10. Read the text "How to Find Oil" and do the exercises.

How to Find Oil

Photographs from aircraft and satellites are used to begin the onshore search for oil and gas which is underground. This **cuts down** the time spent searching on the surface. The photographs are studied very carefully for the structures where oil might be found. If an area shows promise, then teams are sent to find out more about the rocks.

Geologists and geophysicists work closely together using a variety of methods. All the information is carefully considered, with the help of computer analysis, before any decisions to **drill** are made. A geologist collects small **samples of rock**. Sometimes the samples of rock are dug out by hand or cylindrical **cores** are drilled to give samples which can be cut and studied under a microscope. These help them to find out where the rocks have come from, what they are made of and how the rocks are arranged in strata.

Geologists also find out about the physical and chemical **properties** of the rocks and the fossil record from ancient times. All these clues give information to build up a picture of the area being surveyed. A geophysicist adds to the information of a geologist by studying the physics of the Earth.

Surveys are made of the magnetic field, the gravity and how waves travel through the layers.

Magnetometers measure very small changes in the strength of the Earth's magnetic field. Sedimentary rocks are nearly non-magnetic and igneous rocks have a stronger magnetic effect. Because of these different effects on the magnetic field, measurements can be made to work out the **thickness** of the sedimentary layers which may contain oil.

Gravitometers measure the strength of the Earth's gravitational pull. This is not the same all over the Earth because of the different densities of the rocks. Igneous rocks like granite are denser than sedimentary rocks. Granite near the surface will have a stronger pull than the same lump deeper down, so measurements help to build up more information about the layers of rock.

Shock waves or seismic waves are used to help give a picture of deep rock structures. The idea is to make artificial shock waves and record how they travel through the Earth. The **shock wave** travels through the water and strikes the sea bed. Some of the energy of the wave is reflected back to the hydrophones. The rest of the wave carries on until it reaches another rock layer.

The time taken for the waves to travel from the source to the hydrophones is used to calculate the distance traveled – hence the thickness of the rock layers. The amplitude of the wave gives information about the density of the reflecting rock. A survey using artificial shock waves is called a **seismic survey**. The data from a survey is recorded and displayed by computer as a pattern of lines, called a seismograph.

Sometimes, surveys show that a structure is present which may contain oil and gas. If so, an exploratory well or **wildcat well** is drilled. Very few exploration wells find oil. Even in areas like the North Sea, where we know a great deal about the geology, only one in every eight wells which are drilled will find oil or gas in quantities worth developing.

Drilling is a very expensive activity, with each well on average costing several million dollars. Even with today's technology, there is still a low probability that oil or gas will be found. Most oil wells are between 900 and 5,000 metres deep, but it is now possible to drill 8 km below the surface, an achievement made possible by skilled operators using powerful equipment and advanced technology. However, the costs of drilling can double or treble when in very deep water, hostile **environments** and when high pressure or temperature is **encountered**.

The rock is drilled with a rotating **drill bit,** similar to those that are used to drill a hole in wood. The drill bit is attached to a **string of** steel **pipes**, each approximately 9 metres long. The derrick, the structure that stands above the hole, must be strong, as the drill pipe and bit are **suspended from** it. Only a small proportion of the total weight of the drilling string is allowed to bear on the drill bit. This proportion will vary depending on the rock formation being drilled. The derrick must also be tall enough to enable the individual lengths of drill pipe to be added to or removed from the string.

The drilling process is **lubricate**d and cooled by a carefully constituted mud. This passes down inside the pipes to the drill bit and then returns to the top of the hole between the pipe and the sides of the hole, bearing rock debris with it. This provides the geologists with rock samples to indicate the kind of rock the drill is passing through.
The weight of the mud also prevents the escape of oil or gas if it is found. Usually the gas or oil is under pressure in the ground. To stop wasteful and dangerous **gushers**, a set of valves called a **Christmas tree** is fitted to the **well head** to control the flow of fluids from the well.

(*Material is supplied by the Institute of Petroleum)*

11. Form adjectives and nouns from the following verbs.

search lubricate measure drill flow waste trap migrate explore saturate

12. Give Russian equivalents to the following terms.

onshore search	to give a picture of deep rock structures
show promise	the time taken for the waves to travel
teams	to calculate the distance traveled
fossil record	the reflecting rock
the rocks are arranged in strata	oil and gas in quantities worth developing
the area being surveyed	a low probability
to work out the thickness	advanced technology
gravitational pull	hostile environments
to build up more information	rock formation being drilled

13. Give English equivalents to the Russian terms.

Аэрофотосъёмка и съёмка со спутников; возможное залегание нефти; перспективная территория; работать в тесном взаимодействии; решение о бурении скважины; небольшие образцы горных пород; состав пород; ранние геологические эпохи; нефтенасыщенные осадочные породы; толщина пластов горных пород; совокупность линий; поисковая или поисково – разведочная скважина; количества, достаточные для промышленной разработки; современные методы исследования; глубокое подводное бурение; неблагоприятная среда; система стальных труб; буровая вышка; буровая колонна и долото; буровой раствор; затрубное пространство; обломки; предотвратить утечку нефти; фонтанирование скважин; фонтанная арматура; устье скважины.

14. Answer the following questions and give more \ extra information.

1. What equipment is used in searching onshore oil and gas?
2. What methods are used to search for oil and gas?
3. Do specialists work closely together?
4. What is a seismic survey?
5. Do surveys show any necessary data?
6. Can you prove that drilling is a very expensive activity?
7. Could you name drilling equipment?
8. How can you stop wasteful and dangerous gushers?
9. What is a carefully constituted mud for?
10. Why must the derrick be strong enough?

Terms and Vocabulary

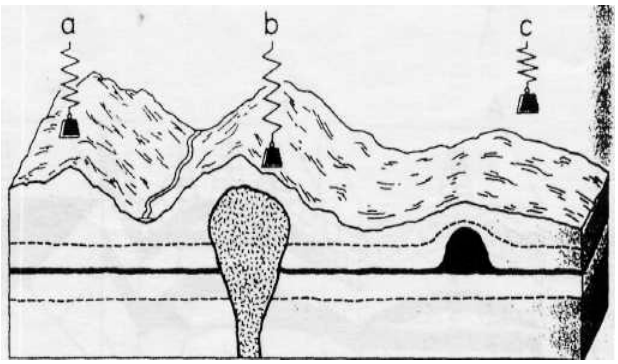
readings	данные, показания
exploration	детальная разведка
relay the data	передавать данные
weight	грузик
variations	колебания
battery of tests	серия тестов
survey	исследование
drill sample cores	бурить для получения кернов
yield	давать; выдавать; производить
country rock	вмещающая порода
topsoil	верхний слой почвы

background	фоновое
track down	разыскивать; исследовать до конца
gangue mineral	минеральная примесь
counter	счётчик излучения
underlying rock	подстилающая порода
bounce (v)	отскакивать

15. Read the text "Geological Prospecting" and do the exercises.

Geological Prospecting

To track down useful minerals or other substances below the ground the geologist gathers all information already known about the area to be explored. Next, he or she maps this geologically, noting surface clues like faults and gangue minerals including quartz. Then the geologist can bring to bear any of a battery of tests. Geochemical tests analyze rock and other samples for trace elements that may lead the geologist to a major ore body. Geophysical tests include the following. Geiger counters or scintillation counters detect radioactive substances such as uranium. Gravimeters reveal variations in the density and identify the composition of underlying rocks.

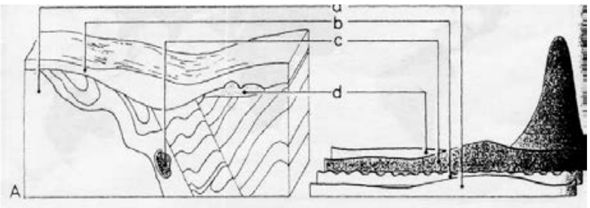


Gravimetric readings

A weight hangs from a coiled spring whose length varies with the force of gravity exerted by the rocks beneath.

a. Normal reading.
b. High reading from dense igneous rock near the surface.
c. Low reading from low density salt dome.

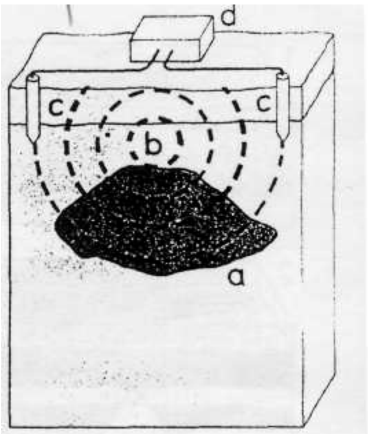
Magnetometers indicate buried iron ores. Because iron is often found with sulfides, magnetometers may lead indirectly to non-ferrous metals, too.



Magnetometer readings (below)
Different rocks (A) produce local variations in Earth's magnetic field and so yield different readings (B) from a magnetometer.

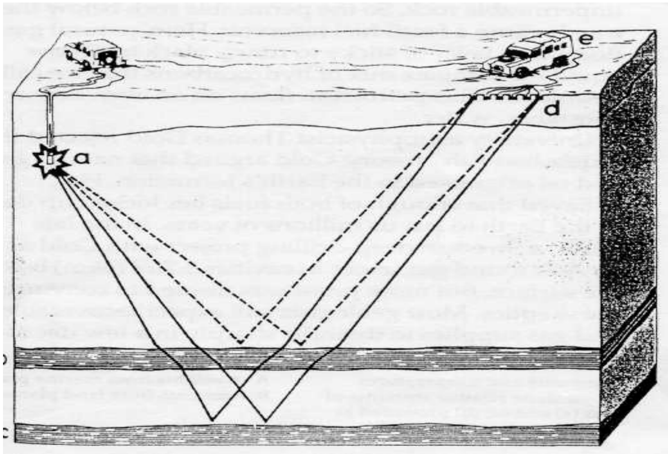
a. Country rock producing regional magnetism
b. Topsoil producing background magnetism
c. Deeply buried ores
d. Ores just below the surface

Electrical surveys show certain ores affecting natural ground currents related to the Earth's magnetic field.



Electrical survey
An ore deposit
(a) affects
natural ground currents.
(b)flowing between
buried electrodes.
(c)millivoltmeter.
(d)registers voltages
at the electrodes

Seismic surveys test for various deposits, including oil, gas, and coal. Seismic surveying involves setting off explosions or vibrations that send shock waves down into the ground and timing their return from surfaces that bend or bounce them back. The speed of their return indicates the depth and nature of the rocks below.



Seismic survey
Dynamite exploded underground.
produces shock waves (a).
bent and bounced back by rock layers (b,c).
at different depths to surface pickups (d).
These relay the data to a recording truck (e).

All these prospecting methods merely hint at what lies underground. Only exploration can prove an ore is actually there and rich and big enough to be worth mining. If prospecting gives encouraging results, exploration follows. This means drilling sample cores or digging trial trenches to find out if development would pay.

(David Lambert "The Field Guide to Geology", Cambridge University Press, 1998)

16. Find the answers to the following questions.

1. What are the stages for a geologist to find useful minerals or other minerals?
2. How can geochemical tests help geologists?
3. What equipment do geophysical tests include?
4. Is there any difference between electrical surveys and seismic ones?
5. Can geological prospecting alone prove there should be oil and gas?

17. Draw a diagram of geological prospecting and describe it.

18. Situational game.

Two groups – TPU students and TSU ones. The major is "Oil Exploration". Discuss methods, elements of petroleum prospect, equipment, stages and tests of geological prospecting to have the opportunity to intern in one of the international companies.

Use the following communicative formulae:

On the one hand……on the other hand
All in all……….

Summing it up………..
In short………
Perhaps (may be \ possibly)…
It seems so…
To some extend (degree)…
First of all…\ to begin with…
As a matter of fact…
I'm inclined to think…

Agreement	Disagreement
I (fully) agree.	I'm against it (object to).
I am of the same opinion.	You are wrong (mistaken).
In a way, yes.	There's something in what you say, but…
I suppose (expect \ believe) so.	On the contrary.
I won't deny.	I disagree with you (on that point).

Exercise 19. Listen to the video lecture "Crude Oil".

Before watching
a) Read and learn the following:

Terms and Vocabulary

molecule	молекула	a hot water bath	водяная баня
hydrogen	водород	vaporize,v	испарять(ся)
carbon	углерод	vapor,n	пар
separating	сепарация	a naked flame	открытое пламя
distillation	перегонка	flammable,adj	огнеопасный; легковоспламеняющийся
a fume cupboard	вытяжной шкаф, лабораторная тяга	condense,v	конденсировать(ся); сгущать(ся); сжижать(ся)
spit, v	разбрызгивать, шипеть	drip down	стекать
side arm	боковой отвод	a bung stem	пробка
fractional distillation	фракционная (дробная) перегонка	fractionating column	фракционирующая ректификационная колонна

a conical flask	коническая колба	fractional distillation columns	ректификационная колонна перегонки
a glass spiral	стеклянный змеевик	Celsius	термометр Цельсия; шкала термометра Цельсия
a colorless liquid	бесцветная жидкость		

While watching

b) Fill in the gaps with the terms you hear.

The hydrocarbons with low boiling points begin **---- ----** immediately. They are **---- .** So, it is safely not to heat with **---- ---- ----** . As the **----** rises, it is in the side arm where it cools and **----** . This happens at about 40 degrees Celsius. The hydrocarbons, which boil at this temperature, **---- ----** the side arm and form the first fraction. It is **---- ---- ----** . The temperature stays at around 40 until all the hydrocarbons with this boiling point are vaporized.

c) State whether the following statements are T (True) or F (False). Correct the false ones.

1. Crude oil molecules are made of oxygen and carbon.
2. Complex molecules with many atoms form long – chain molecules.
3. The simple operation of distillation takes place in a lab.
4. The hydrocarbons, which boil at 40 degrees Celsius, form the first fraction.
5. The second fraction is slightly yellow in color.
6. The hydrocarbons which are still vaporous at the very bottom of the column condense to liquid.
7. The huge fractional distillation column becomes cooler towards the top.
8. Hydrocarbons with lower boiling points are collected near the top.

After watching

d) Answer the following questions.

1. What is the lecture about?
2. How large are the molecules in the oil mixture?
3. What temperature is enough for the separation to be started?
4. Where does the most vapor condense?

5. What is a conical flask for?
6. What does the boiling point depend on?
7. Why do we start separating with a bung stem?
8. Do you consider hydrocarbons to be inflammable?

WORDLIST

ENGLISH	RUSSIAN
buoyancy	плавучесть
buoyant	лёгкий, плавучий, держащийся на поверхности
caprock	кепрок (вышезалегающая экранирующая порода),
chance of success	перспектива
Christmas tree	фонтанная арматура (ёлка)
core	керн
core samples	образцы керна
density	плотность
deposit	месторождение
determine (v)	измерять, определять
drill (v)	бурить
drill bit	буровая коронка, долото
entrapment	улавливание, захват
environment	окружающая среда
evaluate (v)	оценивать, рассчитать
expand (v)	расширяться, увеличиваться в объёме
expel (v)	вытеснять
FVF (formation volume factor)	объёмный коэффициент пласта
gravity meter	гравиметр
gravity survey	гравиметрическое исследование \ работа
GRV (gross rock volume)	суммарный (общий) объём породы
gusher	фонтанирующая скважина
hydrocarbon generation	образование углеводородов
hydrocarbons in place	углеводороды в пласте
hydrophone	гидрофон
identify (v)	определять, идентифицировать
interpret (v)	расшифровывать
lead (n)	возможная ловушка углеводородов

lubricate (v)	смазывать
magnetic survey	магнитная съёмка, магнитная разведка
magnetometer	магнитометр
matured hydrocarbons	зрелые углеводороды
mud	буровой раствор
oil seep	выход нефти
pockmark	оспина
process of depth conversion	процесс глубинного преобразования
property	свойство, характеристика
prospect	поиск, разведка, перспективная площадь
ratio	соотношение, коэффициент
recoverable hydrocarbons	промышленные запасы углеводородов
reflect back (v)	отражать
reflected sound wave	отражённая звуковая волна
rock sample	образец породы
saturation	насыщенность
scale features	особенности рельефа на карте
seal (v) – sealed – a seal	придавать непроницаемость – изолированный – изолирующий слой
seismic survey	сейсморазведка
seismology	сейсмология
seismometer	сейсмограф
shrink (v)	сжиматься
sniffer	газоанализатор
source rock	нефтематеринская порода
string of pipes	колонна труб
subsurface geology	подземная геология
substructure profile	разрез (профиль) пласта
survey(v)	производить съёмку или изыскание
thickness	мощность (пласта, слоя)
volumetric equation	уравнение объёма
well head	устье скважины

UNIT 2

OIL EXTRACTION

Oil extraction = oil production is a process of oil recovery from a well.

Lead-in

Associations: close your eyes and think of ***Oil extraction*****.** You should jot down all the things associated with the process that come into your minds. The time limit is 2 minutes. If you don't know the English terms, you can write down things in Russian. Then start sharing what you have jotted down. Listen to other students making suggestions, explanations and try to learn the English words for the ideas which you have tried to put down.

Terms and Vocabulary

extract oil	добывать нефть
establish (v)	оценивать, устанавливать
refinery	нефтеперерабатывающий завод
reserves	запасы
decrease (v)	уменьшать, убывать, понижаться
increase (v)	увеличивать,повышать, усиливать
discover (v)	обнаруживать, открывать
recover (v)	получать (керн), добывать(нефть, газ)
pump (v\n)	качать, откачивать \ насос
substance	вещество, материя
composition	состав, соединение
viable	жизнеспособный
recovery factor	коэффициент нефтеотдачи
extract (v)	извлекать (нефть, газ или инструмент из скважины)
excess pressure	избыточное давление
sluggish	медлительный, медленный
treacle	вязкая жидкость
seam	пласт; тонкий слой; прослой

1. Pronounce the following words. Pay special attention to the underlined stress.

re**fi**nery **su**bstance re**ser**ve com**mer**cial **qua**lity a**mou**nt
tech**no**logy **fur**ther **re**servoir su**ffi**cient **sur**face **de**sert in**stall**
re**mo**tely **a**ngle **li**quid

2. The following words and phrases appear in the text.

production	freely flowing wells
inject (v)	thin seams of rock
edges of a reservoir	economically viable
production facilities	bottom of a well
drill at an angle	recovery factor

- Which of these terms do you already know?
- Give Russian equivalents to the above–given English terms.
- Define the term "recovery factor".
- Find the terms (or phrases) in the text and decide whether:

A – you need to know the terms now and add them to your active vocabulary;
B – you only need to know the term now because it is preventing you from understanding the general meaning of the text;
C – you don't need to know this term and add it to your active vocabulary.

3. Complete the following table. The final column of the table should be completed by filling the word class judging by its position in relation to other words and its function in the text.

Term	**A**	**B**	**C**	**Word class**

4. Read the text "How to Extract Oil" and do the exercises.

How to Extract Oil

Discovering new **reserves** of oil is only the beginning of the story. It's then the job of a new team of economists, scientists and engineers to decide whether – and how – to go into large-scale commercial production.

Once oil or gas have been **discovered,** it has to be **established** how much is there, how much can be **recovered,** what its quality is and how the oil and gas can be transported safely to a **refinery** or terminal. In other words, is the find economically **viable**? If so, further wells will have to be drilled and production facilities established.

The recovery factor – the amount of oil that can be economically **extracted** compared with the total amount estimated to be in the ground – varies widely. Twenty years ago a recovery factor of about 30 per cent was normal. Today the average is about 45 per cent. Improved technology is likely to **increase** this further.

Crude oil is found in underground pockets or traps. Gas and water are generally found in the reservoir too – usually under pressure. This pressure is sometimes sufficient to force the oil to the surface of the well unaided and **excess pressure** may cause problems.

In the early stages of production an oilfield may have freely flowing wells, but as oil is extracted the pressure **decreases** and **pumping** may become necessary. Alternatively, it may be possible to increase the pressure by injecting further gas or water into the edges of the reservoir.

In other cases, the pressure is inadequate from the beginning and pumps at the bottom of wells have to be used. The fluid extracted from the well usually contains oil, gas and water. It has to be processed so that the crude oil and gas can be transported by pipeline or tanker.

Crude oil is a natural substance whose composition varies. Even in the same oilfield, where oil is obtained from different depths, it can vary greatly in **composition** and appearance. It may be an almost colourless liquid or a **sluggish**, black **substance**, so heavy that it cannot be pumped at atmospheric temperatures. Generally, however, crude oils look rather like thin, brown **treacle**.

There is no single solution to the problem of getting oil out. Production and transport methods will depend on where the oil is found, and in particular, whether it has been found under the land or under the sea. Obviously, it is a lot harder and more expensive to drill for oil beneath the sea than on land, which is one reason why the majority of the oil that we use is produced onshore.
There are several different types of platform that can be used, depending on the conditions. Usually, the legs of the platform must extend at least 30 metres above the surface of the sea, keeping all equipment well clear of the

largest waves. For smaller offshore discoveries it is not usually economic to install a platform. In some cases, floating or underwater production systems controlled remotely have been developed.

Oil is generally produced in places far away from where it is used: in deserts, frozen wastes, jungles or far offshore. A pipeline hundreds of miles long or super-tanker – or both – may be the only way of getting the oil to the refinery where it will be turned into a useable product.

To reach the edges of the reservoir, wells are commonly drilled at an angle. It is now possible drill vertically downwards and then outwards horizontally. This can save a great deal of money, as several wells can be drilled from a single point and oil extracted from thin **seams** of rock.

(Material supplied by the Institute of Petroleum)

5. Identify what the text is about.

6. Decide how useful the text is for your purposes.

7. Decide how you will make use of the text.

8. Form the adjectives and nouns from the following verbs.

extract pump refine recover produce drill trap

9. Find Russian equivalents to the following terms.

1.underground pockets	7.frozen wastes
2.composition	8.useable product
3.economically viable	9.pipeline
4.recovery factor	10.drill vertically
5.production	11.freely flowing wells
6.underwater production systems	12.edges of a reservoir

10. Match the words with their definitions.

1.recovery factor	A. a plant where crude oil is separated and transformed into marketable products
2. economically viable	B. recover, extract
3. reservoir	C. means of oil transportation

4. refinery	D. the amount of oil that can be economically extracted
5. produce	E. quantity, quality and safety transportation of oil to a refinery
6. trap	F. a porous and permeable underground formation containing natural accumulation of producible hydrocarbons
7. pipeline	G. underground reservoir that prevents the escape of oil contained in it

11. Work in pairs. Ask your partner the following questions.

1. What team is needed to solve the problem of production?
2. Who usually estimates the quality and quantity of oil in a reservoir?
3. What is the reason of an increased recovery factor?
4. Is crude oil the only hydrocarbon found in a reservoir?
5. Does reservoir pressure cause problems?
6. Why is pumping so necessary?
7. What is the way to increase pressure?
8. Does oil in one reservoir differ from that of the other one?
9. What does oil look like?
10. What do production and transport methods depend on?
11. Where is it cheaper to drill oil?
12. Why are platforms situated high above the surface of the sea?
13. Is it necessary to install a platform offshore?
14. What is the only way of getting oil to the recovery? Why?
15. If you want to reach the edges of the reservoir, what will you do?

Exercise 12. Video.

a) You will hear a lecture on Petroleum Engineers Job. For statements 1–10 complete the notes that summarize what the speaker says. You will need to write a word or a short phrase in each box.

1. To find new supplies of these we depend on petroleum engineers.

2. They	the world for reservoirs containing oil or natural gas.
3. They	with geologists and other specialists to extract oil.

4. The the map of the underground.

5. The a drilling method.

6. Petroleum engineers also develop

7. are used to force out the oil and natural gas.

8. is often used to explore drilling and extraction options in techniques.

9. You'll need problem solving skills.

10. You'll need with the team on highly detailed plans.

b) Describe the job of Petroleum Engineers.

WORDLIST

ENGLISH	RUSSIAN
extract oil	добывать нефть
composition	состав, соединение
decrease (v)	уменьшать, убывать, понижаться
discover (v)	обнаруживать, открывать
establish (v)	оценивать, устанавливать
excess pressure	избыточное давление
extend (v)	простираться
extract (v)	извлекать (нефть, газ или инструмент из скважины)
force (v)	вытеснять
increase (v)	увеличивать, повышать, усиливать
inject (v)	закачивать
install (v)	устанавливать
large-scale commercial production	широкомасштабная промышленная эксплуатация
pump (v\n)	качать, откачивать \ насос
recover (v)	получать (керн), добывать(нефть, газ)
recovery factor	коэффициент нефтеотдачи
refinery	нефтеперерабатывающий завод

remotely	на расстоянии
reserves	запасы
safely	безопасно
sluggish	вязкий, медлительный, медленный
substance	вещество, материя
thin seams	тонкие пропластки
total amount	общее количество
treacle	вязкая жидкость
viable	жизнеспособный

UNIT 3

RESERVOIR ROCK PROPERTIES

Lead-in

What are the typical rocks in the Earth's crust?
What rocks show there is oil underground?
What are the most common reservoir rocks?
What properties of reservoir rock do you know?
What is a trap?

Terms and Vocabulary

closure	купол \ замыкание ловушки
crest	антиклинальный перегиб
gas cap	газовая шапка
gas-oil contact	газонефтяной контакт
oil-water contact	водонефтяной контакт
producible oil	промышленные запасы нефти
transition zone	переходная зона
oil saturation	нефтенасыщенность
bottom water	подошвенная вода
edge water	краевая \ контурная вода
porous	пористый
permeable	проницаемый
diatrophism	тектоническое воздействие
impermeable	непроницаемый
reservoir rock	коллекторская порода, пористая порода пласта коллектора
property	свойство, характеристика
cross-section	профиль, поперечное сечение
existency	наличие
adjacent to	граничащий; прилегающий; примыкающий, смежный
planar	плоский, плоскостной
be tilted	наклоненный
be enclosed	окружённый

1. Pronounce the following words. Pay special attention to the underlined stress in the following words.

illust**rate** im**per**meable sur**round** con**tain** re**lation**ship e**xis**tence per**mit** **la**terally a**dja**cent **hy**drody**namic** pro**du**cible un**e**qual **o**pposite **te**mperature satu**ratio**n

2. Read the text "Hydrocarbon Traps" and do the exercises.

Hydrocarbon traps may be illustrated by considering a **porous, permeable** formation that has been folded into an anticlinal trap by **diatrophism** and is enclosed between **impermeable** rocks [Fig. 1].

Hydrocarbon Traps

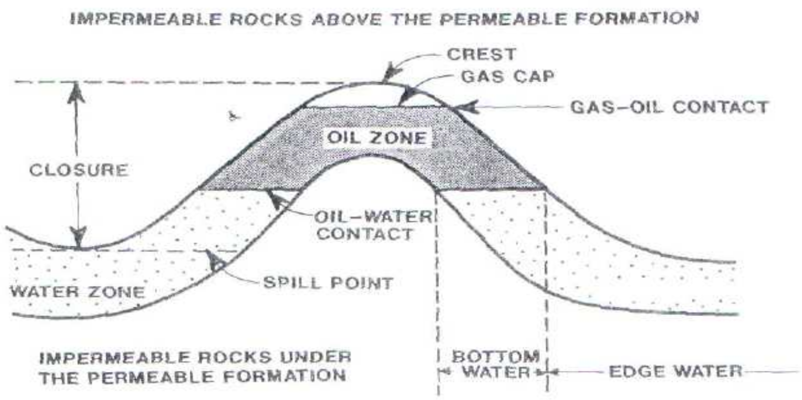


Fig.1. Idealized cross-section through an anticlinal trap formed by a porous, permeable formation surrounded by impermeable rocks. Oil and gas are trapped at the top of the anticline.

The **closure** of the trap is the distance between the **crest** and the **spill point** (lowest point of the trap that can contain hydrocarbons). In most cases, the hydrocarbon trap is not filled to the spill point. It may contain a **gas cap** if the oil contains light hydrocarbons and the pressure-temperature relationship of the zone permits the **existence** of a gas zone at the top of the reservoir.

If a gas cap exists, the **gas-oil contact** is the deepest level of producible gas. Likewise, the **oil-water contact** is the lowest level of **producible oil**. **Transition zones** between various zones grading from high **oil saturation** to hydrocarbon-free water. For example, the water zone immediately below the oil-water contact is the **bottom water,** whereas the **edge water** is laterally **adjacent to** the oil zone.

The gas-oil and water-oil contacts are generally **planar**, but they may **be tilted** due to hydrodynamic flow of fluids, a large permeability contrast between opposite sides of the reservoir, or unequal production of the reservoir.

3. Say whether the following statements are T(True) or F(Fals)e. If F (False), correct them according to the text.

1. Hydrocarbon traps are considered to be ones enclosed between permeable rocks.
2. Hydrocarbon traps occurred as a result of diatrophism.
3. Porous, permeable formation isn't surrounded by impermeable rocks.
4. Oil and gas are trapped at the bottom of the anticline.
5. The hydrocarbon trap is not filled to the spill point.
6. The existence of a distinct gas zone at the top of the reservoir is allowed.
7. The gas-oil contact is the deepest level of producible gas.
8. The gas-oil and water-oil contacts are generally tilted.

4. Answer the following questions and give more \ extra information.

1. Why are hydrocarbon traps enclosed between impermeable rocks?
2. Is there a porous formation in an anticline trap?
3. Where are oil and gas trapped?
4. Are transition zones important in oil and gas entrapment?
5. When is the gas-oil contact the deepest level of producible gas?
6. Why are gas-oil and water-oil contacts tilted?
7. What is a closure of the trap?

Terms and Vocabulary

primary migration	первичная миграция
secondary migration	вторичная миграция
interstitial fluids (water)	флюиды, циркулирующие в пустотах горных пород
subsidence	оседание; опускание породы
bulk density	средняя плотность
cohesive strength	прочность сцепления
precipitates – precipitation	осадок – осаждение
salinity	солёность
capillary pressure	капиллярное давление
tortuosity	сложность поровых каналов
distinct droplet	капля

interfacial tension	интерфациальное натяжение
adhesion	адгезия \ прилипание (вледствие смачивания)
wettability	смачиваемость
contact angle	угол касания \ краевой угол (смачивания)
fluid flow	движение (поток) флюидов
release (fluids)	выделение (флюидов)
pore size distribution	распределение пор по размерам (в породе)
pore throat	горловина пор
displace(v) – displacement	вытеснять – вытеснение; смещение
leading pore	«ведущая» пора
trailing pore	«отстающая» пора
entry (pressure)	вход (входное давление – минимальное вытеснение из пористой среды одной жидкости другой)
filament (s)	капилляр (ы)
outcrop	обнажение пород \ выход пластов на дневную поверхность
oil seep	выход нефти
uplift	давление воды снизу
tar pit	смоляная яма
caprock	кепрок (вышезалегающая экранирующая порода)
retain(v)	удержать
light hydrocarbon	лёгкий углеводород
shale	сланец
originate (v)	происходить, возникать
compaction	уплотнение
fine-grained	мелкозернистый
displacement pressure	давление вытеснения
constriction	сжатие, сокращение

5. Pronounce the following words. Pay special attention to the letters in bold and the underlined stress.

m**igra**tion **in**ter**stitia**l s**u**bs**i**dence [səbs′ɑidəns] ca**pil**lary **tor**tu**o**sity
gen**e**sis **ge**o**che**mical o**ri**ginal co**he**sive b**uo**yancy **hy**drody**na**mic
suf**fi**cient **effe**ctive **e**r**o**sion **stru**c**tu**ral cons**ti**tuents

6. Read the text "Migration and Accumulation of Petroleum" and do the exercises.

Migration and Accumulation of Petroleum

The genesis of petroleum occurs in compacted clay and **shale** beds, which are essentially impermeable to **fluid flow**. The processes by which hydrocarbons migrate from the source rock to a porous, permeable reservoir are called **primary migration**. After leaving the source rock, the hydrocarbons migrate upward through permeable beds until they reach a sealed hydrocarbon trap where accumulation occurs forming a hydrocarbon reservoir. This process has been called **secondary migration.**

Primary Migration

The geochemical evidence of the generation for petroleum shows that hydrocarbons do not generally **originate** in the structural and stratigraphic traps in which they are found. The petroleum reservoirs are porous, permeable geologic structures, whereas the source rocks have been identified as compacted, impermeable shales.

Compaction of sediments begins as soon as the sediments begin to accumulate. During original accumulation, the loose, **fine-grained** sediments contain more than 50 % water. As they are buried deeper, due to **subsidence** and continued deposition of sediments on top, the **interstitial water** from the deeper sediments is expelled, resulting in a decrease in porosity and an increase in **bulk density**.

The material acquires **cohesive strength** as the grains are pressed together tightly. Chemical changes occurring in the interstitial fluids may produce **precipitates** that cement the grains into an even more cohesive formation. The **salinity** of compaction fluids moving in an upward direction gradually increases until **precipitation** occurs due to supersaturation.

Secondary Migration

As petroleum reservoirs exist in a water environment, the migration of hydrocarbons from the point of **release** in a source rock to the top of the trap is intimately associated with **capillary pressure** phenomena and hydrology. The **pore distributions**, **tortuosity** of continuous channels, porosity, permeability and chemical characteristics of reservoir rocks and their interstitial fluids differ widely.

The migration of oil as **distinct droplets** in water-saturated rock is opposed by the capillary forces, which are functionally related to pore size, **interfacial tension** between oil and water and **adhesion** of oil to mineral surfaces (**wettability**). This is expressed through a **contact angle** for a capillary of uniform size as:

$$P_c = \frac{2\sigma \cos\theta}{r_c},$$

where P_c – capillary pressure, Pa; σ – interfacial tension, $(N\cdot10^{-3})\backslash m$; θ – contact angle; r_c – radius of the capillary, m.

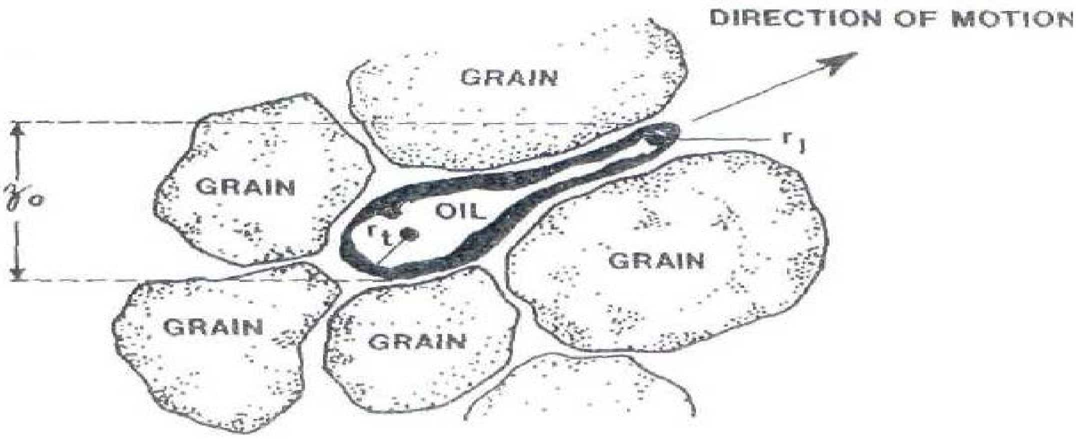


Fig. 2. Displacement of an oil droplet through a pore throat in a water-wet rock

The more usual case is one in which the oil droplet exists within the confines of a large pore containing several smaller-sized **pore throat** exits.

Under these conditions, the pressure required **to displace** the droplet from the large pore through the **constriction** of a pore throat (**displacement pressure**) is the difference between the capillary pressures of the **leading** and **trailing**

pores. The two forces in a reservoir that are most likely to be operating on the droplet are buoyancy and hydrodynamic pressure.

As the oil leaves the source rock under the forces of compaction, large saturations develop at the **entry** of the reservoir rock. The oil then begins to migrate upward as a continuous phase in long **filaments** within the pores. Under these circumstances, sufficient buoyant and hydrodynamic forces can develop to cause migration of the oil.

Secondary migration of petroleum ends in the accumulation in a structural or stratigraphic trap and sometimes in a trap that is a complex combination of the two. The hydrocarbons accumulate at the highest point of the trap and the fluids are stratified in accordance with their densities, which show that individual hydrocarbon molecules are free to move within the reservoir.
The petroleum accumulation may become:

1. exposed by **an outcrop** and develop **an oil seep**;
2. **uplifted** and eroded to form **a tar pit.**

In addition, petroleum may be transported to another sedimentary sequence as a result of rapid erosion and clastic transport.
The **caprock** (oil trap seal) may not be absolutely impermeable to **light hydrocarbons**. The capillary pressure relationship of the rocks overlying the oil traps may form an effective vertical seal for liquid petroleum constituents, but the seal may not be completely effective in **retaining** lighter hydrocarbons.

(***F.K. North, Petroleum Geology, London, 1985***)

7. Form adjectives and nouns from the following verbs.

migrate identify compact accumulate form press develop saturate occur

8. Give Russian equivalents to the following English phrases.

clay and shale beds	an increase in bulk density
fluid flow	the grains are pressed together tightly
a sealed hydrocarbon trap	even, more cohesive formation
compacted, impermeable shales	differ widely
loose, fine-grained sediments	within the confines of a large pore

from the deeper sediments	through the constriction of a pore throat
a decrease in porosity	at the entry of the reservoir rock
a tar pit	in accordance with their densities

9. Define the terms given below.

1. primary migration	5. oil seep
2. secondary migration	6. hydrocarbon migration
3. wettability	7. source rock
4. caprock	8. trap

***10. Compose collocations from the following terms*.**

1.hydrocarbon	A. rock
2. reservoir	B. migration
3. capillary	C. trap
4. secondary	D. reservoir
5. stratigraphic	E. pressure
6. hydrocarbon	F. accumulation
7. interstitial	G. formation
8. hydrodynamic	H. water
9. cohesive	I. shales
10. impermeable	G. molecules

11. Answer the questions listed below.

1. Where does petroleum occur?
2. Why do hydrocarbons migrate upward?
3. The source rocks are identified as compacted, impermeable shales, aren't they?
4. When does compaction of sediment begin?
5. What is the result of interstitial water expelling from the deeper sediments?
6. Why do grains become cemented into an even more cohesive formation?
7. Does supersaturation affect the salinity of compaction fluids?
8. What is hydrocarbon migration associated with?
9. Are there any forces in a reservoir?
10. Where do hydrocarbons accumulate?
11. Can you say that fluids are stratified in a trap?
12. What is the result of petroleum accumulations?

12. Put a preposition into the following gaps.

1. Petroleum occurs _________ compacted clay and shale beds.
2. Hydrocarbons migrate _____ the source rock ______a porous, permeable reservoir.
3. ______leaving the source rock, the hydrocarbons migrate upward ___________permeable beds.
4. The salinity _________compaction fluids moving in an upward direction gradually increases ______precipitation occurs ____ __________supersaturation.
5. Secondary migration ______petroleum ends _____ the accumulation ________ a structural or stratigraphic trap.
6. The hydrocarbons accumulate ______the highest point _____ the trap.
7. Petroleum may be transported ________ another sedimentary sequence as a result __________rapid erosion and clastic transport.

Terms and Vocabulary

void space	пустотное пространство
fraction	часть \ доля
grain volume	объем зёрен
pore volume	поровое пространство
porosity value	значение пористости
packing arrangement	расположение (упаковка зёрен)
wide-packed system	неплотно уложенная система
close-packed system	плотно уложенная система
uniformity (sorting)	однородность
grain size	размер зерен
gradation	постепенный переход из одного состояния в другое
effective (intercommunicating)	действующая (эффективная) пористость (сообщающаяся \ взаимосвязанная)
squeeze out (v)	выжимать
expulsion	выделение \ вытеснение
overburden pressure	давление покрывающих пород
random (packing)	хаотическая \ неупорядоченная (упаковка)
close (packing)	плотная (упаковка)
consolidated – unconsolidated	затвердевший – незатвердевший
interconnected – interconnection	связанный – связанность

conductivity	удельная проводимость
vesicular porosity	везикулярный пористость;
hydration	гидратация
heterogeneity	неоднородность
leaching	выщелачивание \ вымывание
dead-end	пустой
irreducible (fluids)	остаточные (флюиды)
connate water	погребенная \ реликтовая вода
primary (matrix) porosity	первичная пористость
intercrystalline	интеркристаллический
cleavage	кливаж \ спайность
plane	плоскость \ горизонт
lattice (crystal)	решетка (кристаллическая)
subcapillary	субкапиллярный
intergranular (interparticle)	межзернистый
opening (s)	пора (мн. пустоты в породе)
bedding plane	плоскость напластования
miscellaneous (sedimentary voids)	смешанный
detrital (fragmentary)	обломочный
vuggy	пористый
cavernous	пещеристый \ кавернозный \ имеющий пустоты
secondary (induced) porosity	вторичная (наведенная) пористость
diagenesis	диагенез
catagenesis	катагенез
dolomitization	доломитизация
solution porosity	пористость раствора
cavern	каверна (карстовая пустота)
fracture porosity	пористость разрыва
structural failure	структурное оседание
saddle reef	пластовая жила, имеющая форму антиклинали
crest	гребень \ сводная часть складки
flat	горизонтально залегающий пласт
pitch	угол падения \ погружение антиклинали
slumping	оползание
fissure	разрыв \ трещина в породе
consolidation (cementation)	уплотнение

bulk volume	величина, объем
govern (v)	регулировать; управлять
framework	структура, основа
shaly	сланцеватая
duration	продолжительность
negligible	незначительный, неважный
mode of origin	условия происхождения
replacement	замена; замещение

13. Detailed reading. Read the text "Porosity" and do the exercises.

Porosity

Porosity is an availability of pore spaces between rock particles. Porosity is a ratio of open space to total volume of rock and is calculated in percentage

Sand grains and particles of carbonate materials that make up sandstone and limestone reservoirs usually never fit together perfectly due to the high degree of irregularity in shape. The **void space** created throughout the beds between grains, called **pore space** or interstices, is occupied by fluids (liquids \ gases). The porosity of a reservoir rock is defined as that **fraction** of the **bulk volume** of the reservoir that is not occupied by the solid **framework** of the reservoir.

According to this definition, the porosity of porous materials could have any value, but the porosity of most sedimentary rocks is generally lower than 50 %.

Factors governing the magnitude of porosity

Fraser and Graton determined the porosity of various **packing arrangements** of uniform spheres. They have shown that the cubic or **wide-packed system** has a porosity of 25.9 %.

The porosity for such a system is independent of the **grain size** (sphere diameter). However, if smaller spheres are mixed among the spheres of either system, the ratio of pore space to the solid framework becomes lower and porosity is reduced. Fig. 3 shows a three-grain-size cubic packing. The porosity of this cubic packing is now approximately 26.5 %.

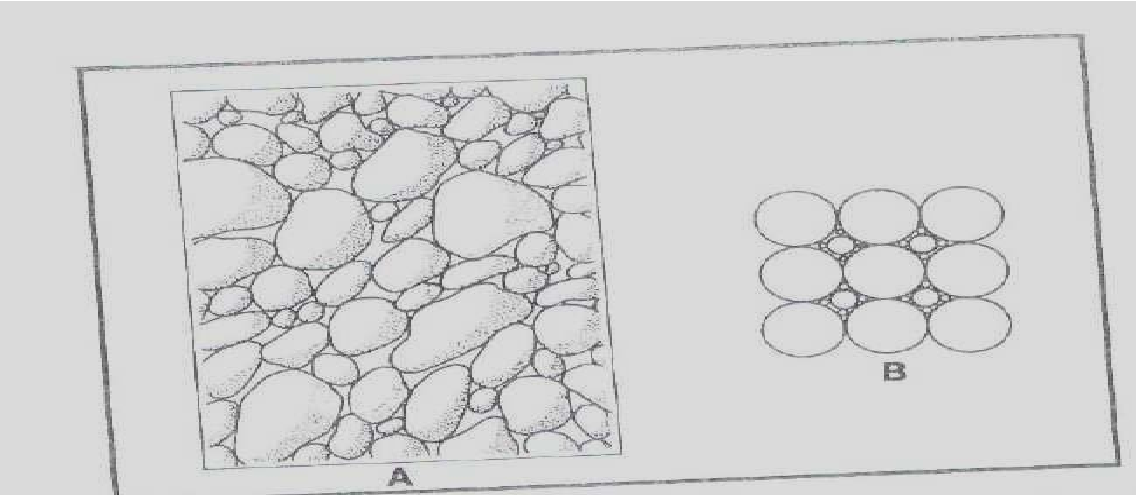


Fig. 3. Collection of (a) different sized and shaped sand grains; (b) spheres illustrating a cubic packing of three grain sizes

The porosities of petroleum reservoirs range from 55 to 40 % but more frequently are between 10 to 20 %. The factors governing the magnitude of porosity in clastic sediments are:

1. **uniformity of grain size (sorting)**: is the **gradation** of grains. If small particles of silt or clay are mixed with larger sand grains, the **effective (intercommunicating) porosity** will be considerably reduced. These reservoir rocks are referred to as dirty or **shaly**. Sorting depends on at least four major factors: size range of the material, type of deposition, current characteristics, and the **duration** of the sedimentary process;
2. **degree of cementation (consolidation):** highly cemented sandstones have low porosities, whereas soft **unconsolidated** rocks have high porosities. **Cementation** takes place both at the time of lithification and during rock alteration by circulating groundwater. Cementing materials include: calcium carbonate, iron sulfides, dolomite, clays, including any combination of these materials;
3. **amount of compaction during and after deposition**: **compaction** tends to close **voids** and **squeeze** fluid **out** to bring the material particles closer together, especially fine-grained sedimentary rocks. The **expulsion** of fluids by compaction at an increased temperature is the basic mechanism for primary migration of petroleum from the source to reservoir rocks. Whereas compaction is an important lithifying process in claystones, shales and fine-grained carbonates, **it is negligible** in closely packed sandstones or conglomerates.

Generally, porosity is lower in deeper, older rocks. Many carbonate rocks show little evidence of physical compaction;

4. **methods of packing**: with increasing **overburden pressure**, poorly sorted angular sand grains show a progressive change from **random packing** to a **closer packing**.

Engineering classification of porosity

During sedimentation and lithification, some of the pore spaces initially developed became isolated from the other pores by various diagenetic and catagenetic processes such as cementation and compaction. Many of the pores will be interconnected, whereas others will be completely isolated. This leads to two distinct categories of porosity: ***total (absolute)*** and ***effective***, depending upon which pore spaces are measured in determining the volume of these pore spaces. The difference between the total and effective porosities is the isolated or non-effective porosity.

Absolute porosity is the ratio of the total void space in the sample to the bulk volume of that sample, regardless of whether or not those void spaces are interconnected. A rock may have considerable absolute porosity and yet have no fluid **conductivity** for lack or poor interconnection.

Effective porosity is the ratio of the interconnected pore volume to the bulk volume. This porosity is an indication of the ability of a rock to conduct fluids. Effective porosity is affected by a number of lithological factors including type, content and hydration of clays present in the rock, **heterogeneity** of grain sizes, packing and cementation of the grains and any weathering and **leaching** that may have affected the rock. Many of the pores may be **dead-ends** with only one entry to the main channel system. Depending on wettability, these dead-end pores may be filled with water or oil, which are **irreducible fluids**.

In order to recover oil and gas from reservoirs, hydrocarbons must flow several hundred feet through pore channels in the rock before they reach the producing wellbore. If the petroleum occupies non-connected void spaces, it cannot be produced and is of little interest to the petroleum engineer. Therefore, effective porosity is the value used in all reservoir engineering calculations.

Geological classification of porosity

As sediments are deposited in geologically ancient seas, the first fluid that filled pore paces in sand beds was seawater, generally referred to as **connate water**. A common method of classifying porosity of petroleum reservoirs is based on whether pore spaces in which oil and gas are found originated when the sand beds were laid down ***(primary \ matrix porosity*)**, or if they were formed through subsequent **diagenesis** (**dolomitization i**n carbonate rocks), **catagenesis**, earth stresses and solution by water flowing through the rock (***secondary or induced porosity***).

The following general classification of porosity, adapted from Ellison, is based on time origin, **mode of origin** and distribution relationships of pore spaces.

Characteristic features of the two basic porosity types:

Primary porosity

1. **Intercrystalline** – voids between **cleavage planes** of crystals, voids between individual crystals and void in **crystal lattices**. Many of these voids are **subcapillary**, i.e. pores less than 0.002 mm in diameter. The porosity found in crystal lattices and between mud-sized particles has been called “microporosity”. Usually high recovery of water in some productive carbonate reservoirs may be due to the presence of large quantities of microporosity.
2. **Intergranular (interparticle)** – voids between grains, i.e. interstitial voids of all kinds in all types of rocks. These openings range from subcapillary through super-capillary (voids greater than 0.5 mm in diameter).
3. **Bedding planes** – voids of many varieties are concentrated parallel to the bedding planes. The larger geometry of many petroleum reservoirs is controlled by such bedding planes. Differences of sediments deposited, of particle sizes and arrangements and of the environments of deposition are causes of bedding plane voids.
4. **Miscellaneous sedimentary voids** – (1) voids resulting from the accumulation of detrital fragments of fossils; (2) voids resulting from the packing of oolites; (3) **vuggy and caverneous** voids of irregular and variable sizes formed at the time of deposition; (4) voids created by living organisms at the time of deposition.

Secondary porosity

Secondary porosity is the result of geological processes (diagenesis and catagenesis) after the deposition of sediment. The magnitude, shape, size and interconnection of the pores may have no direct relation to the form of original sedimentary particles. **Induced porosity** can be subdivided into three groups based on the most dominant geological process.

1. **Solution porosity** – channels due to the solution of rocks by circulating warm or hot solutions; **openings** caused by weathering (enlarged joints or solution **caverns)**; and voids caused by organisms and later enlarged by solution.
2. **Dolomitization** – a process by which limestone is transformed into dolomite. Some carbonate rocks are almost pure limestones and if the circulating ore water contains significant amounts of magnesium cation, the calcium in the rock can be exchanged for magnesium in the solution. Because the ionic volume of magnesium is considerably smaller that that of the calcium which it replaces, the resulting dolomite will have greater porosity. Complete **replacement** of calcium by magnesium can result in a 12–13 % increase in porosity.
3. **Fracture porosity** – openings created by **structural failure** of the reservoir rocks under tension caused by tectonic activities such as folding and faulting. These openings include joints, **fissures and fractures**. Porosity due to fractures alone in carbonates usually does not exceed 1 %.
4. **Miscellaneous secondary voids** – (1) **saddle reefs** which openings at the rest of closely folded narrow anticlines; (2) **pitches and flats** which are openings formed by the parting of beds under gentle **slumping**; (3) voids caused by submarine slide breccias and conglomerates resulting from gravity movement of seafloor material after partial lithification.

In carbonate reservoirs secondary porosity is much more important than primary porosity. Primary porosity is dominant in clastic (detrital \ fragmental) sedimentary rocks (sandstones, conglomerates and certain oolite limestones). It is important to emphasise that both types of porosity often occur in the same reservoir rock.

(***F.K. North, Petroleum Geology, London, 1985***)

14. Give Russian equivalents to the English ones.

1. void space	14. conductivity
2. pore space	15. dead–ends
3. framework	16. leaching
4. packing arrangement	17. irreducible fluids
5. wide–packed system	18. plane
6. close–packed system	19. bedding plane
7. uniformity	20. lattice

8. solution porosity	21. miscellaneous
9. gradation	22. vuggy
10. squeeze out	23. slumping
11. expulsion	24. heterogeneity
12. interconnected	25. structural failure

15. Find the synonyms to the following terms.

pore space effective porosity primary porosity intergranular
secondary porosity absolute porosity grain size sorting

16. Translate the following sentences.

1. The material of which a petroleum reservoir rock may be composed of can range from very loose and unconsolidated sand to very hard and dense sandstones.

2. As the sediments were deposited and the rocks were being formed during past geological times, some void spaces that developed became isolated from the other void spaces by excessive cementation.

3. From the reservoir – engineering standpoint, effective porosity is the desired quantitative value because it represents the space that is occupied by mobile fluids.

4. Rock properties are determined by performing laboratory core analysis.

5. Many of the void spaces are interconnected while some of the pore spaces are completely isolated.

17. Answer the following questions.

1. What is porosity? (definition)
2. What is the average value of porosity?
3. What factors govern the magnitude of porosity?
4. There are two categories of porosity. What are they?
5. What is the difference between effective porosity and total porosity?
6. What is effective porosity?
7. How is effective porosity affected by?
8. What is absolute porosity?

9. Can a rock have considerable absolute porosity, but have no fluid conductivity? Why?
10. What is the geological classification of porosity? (description).
11. What is the difference in translating the following terms: joint, fissure, and fracture?
12. What is the general geological classification of porosity based on?
13. What are the main characteristic features of primary porosity?
14. What is secondary porosity?
15. What are the three groups of secondary porosity? What are these groups based on?
16. In what type of reservoir rock is secondary porosity more important than primary porosity?
17. Can both types of porosity occur in one and the same reservoir rock?
18. What are fluids?
19. What is microporosity?
20. What rocks show little evidence of physical compaction?
21. What are cementing materials?
22. What is cementation?
23. What is the basic mechanism for primary migration of petroleum?
24. What is pore space?
25. What is the porosity of most sedimentary rocks?
26. What is the approximate porosity of a cubic system?
27. What does sorting depend on? (factors).
28. When does cementation take place?
29. What is the porosity of petroleum reservoirs in Tomsk region? (average).
30. What porosity – effective or absolute – is used in reservoir engineering calculations?

Terms and Vocabulary

fresh water	пресная вода
fluid flow equation	уравнение течения флюидов (Дарси)
primary (matrix) permeability	первичная проницаемость
secondary (induced) permeability	вторичная проницаемость
fracturing	трещиноватость
conduit	выводящий канал
tight reservoir	непроницаемый пласт
directional (anisotropic) permeability	неодинаковая по различным направлениям (анизотропная \ двоякопреломляющаяся) проницаемость

anisotrophy	анизотропия
subsequent compaction	последовательное \ постепенное уплотнение
vertical permeability	вертикальная проницаемость
horizontal permeability	горизонтальная проницаемость
be interbedded	впластованный (залегающий между пластами)
immiscible	несмешивающийся
interface	поверхность контакта
equilibrium	равновесие
curvature	искривление
(non-)wetting	(не)смачивание
preferential wetting	избирательное смачивание
saturation	насыщенность
(non-)wetting phase	(не)смачивающая фаза

18. Read the text "Permeability" and do the exercises.

Permeability

Permeability is easiness with which fluid can move through porous rock.
High permeability means numerous channels for oil and gas migration.
A reservoir rock must have the ability to allow petroleum fluids to flow through its interconnected pores. This rock property is termed permeability. The permeability of a rock depends on the effective porosity. Therefore, permeability is affected by the rock grain size, grain shape, grain size distribution (sorting), grain packing and the degree of consolidation and cementation. Permeability is affected by the type of clay present, especially where **fresh water** is present.

French engineer Henry Darcy developed a **fluid flow equation** that since has become one of the standard mathematical tools of the petroleum engineer. One Darcy is a relatively high permeability and the permeability of most reservoir rock is less than one Darcy. The common measure of rock permeability is in millidarcies (mD) or μm^2 in SI units.

The term **absolute permeability** is used if the porous rock is 100 % **saturated** with a single fluid (phase), such as water, oil or gas. When two or more fluids are present in the rock, the permeability of the rock to the **flowing fluid** is called **effective permeability**.

Because fluids interfere with each other during their movement through the pore channels in the rock, the sum of effective permeability will always be less than the absolute permeability. The ratio of effective permeability of one phase during multiphase flow to the absolute permeability is the **relative permeability** to that phase.

Classification of permeability

Petroleum reservoirs can have **primary permeability**, which is also known as the **matrix permeability** and **secondary permeability**. Matrix permeability originated at the time of deposition and lithification (hardening) of sedimentary rocks. As with **secondary (induced) porosity,** secondary permeability resulted from the alteration of the rock matrix by: compaction, cementation, fracturing and solution. Whereas, compaction and cementation generally reduce the primary permeability; **fracturing** and solution tend to increase. In some reservoir rocks, particularly low-porosity carbonates, secondary permeability provides the main **conduit** for fluid migration.

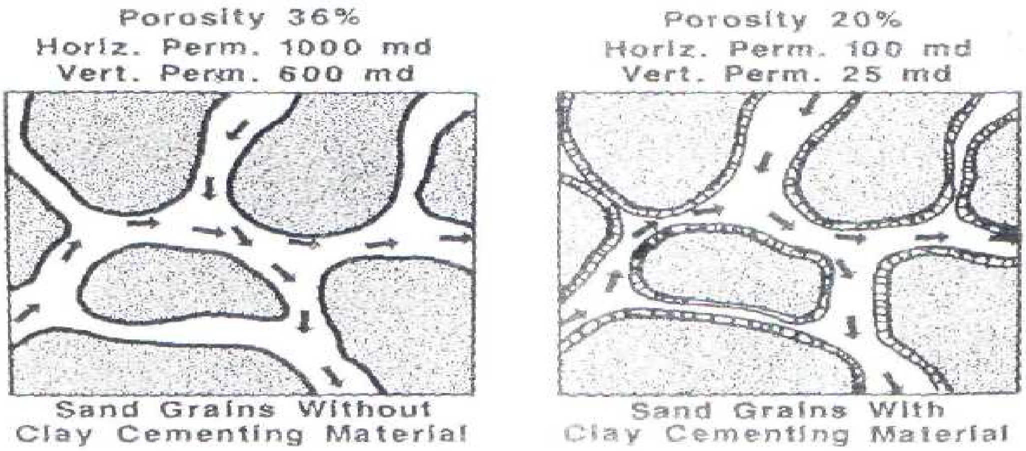


Fig. 4. Effects of clay cementing material on porosity and permeability

Factors affecting the magnitude of permeability

Permeability of petroleum reservoir rocks may range from 0.1 to 1000 or more millidarcies. The quality of a reservoir as determined by permeability in mD, may be judged as:

- K < 1 = poor
- 1 < K = fair
- 10 < K < = moderate
- 50 < K < 250 = good
- K > 250 = very good

Reservoirs having permeability below 1 mD are considered **"tight".** Such low permeability values are generally found in limestone matrices and also in tight gas sands of western United States.

The factors affecting the magnitude of permeability in sediments are:

1. ***shape and size of sand grains*****:** if the rock is composed of large and flat grains uniformly arranged with the longest dimension horizontally – its horizontal permeability (kH) will be very high, whereas, the **vertical permeability** (kv) will be medium-to-large. If the rock is composed mostly of large and uniformly rounded grains, its permeability will be considerably high and of the same magnitude in both directions. Permeability of reservoir rocks is generally lower, especially in the vertical direction, if the sand grains are small and of irregular shape. Most petroleum reservoirs are in this category. Reservoirs with **directional permeability** are called **anisotropic**. **Anisotrophy** greatly affects fluid flow characteristics. The difference in permeability measured parallel and vertical to the bedding plane is a consequence of the origin of that sediment. **Subsequent compaction** of the sediment increases the ordering of the sand grains so that they generally lie in the same direction;
2. ***cementation*****:** both permeability and porosity of sedimentary rocks are influenced by the extent of cementation and the location of the cementing material within the pore space;
3. ***fracturing and solution***: in sandstones, fracturing is not important cause of secondary permeability, except where sandstones are **interbedded** with shales, limestones and dolomites.

Capillary pressure

Capillary pressure is the difference in pressure between two **immiscible** fluids across a **curved interface** at **equilibrium**. **Curvature** of the interface is the consequence of **preferential wetting** of the capillary walls by one of the phases.

(***F.K. North, Petroleum Geology, London, 1985***)

19. Find the words to the following definitions and translate them into Russian.

1.	A. the ability to flow through interconnected pores
2.	B. sorting
3.	C. a fluid flow equation
4.	D. a single fluid
5.	E. matrix permeability
6.	F. to grow
7.	G. movement
8.	H. “tight” reservoirs
9.	I. a rock formed from material derived from pre-existing rocks by the accumulation and cementation of mineral grains transported by wind, water, or ice to the site of deposition or by chemical precipitation at the depositional site
10.	J. a medium – grained clastic rock formed from sand on a beach, in a river bed or in a desert
11.	K. chemical compound formed only of carbon and hydrogen
12.	L. the difference in pressure between two immiscible fluids across a curved interface at equilibrium
13.	M. induced porosity
14.	N. hardening

20. Match the word phrases in the left column with the word phrases in the right. Find them in the text and write these sentences out. Give Russian equivalent to the English ones.

1. a fluid flow 2. the degree 3. the ratio 4. large and flat 5. reservoirs 6. the location 7. both permeability and porosity	A. grains uniformly arranged B. of effective permeability C. are called anisotropic D. of sedimentary rocks E. equation F. of the cementing material within the pore space. G. of consolidation and cementation

21.Fill in the gaps with the missing words.

A (1)________ rock must have the ability to allow (2)_______ fluids to flow through its interconnected (3)________. Permeability is affected by the type of (4)________ present, especially where fresh (5)________ is present. Petroleum reservoirs can have (6)________ permeability, which is also known as the (7)________ permeability and (8)________ permeability. Whereas, compaction and cementation generally (9)________ the primary permeability; fracturing and solution tend to (10)_______. Reservoirs having permeability below 1mD are considered (11)________. The factors affecting the (12)________ of permeability in sediments are: shape and size of sand grains, (13)________, fracturing and (14)________ .

a. Answer the following questions.

1. What is permeability affected by?
2. Why has a fluid flow equation become one of the standard mathematical tools of the petroleum engineer?
3. If the porous rock is 100 % saturated with a single fluid (phase), such as water, oil or gas, what term is used related to permeability?
4. Why is permeability called effective?
5. What is the result of fluid interference with each other?
6. Could you define the term “relative permeability”?
7. When did matrix permeability originate?
8. Why is primary permeability reduced?
9. What does secondary permeability provide?
10. Where are low permeability values generally found?

11. Are there any factors that affect the magnitude of permeability in sediments?

Terms and Vocabulary

adhesion	адгезия \ связанность (породы) \ слипание
wet	смачивать
water – wet	гидрофильный \ смачиваемый водой
brine-oil (rock system)	нефтепромысловые минерализованные пластовые воды
preference (preferentially)	избирательность \ избирательно
imbibe(v)	пропитывать (погружение)
displace (v)	вытеснять
be saturated with	насыщенный
interaction	взаимодействие
exhibit (v)	показывать \ проявлять
fractional wetting	смачивание отдельных пластов
spotted \ heterogeneous wetting (dalmatian wetting)	далматская смачиваемость
mixed wetting	смешанная смачиваемость
oil-wet	смачиваемый нефтью
filament	канал
path	путь (прохождения флюидов)
oil displacement	вытеснение нефти (из пласта)
residual oil saturation	остаточная нефтенасыщенность
invade (v)	проникать
brine	солёная вода, рассол
aqueous	водный
lining	внутреннее покрытие
electrostatic force	электростатическая сила
rupture (v)	разрывать \ разрушать
bulk phase	фаза мощности
wettability of formation	смачиваемость пласта
intermediate wetting	промежуточная смачиваемость
preferential wetting	предпочтительная смачиваемость
relative wetting	относительная смачиваемость
rock wetting	смачиваемость горной породы
film	плёнка
scattered	рассеянный
immiscible (fluids)	несмешивающиеся (флюиды)

23. Pronounce the following words. Pay special attention to the letters in bold.

adh**e**sion p**o**rous m**e**dium imm**i**scible n**eu**tral rup**tur**es interm**e**diate irred**u**cible interfa**cia**lly stabil**i**zed anal**y**ses constit**ue**nts

24. Read the text "Wettability" and do the exercises.

Wettability

Wettability is the term used to describe the relative **adhesion** of two fluids to a solid surface. In a porous medium containing two or more immiscible fluids, wettabilty is a measure of the preferential tendency of one of the fluids to **wet** (spread or adhere) the surface.

In water-wet **brine**-oil-rock system, water will occupy the smaller pores and wet the major portion of the surfaces in the larger pores. In area of high oil saturation, the oil rests on a **film** of water spread over the surface. If the rock surface is **preferentially** water-wet and the rock is saturated with oil, water will **imbibe** into the smaller pores, **displacing** oil from the core when the system is in contact with water.

If the rock surface is preferentially oil-wet, even though it may **be saturated with** water, the core will imbibe oil into the smaller pores, displacing water from the core when it is contacted with water. Thus, a core saturated with oil is water-wet if it will imbibe water and, conversely, a core saturated with water is oil-wet if it will imbibe oil.

Actually, the wettability of a system can range from strongly water-wet to strongly oil-water depending on the brine-oil **interactions** with the rock surface. If no **preference** is shown by the rock to either fluid, the system is said to **exhibit** neutral wettability or intermediate wettability, a condition that one might visualize as being equally wet by both fluids (50 % \ 50 % wettability).

Other descriptive terms have evolved from the realization that components from the oil may wet selected areas throughout the rock surface. Thus, **fractional wettability** implies **spotted, heterogeneous wetting** of the surface, labeled "**Dalmatian wetting**" (by Brown and Fatt). Fractional wettability means that **scattered** areas throughout the rock are strongly wet by oil, whereas the rest of the area is strongly water-wet. Fractional

wettability occurs when the surfaces of the rocks are composed of many minerals that have very different surface chemical properties, leading to variations in wettability throughout the internal surfaces of the pores.
This concept is different from neutral wettability, which is used to imply that all portions of the rock have an equal preference for water or oil. Cores exhibiting fractional wettability will imbibe a small quantity of water when oil saturation is high and also will imbibe a small amount of oil when the water saturation is high.

The term **“mixed wettability”** commonly refers to the conditions where the smaller pores are occupied by water and are water-wet, but the larger pores of the rock are **oil-wet** and a continuous **filament** of oil exists throughout the core in the larger pores. Because the oil is located in the large pores of the rock in a continuous **path**, **oil displacement** from the core occurs even at very low oil saturation; hence, the **residual oil saturation** of mixed-wettability rocks is usually low.

Mixed wettability can occur when oil containing interfacially active polar organic compounds **invade** a water-wet rock saturated with **brine**. After displacing brine from the larger pores, the interfacially active compounds react with the rock surface, displacing the remaining **aqueous** film and, thus, producing an oil-wet **lining** in the large pores. The water film between the rock and the oil in the pore is stabilized by a double layer of **electrostatic forces**. As the thickness of the film is diminished by the invading oil, the electrostatic force balance is destroyed and the **film ruptures**, allowing the polar organic compounds to displace the remaining water and react directly with the rock surface.

Wettability has a profound influence on all types of fluid-rock interactions: capillary pressure, relative permeability, electrical properties, irreducible water saturation and residual oil and water saturations. On the other hand, the wettability is affected by minerals exposed to fluids in the pores of the rock, chemical constituents in the fluids and the saturation history of the samples. Wettability presents a serious problem for core analyses because drilling fluids and core-handling procedures may change the native-state wetting properties, leading to erroneous conclusions from laboratory tests.

(***F.K. North, Petroleum Geology, London, 1985***)

25. Give Russian equivalents to the English ones.

relative adhesion	scattered areas throughout the rock
two or more immiscible fluids	have an equal preference for water or oil
water–wet brine-oil-rock system	interfacially active polar organic compounds
a film of water	profound influence
area of high oil saturation	chemical constituents in the fluids
exhibit neutral wettability	native-state wetting properties

26. Read the sentences and decide whether they are True (T) or False (F). If False (F), correct the statements.

1. In water–wet brine-oil-rock system, water will occupy the larger pores and wet the major portion of the surfaces in the smaller pores.
2. Water will saturate the smaller pores, displacing oil from the core when the system is in contact with water.
3. The wettability of a system can range from strongly water-wet to strongly oil-water depending on the brine-oil interactions with the rock surface.
4. The residual oil saturation of fractional-wettability rocks is usually low.
5. The water film between the rock and the oil in the pore isn't stabilized by a double layer of magmatic forces.
6. Compounds displace the remaining water and react directly with the oil surface when the electrostatic force balance is destroyed.

27. Answer the following questions and find the proof in the text.

1. What term is used to describe the relative adhesion of two fluids to a solid surface?
2. In what system, will water occupy the smaller pores and wet the major portion of the surfaces in the larger pores?
3. A core saturated with water is oil-wet if it will imbibe oil, isn't it?
4. When does fractional wettability occur?
5. What is neutral wettability used to imply?
6. What does the term "mixed wettability" commonly refer to?
7. Where is oil located?
8. Does oil displacement from the core occur at low oil saturation?
9. Does wettability have a profound influence on all types of fluid-rock interactions?

10. What factors affect the wettability?
11. Why does wettability present a serious problem for core analyses?

28. Complete the sentences using the terms of the text.

1. ________ is a measure of the preferential tendency of one of the fluids to ________ (spread or adhere) the surface.
2. ________ wettability implies ________ ________ wetting of the surface, labeled "Dalmatian wetting".
3. ________ wettability occurs when the surfaces of the rocks are composed of many minerals.
4. ________ wettability can occur when oil containing interfacially active polar organic compounds ________ a water-wet rock saturated with ________.
5. The water film between the rock and the oil in the pore is stabilized by a double layer of ________ ________ .
6. If the rock surface is ________ water-wet and the rock is saturated with oil, water will ________ into the smaller pores, ________ oil from the core when the system is in contact with water.
7. The film ________ , allowing the polar organic compounds to displace the remaining water and react directly with the rock surface.
8. Wettability presents a serious problem for ________ analyses.

29. Work in pairs. Compose dialogues describing primary and secondary hydrocarbon migration using the terminology of the text and communicative formulae.

30. You have to give a lecture on reservoir rock properties. Two groups work out presentations on this topic.

31. Video Lecture.

a) Listen to the lecture and find the answers to the following questions.

1. What is the lecture about?
2. What activity has always been a challenge? Why?
3. What scientific agency is mentioned in the lecture?
4. What is its main responsibility?
5. How does it solve the mystery of the planet?
6. How do geoscientists use new technology in their work?

b) Discuss the ways of oil and gas exploration.

WORDLIST

ENGLISH	RUSSIAN
adhesion	адгезия \ прилипание (вледствие смачивания) \ слипание
anisotrophy	анизотропия
aqueous	водный
interbedded	впластованный (залегающий между пластами)
saturated with	насыщенный
bedding plane	плоскость напластования
bottom water	подошвенная вода
brine	солёная вода, рассол
brine-oil (rock system)	нефтепромысловые минерализованные пластовые воды
bulk density	средняя плотность
bulk phase	фаза мощности
capillary pressure	капиллярное давление
caprock	кепрок (вышезалегающая экранирующая порода)
catagenesis	катагенез
cavern	каверна (карстовая пустота)
cavernous	пещеристый \ кавернозный \ имеющий пустоты
cleavage	кливаж \ спайность
close (packing)	плотная
close-packed system	плотно уложенная система
closure	купол \ замыкание
cohesive strength	прочность сцепления
conductivity	удельная проводимость
conduit	выводящий канал
connate water	погребенная \ реликтовая вода
consolidated – unconsolidated	Затвердевший – незатвердевший
contact angle	угол касания \ краевой угол (смачивания)
crest	антиклинальный перегиб, гребень \ сводная часть складки
curvature	искривление
dead-end	пустой
detrital (fragmentary)	обломочный

diagenesis	диагенез
diatrophism	тектоническое воздействие
directional (anisotropic) permeability	неодинаковая по различным направлениям (анизотропная \ двоякопреломляющаяся) смачиваемость
displace (v) – displacement	вытеснять– вытеснение \ смещение
distinct droplet	капля
dolomitization	доломитизация
edge water	краевая \ контурная вода
effective (intercommunicating)	действующая (эффективная) пористость (сообщающаяся \ взаимосвязанная)
electrostatic force	электростатическая сила
entry (pressure)	вход (входное давление – минимальное вытеснение из пористой среды одной жидкости другой)
equilibrium	равновесие
exhibit (v)	показывать \ проявлять
expulsion	выделение \ вытеснение
filament	канал
filament(s)	капилляр(ы)
film	плёнка
fissure	разрыв \ трещина в породе
flat	горизонтально залегающий пласт
fluid flow	поток флюидов
fluid flow equation	уравнение течения флюидов
fraction	часть \ доля
fractional wetting	смачивание отдельных пластов
fracture porosity	пористость разрыва
fracturing	трещиноватость
fresh water	пресная вода
gas cap	газовая шапка
gas-oil contact	газонефтяной контакт
gradation	постепенный переход из одного состояния в другое
grain size	размер зерен
grain volume	объем зерен
Heterogeneity	неоднородность

horizontal permeability	горизонтальная проницаемость
hydration	гидратация
imbibe(v)	пропитывать (погружение)
immiscible	несмешивающийся
impermeable	непроницаемый
interaction	взаимодействие
interconnected – interconnection	связанный - связанность
intercrystalline	интеркристаллический
interface	поверхность контакта
interfacial tension	интерфациальное натяжение
intergranular (interparticle)	межзернистый
intermediate wetting	промежуточная смачиваемость
interstitial fluids (water)	флюиды, циркулирующие в пустотах горных пород
invade(v)	проникать
irreducible (fluids)	остаточные флюиды
lattice (crystal)	решетка
leaching	выщелачивание \ вымывание
leading pore	«ведущая» пора
light hydrocarbon(s)	лёгкий углеводород
lining	внутреннее покрытие
miscellaneous (sedimentary voids)	смешанный
mixed wetting	смешанная смачиваемость
(non-)wetting	(не)смачивание
(non-)wetting phase	(не)смачивающая фаза
oil displacement	вытеснение нефти (из пласта)
oil saturation	нефтенасыщенность
oil seep	выход нефти
oil-water contact	водонефтяной контакт
oil-wet	смачиваемый нефтью
opening (s)	пора (мн. пустоты в породе)
outcrop	обнажение пород \ выход пластов на дневную поверхность
overburden pressure	давление покрывающих пород
packing arrangement	выкладка породных полос \ закладка кусковым материалом
path	путь (прохождения флюидов)
permeable	проницаемый
pitch	угол падения \ погружение

	антиклинали
plane	плоскость \ горизонт
pore size distribution	распределение пор по размерам (в породе)
pore throat	горловина пор
pore volume	поровое пространство
porosity value	значение пористости
porous	пористый
precipitates – precipitation	осадок – осаждение
preference (preferentially)	избирательность \ избирательно
preferential wetting	предпочтительная смачиваемость \ избирательное смачивание
primary (matrix) permeability	первичная проницаемость
primary (matrix) porosity	первичная пористость
primary migration	первичная миграция
producible oil	нефтеотдача
property	свойство, характеристика
random (packing)	хаотическая \ неупорядоченная (упаковка)
relative wetting	относительная смачиваемость
release (fluids)	выделение (флюидов)
reservoir rock	коллекторская порода, пористая порода пласта коллектора
residual oil saturation	остаточная нефтенасыщенность
retain(v)	удержать
rock wetting	смачиваемость горной породы
rupture(v)	разрывать \ разрушать
saddle reef	пластовая жила, имеющая форму антиклинали
salinity	солёность
saturation	насыщенность
secondary (induced) permeability	вторичная проницаемость
secondary (induced) porosity	вторичная (наведенная) пористость
secondary migration	вторичная миграция
slumping	оползание
solution porosity	пористость раствора
spotted, heterogeneous wetting (dalmatian wetting)	далматская смачиваемость
squeeze out (v)	выжимать

structural failure	структурное оседание
subcapillary	субкапиллярный
subsequent compaction	последовательное \ постепенное уплотнение
subsidence	оседание; опускание породы
tar pit	смоляная яма
tight (reservoir)	непроницаемый
tortuosity	сложность поровых каналов
trailing pore	«отстающая» пора
transition zone	переходная зона
uniformity (sorting)	однородность
uplift	давление воды снизу
vertical permeability	вертикальная проницаемость
vesicular (porosity)	везикулярный (пузырчатость вспучения)
void space	пустое пространство
vuggy	пористый
water-wet	гидрофильный \ смачиваемый водой
wet	смачивать
wettability	смачиваемость
wetting formation	смачиваемость пласта

UNIT 4

FORMATION EVALUATION

In petroleum exploration and development, **formation evaluation** is used to determine whether a potential oil or gas field is commercially viable. Essentially, it is the process of "recognizing a commercial well when you drill one".

Lead-in

How can you determine a well to be a commercial one?
What are formation evaluation tools?
What is mud logging?
What is coring?

Terms and Vocabulary

coring	отбор кернов
core barrel	керноотборник
plug	заглушка
fracture	разрыв, трещина
reservoir evaluation	оценка свойств и запасов коллектора
mooring cable	швартовный канат
sidewall coring	отбор кернов боковым керноотборником
fluid properties	свойства флюида
core bullet	боёк стреляющего керноотборника
wellbore	ствол скважины
drill stem	бурильная колонна
drilling mud	буровой раствор
formation segregation	разобщение пластов
contamination	загрязнение
abandon a well	ликвидировать скважину \ прекращать бурение по техническим или геологическим причинам
bit	долото
full core	керн, полученный при колонковом бурении
coring gun	стреляющий боковой керноотборник
differential sticking	прихват бурильной колонны за счёт перепада давления в стволе скважины
cuttings (pl)	буровой шлам

core barrel	керноотборник, колонковая труба \ цилиндр
retain (v)	сохранять; удерживать
encounter (v)	встретить(ся), столкнуться
moor to (v)	причалить; пришвартовать(ся)
coherent rock	сцементированный
intact (adj)	целый, неповреждённый

1. Read the text "Coring" and do the exercises.

Coring

One way to get more samples of the formation at a certain depth in the well is **coring**. There are two techniques commonly used at present. The first is the "whole core", a cylinder of rock, usually about 3" to 4" in diameter and, with good luck, up to 50–60 feet long. It is cut with a **core barrel**, a hollow pipe tipped with a ring shaped, diamond chip studded **bit** that can cut a **plug** and **retain** it in a trip to the surface.

If no shales or **fractures** are **encountered**, the full 60 feet length of the core barrel can be filled. More often the plug breaks while drilling, usually at the aforementioned shales or fractures and the core barrel jams, very slowly grinding the rocks in front of it to powder. This signals the driller to give up on getting a full length core and to pull up the pipe.

Taking a **full core** is an expensive operation that usually stops or slows drilling for at least the better part of a day. A full core can be invaluable for later **reservoir evaluation**. One of the tragedies of the oil business is the huge amount of money that has been spent for cores that have been lost because of the high cost of storage. Once a section of well has been drilled, there is, of course, no way to core it without drilling another well.

The other, cheaper, technique for obtaining samples of the formation is **Sidewall Coring**. In this method, a steel cylinder – a coring gun – has hollow-point steel **bullets** mounted along its sides. These bullets are **moored to** the gun by short steel cables. The **coring gun** is lowered to the bottom of the well and the bullets are fired individually as the gun is pulled up the hole. The **mooring cables** ideally pull the hollow bullets and the enclosed plug of formation loose and the gun carries them to the surface.

Advantages of this technique are low cost and the ability to sample the formation after it has been drilled. Disadvantages are possible non recovery because of lost or misfired bullets and a slight uncertainty about the sample depth. Sidewall cores are often shot "on the run" without stopping at each core point because of the danger of **differential sticking**. Most service company personnel are skilled enough to minimize this problem, but it can be significant if depth accuracy is important.

Cores are cut where specific lithologic and rock parameter data are required. They are cut by a hollow core barrel which goes down around the rock core as drilling proceeds. Cores are preferable to **well cuttings** because they produce coherent rock. They are significantly more expensive to obtain, however.

A more serious problem with cores is the change they undergo as they are brought to the surface. It might seem that cuttings and cores are very direct samples but the problem is whether the formation at depth will produce oil or gas. Sidewall cores are deformed and compacted and fractured by the bullet impact. Most full cores that are taken from any significant depth expand and fracture as they are brought to the surface and removed from the core barrel.

Coring supplies **intact** specimens of the formation. It is the only method of making “direct” measurements of rock and **fluid properties**. This means that core samples are one of the most valuable sources of data for the study of subsurface rocks and reservoirs. Therefore, coring is a vitally important method of obtaining data for geologists, drilling engineers, petrophysicists, and reservoir engineers.

Drill Stem Tests

Formation evaluation by obtaining samples of formation fluid and formation pressure data is made possible by **drill stem testing** procedures. The testing equipment is lowered into the **wellbore** on the drill pipe and put into place by seating a packer that seals off formation from **contamination** by **drilling mud**. The tool is opened and fluid samples and pressure data are obtained.

Drill stem tests are run in wells in which promising hydrocarbon shows (indications) are encountered in cores and samples. **Segregation** of the individual formations produces results from specific intervals. Pressure data are evaluated to determine the productive potential of the formation being tested. These data and fluid information can facilitate decisions on how the well is to be completed: as a producing well or as a dry hole to be plugged and **abandoned**.

Development of an individual reservoir can also be increased by evaluation of pressure and fluid data. Data similarities suggest the same reservoir.

Dissimilar data are potentially indicative of separate reservoirs, permeability barriers or **contamination**.

(http://www.wikipedia.org)

2. Define following terms with their similar meaning in Russian.

mud logging	core barrel
coring	specimen
technique	productive
cylinder	potential
packer	

3. Give Russian equivalent to the following terms.

a ring shaped, diamond chip studded bit	slight uncertainty about the sample depth
core barrel jams	danger of differential sticking
bullets are moored to the gun	depth accuracy is important
misfired bullets	coherent rock

4. Find the answers to the following questions.

1. How are the samples of the formation at a certain depth obtained?
2. What techniques are commonly used at present?
3. What is the length of a core barrel?
4. What does the length of the core barrel depend on?
5. Why is taking a full core an expensive operation?
6. Do you know any cheaper coring technique?
7. Cores are not preferable to well cuttings, are they?
8. Are cores hard to store?
9. What are the advantages and disadvantages of coring?
10. Is formation evaluation possible to obtain by other tests?
11. What data can facilitate decisions on how the well is to be completed?
12. Can development of an individual reservoir be increased? Prove this.

Terms and Vocabulary

logging	геофизические исследования в скважинах, каротаж
wireline well-logging technique	канатный метод каротажа
acoustic velocity	акустическая скорость
velocity acoustic log	диаграмма акустического каротажа по скорости
resistivity	удельное сопротивление
caliper log	кавернограмма
drilling site	буровая площадка
mudcake	глинистая корка (образующаяся на стенках скважины в результате фильтрации промывочной жидкости в области пористых и проницаемых отложений)
mud filtrate	фильтрат бурового раствора
flushed zone	зона проникновения фильтрата (бурового раствора)
invaded zone	зона проникновения (фильтрата бурового раствора)
spontaneous (Self) Potential Log (SP Log)	диаграмма каротажа потенциалов самопроизвольной поляризации
resistivity log	каротаж по методу сопротивления
conductivity	удельная проводимость
induction electrical log	диаграмма индукционного каротажа
uninvaded zone	не затронутая проникновением зона
radioactivity log	диаграмма радиоактивного каротажа (гамма-каротажа)
gamma-ray density log	диаграмма гамма-каротажа плотности
neutron log	диаграмма нейтронного каротажа
density log	диаграмма плотностного каротажа
sonic log	акустический каротаж
acoustic log	диаграмма акустического каротажа

5. Read the text "(Wire) Well Logging Techniques" and do the exercises.

Wire Well Logging Techniques

A. Electric, Radioactivity and Acoustic (Sonic) Logging

Subsurface geological information can be obtained by **wireline well-logging techniques**. Measurements are made of the electrical, radioactive and acoustic properties of rocks and their contained fluids encountered in the wellbore. Several types of measurements produce information on formation rock **acoustic velocity**, density, radioactivity, porosity, **conductivity, resistivity**, fluid saturation and permeability.

Rock lithology, formation depth and **thickness** and fluid type can also be determined. **Caliper logs** measure borehole diameter. Geologic maps and cross-sections are readily constructed from a variety of well-log data and assist in understanding facies and geometric relationships and the locations of wildcat and development **drilling sites**.

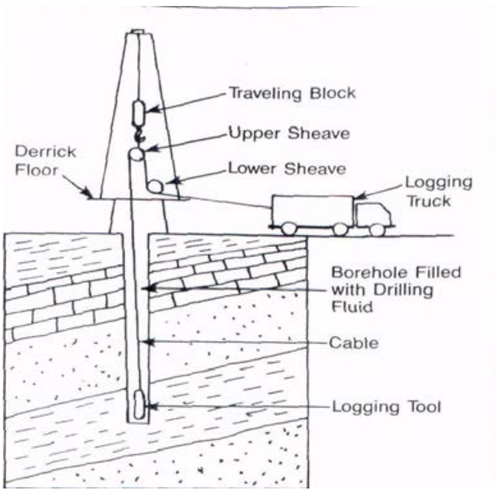


Fig.5. Electric logging schematic

Logs are obtained by lowering a sonde or tool attached to a cable or wire to the bottom of a wellbore filled with drilling mud. Electrical, nuclear or acoustic energy is sent into the rock and returns to the sonde or is obtained from the rock and measured as the sonde is continuously raised from the wellbore bottom at a specific rate.

The well is logged when the sonde arrives at the top of the interval to be investigated. Formation water saturation, permeability, porosity, radioactivity and resistivity are rock properties that affect logging and the types of logs to be obtained.

As a wellbore is drilled the rock formations and their contained fluids are penetrated by the bit and affected by the drilling process. Drilling mud invades the rock surrounding the wellbore, affects the logging of the hole and must be accounted for. A permeable, porous formation which has been penetrated and affected by drilling and invasion by drilling mud, develops parameters important to logging. Significant of these parameters from the center of the wellbore outward into the formation are hole diameter, drilling mud, **mudcake, mud filtrate, flushed zone, invaded zone and uninvaded zone.**

B. Spontaneous (Self) Potential Logs (SP Logs) are used to detect permeable formations and their upper and lower contacts, volume of shale, where present, in permeable formations, and to determine the resistivity of water in permeable formations.

C. Resistivity logs illustrate permeable formations, formation fluid (water versus petroleum) content, and the porosity characteristics of formation resistivity. **Resistivity** represents the tendency of rock materials and their contained fluids to resist the flow of electrical current. Salt water contains dissolved salt and, because it conducts electricity very easily, has low resistivity. Fresh water contains no salt and demonstrates low **conductivity** and high resistivity. Rock materials that contain salty or fresh water offer differing degrees of resistivity and response on **resistivity logs**. Formation resistivity is measured by **induction electrical logs.**

D. Radioactivity logs are **gamma-ray, neutron and density logs**, which are often obtained together.
Gamma-ray logs measure formation radioactivity and are useful in identification and correlation of formation rock types. Gamma-ray logs are useful in estimating shale volume in potential or actual reservoir sandstone or carbonate.

Neutron logs illustrate formation porosity by measuring hydrogen ions. Water \ oil-filled, shale-free, clean formations will be logged as liquid filled porosity. Zones of low porosity on the neutron log correspond to zones of higher radioactivity on the gamma-ray log and are reflective as approximate mirror images of each other.

Density log evaluates formation porosity. It detects gas, evaluates hydrocarbon density and complex rock sequences, identifies evaporate minerals and shale-bearing sandstone units. It is often taken in the same log suite as gamma-ray logs.

E. Acoustic logs illustrate formation porosity. The acoustic log measures the velocity of a sound wave through a rock medium. Sound wave velocity is dependent upon lithology and porosity. The **sonic log** illustrates both the sound wave transit time, which indicates sound velocity and the related porosity of the rock.

6. Define the following terms with the similar meaning in Russian.

acoustic logs
sonic logs
mudcake
mud filtrate
drilling site
rock lithology
radioactivity
sandstone
rock formation
porosity
nuclear energy

7. Give English equivalents to the Russian words.

удельное сопротивление	измерять
каротаж	радиоактивность формации
метод каротажа	пористость породы
плотность	не затронутая проникновением зона
зонд	глинистая корка
скорость	ствол скважины
оценивать	диаметр скважины

8. Complete the sentences using the following terminology.

1. Several types of measurements produce information on formation rock ______ _______, density, radioactivity, porosity, ______, _______, fluid saturation and permeability.
2. ______ _______ invades the rock surrounding the wellbore, affects the logging of the hole and must be accounted for.
3. ______ _______ measure formation radioactivity.
4. _______ ________ illustrate formation porosity.
5. ________ _______ evaluates formation porosity.
6. Formation resistivity is measured by ______ _______ ______.
7. The acoustic log measures the _________ of a sound wave through a rock medium.
8. Logs are obtained by lowering a _______ or tool attached to a cable or wire to the bottom of a well bore filled with ______ ____.

9. Answer the following questions.

1. What properties of rocks are taken into consideration when measurements are made?
2. What information is produced?
3. How do geologic maps and cross-sections help you in your work?
4. What equipment is necessary to obtain logs?
5. When do you think the well is logged?
6. What affects the logging?
7. Could you name significant parameters from the center of the wellbore outward into the formation?
8. What are SP Logs used for?
9. What do resistivity logs illustrate?
10. What are radioactivity logs for?
11. Are acoustic logs important?

10. Groupwork. You are future reservoir engineers searching for commercially viable potential of oil or gas field. Discuss the way you are going to evaluate the formation.

Terms and Vocabulary

stimulation	возбуждение скважины, интенсификация притока флюидов в скважину
acidizing	кислотная обработка
injection	нагнетание
acid fluid solution	кислый электролит
dissolve(v)	растворять
matrix (low pressure) acidizing	матричная обработка (под давлением ниже давления гидроразрыва пласта)
acid fracturing (high pressure acidizing)	кислотный разрыв
fracturing	гидроразрыв пласта
proppant fracturing	гидроразрыв с расклинивающим агентом
propellent stimulation	интенсификация притока флюидов в скважину при помощи пропеллента
hydraulic fracturing	гидравлический разрыв пласта
flow capacity	пропускная способность
“bridging”	закупоривание, перекрывание
treatment	кислотная обработка

producing zone	продуктивная зона (в скважине)
foreign solid	посторонние механические примеси
formation damage	повреждение продуктивного пласта

11. Scan the text "Well stimulation". Find the particular information:

- what stimulation is;
- techniques for well stimulation;
- definition for each type of the technique.

Well Stimulation

Sometimes once the well is fully completed, further **stimulation** is necessary to achieve the planned productivity. There are a number of stimulation techniques:

Acidizing

This involves the injection of chemicals to eat away at any skin damage, "cleaning up" the formation, thereby improving the flow of reservoir fluids. Acidizing is the process of injecting an acid fluid solution into a **producing zone(s)** for the purpose of dissolving **foreign solids** or rock, enlarging existing channels or creating new ones. The channels are opened or enlarged as a result of a chemical reaction. There are two basic types of acidizing:

1. **matrix (low pressure) acidizing** – is used on wells that have **formation damage**. The acids injected below the fracturing point so that the acid is allowed to work through the natural pores of the rock. This procedure is usually used on sandstone formations;
2. **acid fracturing (high pressure acidizing)** – uses a sufficient volume of acid under high pressure to fracture a formation, allowing the acid to penetrate further into the formation. Acid fracturing is used most often on carbonate formations (limestone and dolomite).

Fracturing

This means creating and extending a fracture from the perforation tunnels deeper into the formation increasing the surface area for formation fluids to flow into the well as well as extending past any possible damage near the wellbore. This may be done by either injecting fluids at high pressure (**hydraulic fracturing**), injecting fluids laced with round granular material (**proppant fracturing**) or using explosives to generate a high speed gas flow (**propellent stimulation**).

Hydraulic fracturing is the process of injecting a special fluid, under high pressure into a producing zone to create and extend the produced fractures or high-conductive channels into a formation some distance from the wellbore. The channels are maintained with the aid of proppants or propping materials introduced during the fracturing process, after the fractures have been initiated and extended. The primary objective of this procedure is to stimulate a well to increase its productivity. Hydraulic fracturing is normally used when low permeability is a characteristic of the reservoir in general.

Hydraulic fracturing is being used more and more as a well and reservoir stimulation technique. It is used to:

1. improve the productivity of a well by creating penetrating reservoir fractures in a formation increasing its **flow capacity**;
2. improve the ultimate recovery from a well by extending the flow channels further into the formation;
3. aid in secondary recovery operations by improving the flow capacity in a formation near the wellbore which increases the rate of injection in disposal or **pressure maintenance wells**.

Perforation plays a key role in the success of hydraulic fracturing. HF has two main steps: fracture creation by application of pressure, and injection of fluid carrying proppant, which holds open the fractures to allow production. Once the fracture is created, perforations provide the entrance to the fracture for the proppant. Perforation diameter must be sufficient to prevent **"bridging"**, accumulation of proppant that blocks the entrance hole, preventing further **treatment**.

12. Groupwork. Discuss the task given above. Use the communicative formulae.

13. Pay attention to the underlined stress in the following words.

<u>**ar**</u>ti<u>**fi**</u>cial ef<u>**fe**</u>ctive inc<u>**rea**</u>se re<u>**du**</u>ction dep<u>**le**</u>tion suf<u>**fi**</u>cient
<u>**re**</u>servoir un<u>**ne**</u>cessary hori<u>**zo**</u>ntal <u>**hy**</u>dro<u>**sta**</u>tic pre<u>**ve**</u>nt e<u>**xi**</u>st
pro<u>**vi**</u>de <u>**me**</u>chanism dis<u>**so**</u>lve

14. Read the text "Drive Mechanisms" and do the exercises. First study the following specific term definitions to help you understand the text.

oil sands	sand or porous rock saturated with oil.
drive	natural pressure which forces oil to the surface.
dissolved – gas drive	pressure from gas dissolved in the oil. The dissolved gas expands and forces the oil to move.
gas-cap drive	pressure from a large amount of gas above the oil. The gas expands and forces the oil to move.
water drive	pressure from water below the oil that forces the oil to move.
Christmas tree	a system of valves to control the pressure of the drive in a particular well. It controls the rate of flow to the surface.
secondary recovery	reworking of an oil field that previously could not be brought to the surface.
proved reserves	the amount of oil discovered but still in the ground.
ultimate reserves	the amount of oil believed to be in the ground based on estimates by oil geologists. Both proved reserves and ultimate reserves are measured in barrels of oil.
pool	a single discrete accumulation of oil in a single reservoir with a single trap.
field	a) an area consisting of a single reservoir or multiple reservoirs all grouped on, or related to the same individual geological structural feature and \ or stratigraphic condition; b) set of porous rocks containing hydrocarbons.
reserves	sources discovered by successful exploration.
resource	portions of reserves that have been shown to be accessible and recoverable under current economic and technologic conditions.

Drive Mechanisms

The term "oil pools" refers to deposits of petroleum as though there were underground lakes of oil. A more accurate term, however, is one that is often used in the petroleum industry: oil sands.
The deposits are, in other words, more often like piles of sand or porous rock that have been saturated with oil. Oil does not really flow rapidly through sand or rock, of course, and so it must be pushed or driven. Natural flow is when the reservoir delivers fluid to the well bore. Sufficient pressure energy is needed to lift the fluid to the surface.

There are three kinds of natural ***drives,*** as the forces that push the oil are called. Each drive involves the gas and water that are almost always found with oil.

First is the **dissolved-gas drive**. Gas is dissolved in the oil. As it expands, it exerts the pressure which pushes the oil through rock or sand. Recovery is slow when this type of drive is encountered.

Second is the **gas-cap drive**. Gas has not only dissolved in the oil: a large amount of it has formed above the oil. As the gas expands, it pushes the oil through the rock or sand at a more rapid rate than when only dissolved gas is present.

Third is the **water drive**, in which there is a large amount of water below the oil. Pressure forces the water upward into the oil-bearing rock or sand and moves the oil ahead of it.

If none of these drives is present, the oil must be pumped to the surface. This is more expensive than when natural drives are present, since power for the pumping must be supplied.

Artificial lift – is when insufficient pressure energy exists. In this case the well may require assistance by the application of artificial lift. This provides all or portion of the vertical lift pressure losses.

Gravity drive is less common, although it's an ideal recovery mechanism. The hydrostatic pressure on the oil column and pressure of the gas cap provide the drive to a producing well system. For this drive to be effective it requires maximum structural dip, low oil viscosity, good vertical and horizontal permeability.

Compaction drive. The oil in the reservoir (pore space) is compressed by the weight of overlying sediments and pressure of the fluid is withdrawn from the reservoir, then the pressure depletion can be compensated by the overlying sediments compacting lower sediments. This impact creates a reduction on porosity and thus a potential compression effect.

Combination drive. The production of fluids in the majority of reservoirs is not controlled by one but often by several drive mechanisms in combination.

In the early days of the oil industry, new wells often came in as gushers. In these wells great underground pressure forced the oil upward without any control, and it was necessary to wait until it dropped enough for the oil to flow at a normal rate before any of it could be recovered. Of course, a great deal of oil wasted when a well gushed in this way.

Today, with the great increase in the price of oil – and therefore the value – great care is taken to prevent gushers. They are indeed quite rare, thanks to the use of modern technology. The petroleum industry today is very much concerned about acquiring the greatest possible amount of oil from each deposit without unnecessary waste.

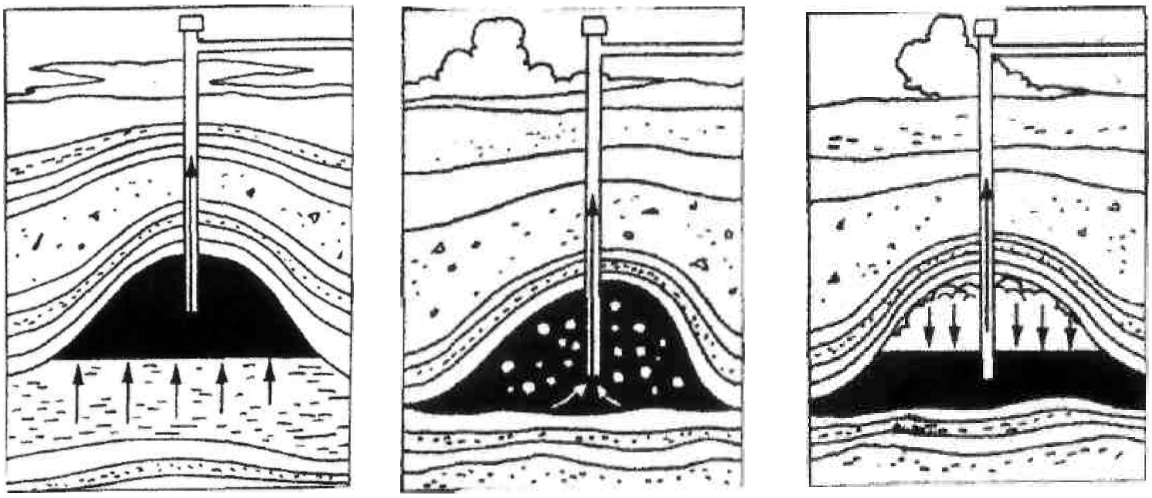


Fig.6. Drive Mechanisms:
1. water drive 2. dissolved-gas drive 3. gas-cap drive

15. Give synonyms to the following words.

1. oil pools – 2. deposits of petroleum – 3. drive – 4. push through – 5. exist – 6. help –	7. part – 8. need – 9. make – 10. extraction – 11. uncontrolled pressure well – 12. decrease –

16. Define the following terms.

1. drive
2. dissolved-gas drive
3. gas-cap drive
4. water drive
5. artificial lift
6. gravity drive
7. compaction drive
8. combination drive

17. State whether the following statements are true or false. Correct the false statements.

1. Oil does not really flow rapidly through sand or rock.
2. To lift the fluid to the surface small amount of energy is needed.
3. The forces that push the oil are called natural ones.
4. As gas expands, it exerts the pressure which pushes the oil through the reservoir.
5. Artificial lift – is when sufficient pressure energy exists.
6. For the gravity drive to be effective low structural dip is required.
7. A great deal of oil wasted when a well gushed.
8. The petroleum industry today is concerned about stopping wasteful gushers.

18. Answer the following questions.

1. The term “oil pools” refers to deposits of petroleum, doesn’t it?
2. What do deposits look like?
3. When does natural flow occur?
4. Are there two kinds of natural drives?
5. In what condition does gas occur in the oil?
6. What type of natural drive makes the recovery slow?
7. Why must oil be pumped to the surface?
8. In what wells is the pressure without control?

19. In pairs discuss the advantages and disadvantages of drive mechanisms you know.

Express your own point of view using the following expressions:

I think …	Я думаю …
I believe …	Я полагаю …
As I see it, …	Как я это вижу, …
As I understand it …	Насколько я понимаю …
I should say …	Я бы сказал …
From my point of view …	С моей точки зрения …
My own point of view of the problem is …	Моя личная точка зрения на данный вопрос состоит в (том, что) …

Ex.20. You will hear a part of a lecture on Petroleum Products.

a) For statements 1–7 complete the notes that summarize what the speaker says. You will need to write a word or a short phrase in each box.

1. Oil and natural gas products give us .

2. will continue to be a reliable source.

3. The electricity – warm in winter and cool in summer.

4. – they contribute to the manufacture of everything from medicines to clothing and .

5. To the latest computers and .

6. Technology provides us with .

7. It provides us with them .

b) Tell about petroleum products using the above given information.

WORDLIST

ENGLISH	RUSSIAN
abandon a well	ликвидировать скважину, прекращать бурение по техническим или геологическим причинам
acid fluid solution	кислый электролит
acid fracturing (high pressure acidizing)	кислотный разрыв
acidizing	кислотная обработка
acoustic logs	диаграмма акустического каротажа
acoustic velocity	акустическая скорость
bit	долото
“bridging”	закупоривание, перекрывание
caliper logs	кавернограмма
Christmas tree	фонтанная арматура («ёлка»)
conductivity	удельная проводимость
contamination	загрязнение
core barrel	керноотборник
coring	отбор кернов
coring gun	стреляющий боковой керноотборник
cuttings	буровой шлам
core bullet	боёк стреляющего керноотборника
density logs	диаграмма плотностного каротажа
differential sticking	прихват бурильной колонны за счёт перепада давления в стволе скважины
dissolve	растворять
dissolved-gas drive	режим растворённого газа
drill stem	бурильная колонна
drilling mud	буровой раствор
drilling site	буровая площадка
drive	пластовый режим
field	месторождение
flow capacity	пропускная способность
fluid properties	свойства флюида
flushed zone	зона проникновения фильтрата (бурового раствора)
formation segregation	разобщение пластов
fracture	разрыв, трещина
fracturing	гидроразрыв пласта

full core	керн, полученный при колонковом бурении
gamma-ray log density logs	диаграмма гамма- каротажа плотности
gas-cap drive	газонапорный режим
hydraulic fracturing	гидравлический разрыв пласта
induction electrical log	диаграмма индукционного каротажа
injection	нагнетание
invaded zone	зона проникновения (фильтрата бурового раствора)
logging	геофизические исследования в скважинах, каротаж
matrix (low pressure) acidizing	матричная обработка (под давлением ниже давления гидроразрыва пласта)
mooring cable	швартовный канат
mud filtrate	фильтрат бурового раствора
mudcake	глинистая корка (образующаяся на стенках скважины в результате фильтрации промывочной жидкости в области пористых и проницаемых отложений)
neutron logs	диаграмма нейтронного каротажа
oil sands	нефтяные пески
plug	заглушка
pool	залежь, бассейн
propellent stimulation	интенсификация притока флюидов в скважину при помощи пропеллента
proppant fracturing	гидроразрыв с расклинивающим агентом
proved reserves	доказанные запасы
radioactivity logs	диаграмма радиоактивного каротажа (гамма-каротажа)
reserves	запасы
reservoir evaluation	оценка свойств и запасов коллектора
resistivity	удельное сопротивление
resistivity logs	каротаж по методу сопротивления
resource	ресурсы
secondary recovery	вторичная добыча
sidewall coring	отбор кернов боковым керноотборником
sonic logs	акустический каротаж

spontaneous (self) potential logs (SP Logs)	диаграмма каротажа потенциалов самопроизвольной поляризации
stimulation	возбуждение скважины, интенсификация притока флюидов в скважину
treatment	кислотная обработка
ultimate reserves	суммарные запасы
uninvaded zone	не затронутая проникновением зона
velocity acoustic logs	диаграмма акустического каротажа по скорости
water drive	водонапорный режим
wellbore	ствол скважины
wireline well-logging technique	канатный метод каротажа

APPENDIX

USING OIL

Crude oil is a mixture of many different *hydrocarbons* – chemicals which contain only hydrogen and carbon atoms.
Crude oil is not much used until it is separated into more useful parts, called *fractions*. This is done by fractional distillation.
Most of the fractions are burnt as fuels. The rest go to make plastics, detergents and many other important chemicals.

1. What is a hydrocarbon?

2. Octane is a hydrocarbon which has eight carbon atoms. Which fraction would you find it in?

3. Which property of hydrocarbons is used to separate them?

4. Which fraction has the lowest boiling range?

5. Which fraction would be the hardest to boil?

6. Which of the fractions are burnt as fuels?

7. Which fraction do you think there is most demand for in the world?

8. What do you think would happen to the price of crude oil if:

   (a) all countries banned the use of nuclear power?

   (b) the Persian Gulf, through which most of the West's oil is carried, was closed by war?

9. Decide what *you* think might happen if the oil runs out.

10. Write a paragraph of 100-150 words explaining what you think will happen.

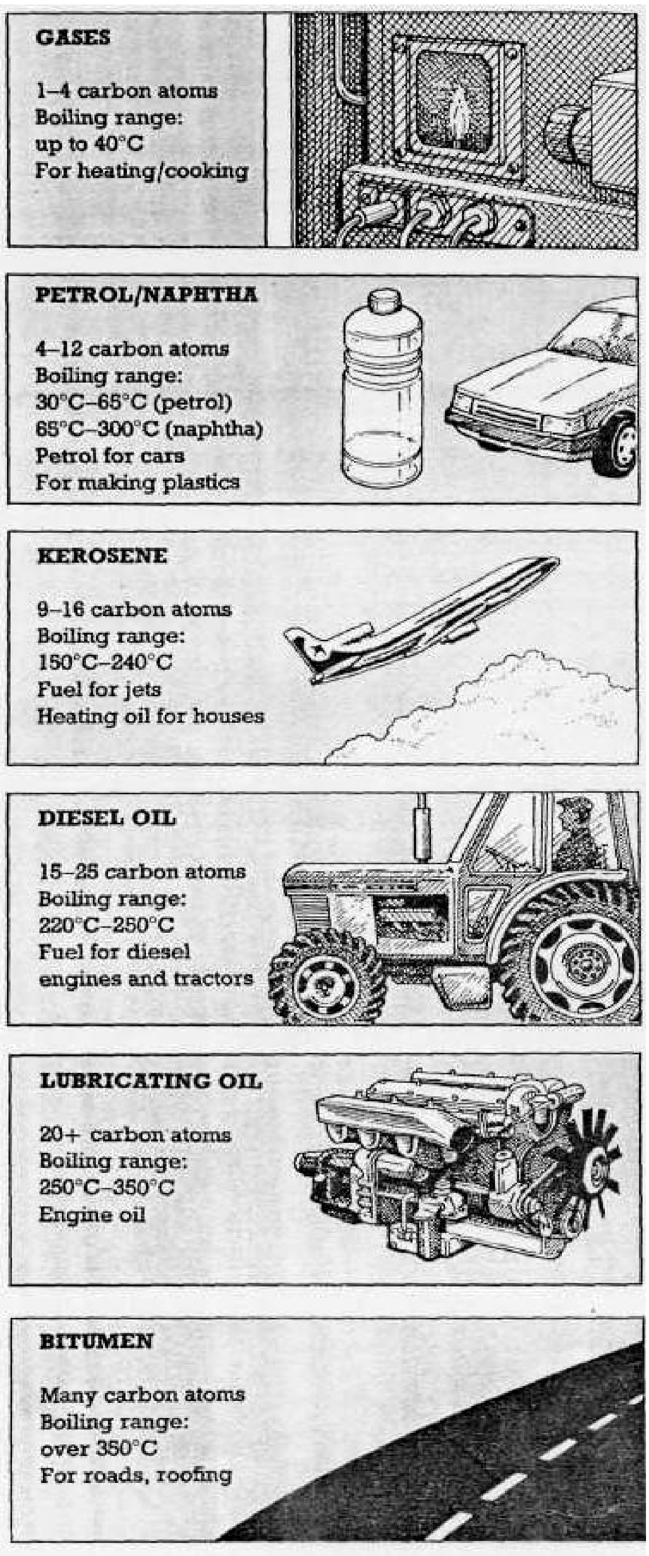


Fig. 7. The Fractions

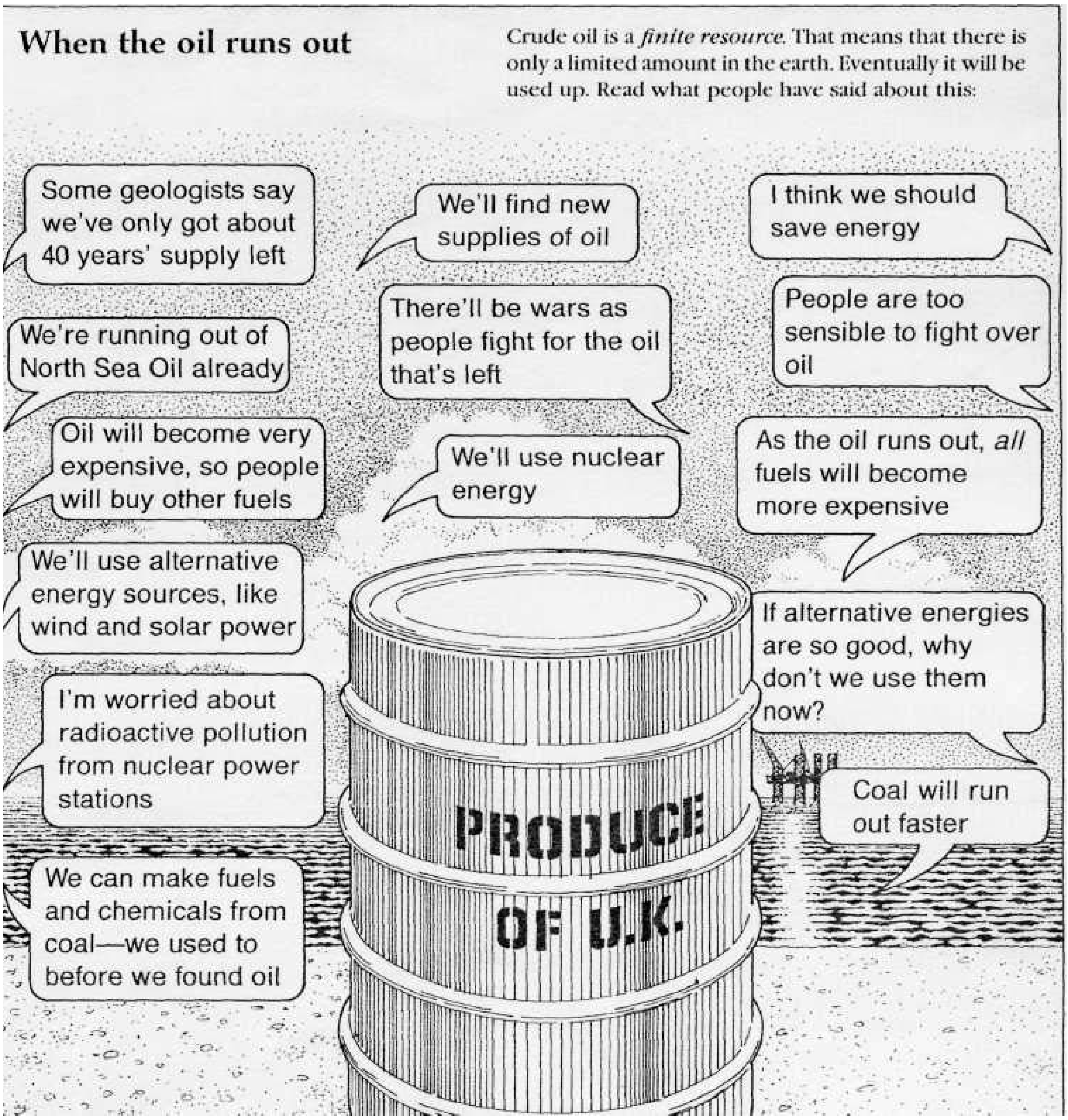


Fig. 8. When the oil runs out.

(*Stephen Beer, David Edwards "Thinking Through Science", London, 1989)*

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Chapter 3

DRILLING

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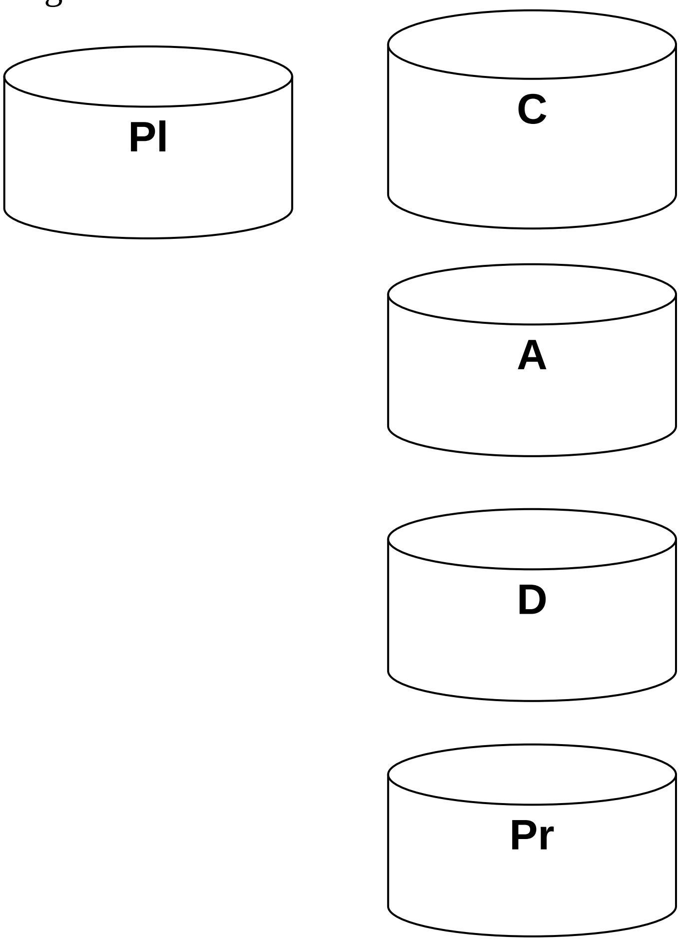
UNIT 1

LIFE OF A WELL

An **oil well** is a term for any perforation through the Earth's surface designed to find and release both oil and gas hydrocarbons.

Lead-in

Life of a well can be divided up into five segments. What are they (in Russian)? List the words in English and place the blocks according to the life stages of a well:



Terms and Vocabulary

abandonment	закрытие (ликвидация скважины)
completion	заканчивание
downhole pressure	давление в скважине
drilling fluid	буровая жидкость
drilling rig	буровая установка
drilling site	буровая площадка
enhanced recovery	повышенная норма добычи
oil rig	нефтяная вышка
production zone	продуктивная зона
reservoir	коллектор
produce (v)	добывать
workovers	капитальный ремонт скважины

1. Pay special attention to the pronunciation of the following words.

se**cur**e **tu**bu**l**ar **re**servoir red**u**ndant p**er**m**ea**bility arti**fic**ial rem**edia**l [rimi:djel] te**ch**ni**que** l**ia**bility pro**h**ibitive a**cce**ss ter**tia**ry

2. Pay attention to the underlined stress in the following words.

Ef**<u>fect</u>** ce**<u>ment</u>** in**<u>te</u>**grity **<u>re</u>**servoir **<u>per</u>**mea**<u>bi</u>**lity re**<u>me</u>**dial tech**<u>nique</u>** lia**<u>bi</u>**lity

3. Define the following terms with their similar meaning in Russian.

Hydrocarbons natural compressor paraffin coil tubing technique concrete cement

4. You are going to learn some vocabulary to help you understand the text. Study the following dictionary entries, paying attention to specific term definition.

<u>Well</u>

1. An open space extending vertically through the floors of a building, as for stairs or ventilation.
2. An abundant source.
3. A mineral spring.
4. A container or reservoir for a liquid, such as ink.

5. A deep hole or shaft sunk into the earth to obtain water, oil, gas, or brine.

<u>Screen</u>

1. The movie industry.
2. A body of troops or ships sent in advance of or surrounding a larger body to protect or warn of attack.
3. A movable device, especially a framed construction such as a room divider or a decorative panel, designed to divide, conceal, or protect.
4. A coarse sieve used for sifting out fine particles, as of sand, gravel, or coal.

<u>Collar</u>

1. A necklace.
2. An arrest, as of a criminal (slang).
3. The part of a garment that encircles the neck.
4. A restraining or identifying band of leather, metal, or plastic put around the neck of an animal.
5. Any of various ring-like devices used to limit, guide, or secure a machine part.

<u>Hole</u>

1. A fault or flaw.
2. An animal's hollowed-out habitation, such as a burrow.
3. An ugly, squalid, or depressing dwelling.
4. A hollowed place in something solid; a cavity or pit.
5. An opening or perforation.

<u>Completion</u>

1. A forward pass that is caught by a receiver.
2. The act of finishing or the state of being finished.

<u>Washout</u>

1. A total failure or disappointment.
2. One who fails to measure up to a standard, especially one who fails a course of training or study.
3. Erosion of a relatively soft surface, such as a roadbed, by a sudden gush of water, as from a downpour or floods.

5. Read the following texts and do the exercises.

Drilling

The well is created by drilling a hole 5 to 30 inches (13–76 cm) in diameter into the earth with an **oil rig** which rotates a **drill bit**. After the hole is drilled, a steel pipe (casing) slightly smaller than the hole is placed in the hole, and

secured with cement. The casing provides structural **integrity** to the newly drilled wellbore in addition to isolating potentially dangerous high pressure zones from each other and from the surface. This process is all facilitated by a **drilling rig** which contains all necessary equipment to **circulate the drilling fluid**, **hoist** and turn the pipe, control **downhole pressures**, remove **cuttings** from the **drilling fluid**, and generate onsite power for these operations.

Terms and Vocabulary

drilling	бурение
oil rig	нефтяная вышка
drill bit	буровое долото
Hole	отверстие, выработка малого сечения, скважина
steel pipe (casing)	обсадная колонна
secure(v)	закреплять
cement	цементный раствор
integrity	целостность
drilling rig	буровая установка
drilling site	буровая площадка
circulate fluid	прокачивать буровой раствор по системе
hoist	подъем
downhole pressure	давление в скважине
drilling fluid	буровая жидкость
cuttings	буровой шлам

Completion

After drilling and casing the well, it must be 'completed'. Completion is the process in which the well is enabled **to produce** oil or gas. In a **cased-hole completion**, small holes called **perforations** are made in the portion of the casing which passed through the **production zone**, to provide a path for the oil to flow from the surrounding rock into the **production tubing**. In open **hole completion**, often 'sand screens' or a 'gravel pack' is installed in the last drilled, uncased reservoir section. These maintain structural integrity of the wellbore in the absence of casing, while still allowing flow from the reservoir into the wellbore. **Screens** also control the migration of **formation sands** into **production tubulars** and surface equipment, which can cause **washouts** and other problems, particularly from **unconsolidated sand** formations in offshore fields.

After a flow path is made, acids and **fracturing fluids** are pumped into the well to fracture, clean, or prepare and stimulate the **reservoir rock** to produce hydrocarbons into the wellbore. Finally, the area above the **reservoir section** of the well is packed off inside the casing, and connected to the surface via a smaller diameter pipe called tubing. This arrangement provides a **redundant** barrier to leaks of hydrocarbons as well as allowing damaged sections to be replaced. Also, the smaller diameter of the tubing produces **hydrocarbons** at an increased velocity in order to overcome the hydrostatic effects of heavy fluids such as water.

In many wells, the natural pressure of the subsurface reservoir is high enough for the oil or gas to flow to the surface. However, this is not always the case, especially in **depleted fields** where the pressures have been lowered by other **producing wells**, or in low **permeability** oil reservoirs. Installing a smaller diameter tubing may be enough to help the production, but **artificial lift methods** may also be needed. Common solutions include downhole pumps, gas lift, or surface pump jacks. The use of artificial lift technology in a field is often termed as "**secondary recovery**" in the industry.

Terms and Vocabulary

completion	заканчивание скважины
produce (v)	добывать
cased-hole completion	заканчивание скважины посредством обсадной колонны
perforation	перфорационное отверстие
production zone	продуктивная зона
production tubing	эксплуатационная насосно-компрессорная колонна
hole completion	заканчивание скважины
gravel pack	гравийный фильтр
screen	фильтр
formation sand	песок из пласта
production tubular	эксплуатационная колонна
washout	размыв, отверстие в бурильной трубе
unconsolidated sand	неуплотненный песок
fracturing fluid	жидкость для гидроразрыва
reservoir rock	порода-коллектор
reservoir section	коллекторская порода
leak	утечка, течь
redundant	излишний, избыточный, резервный
depleted field	истощенное месторождение

producing well	добывающая скважина
permeability	проницаемость
artificial lift methods	методы механизированной добычи
secondary recovery	вторичное извлечение

Production

The production stage is the most important stage of a well's life, when the oil and gas are produced. By this time, the oil rigs and **workover rigs** used to drill and complete the well have moved off the wellbore, and the top is usually outfitted with a collection of valves called a "Christmas Tree". These valves regulate pressures, control flows, and allow access to the wellbore in case further completion work needs to be performed. From the outlet valve of the Christmas Tree, the flow can be connected to a distribution network of pipelines and tanks to supply the product to **refineries**, natural gas compressor stations, or oil export terminals.

As long as the pressure in the reservoir remains high enough, the Christmas Tree is all that is required to produce the well. If the pressure depletes and it is considered economically viable, an artificial lift method mentioned in the completions section can be employed.

Workovers are often necessary in older wells, which may need smaller diameter tubing, **scale** or paraffin removal, repeated acid matrix jobs, or even completing new zones of interest in a **shallower reservoir**. Such **remedial** work can be performed using workover rigs – also known as **pulling units** – to pull and replace tubing, or by the use of a well intervention technique called **coiled tubing.**

Enhanced recovery methods such as **waterflooding**, **steam flooding**, or CO_2 flooding may be used to increase reservoir pressure and provide a "sweep" effect to push hydrocarbons out of the reservoir. Such methods require the use of **injection wells**, and are used when facing problems with reservoir pressure depletion, high **oil viscosity**, or can even be employed early in a field's life; in certain cases – depending on the reservoir's geomechanics – reservoir engineers may determine that ultimate **recoverable oil** may be increased by applying a waterflooding strategy early in the field's development rather than later. The application of such **enhanced recovery** techniques is often termed as **"tertiary recovery"** in the industry.

Terms and Vocabulary

production	выработка, добыча
workover rig	установка для капитального ремонта скважины
refinery	нефтеперерабатывающий завод
workovers	капитальный ремонт скважины
scale	твердый осадок на стенах трубопровода
acid matrix jobs	кислотная обработка
shallower reservoir	коллектор на небольших глубинах
pulling unit	подъемная установка для капитального ремонта скважин
waterflooding	заводнение (нефтяного месторождения)
steam flooding	нагнетание паром
recoverable oil	промышленные запасы нефти, нефтеотдача пласта
remedial	ремонтный
injection well	нагнетательная скважина
oil viscosity	вязкость нефти
enhanced recovery	повышенная норма добычи
tertiary recovery	третичное извлечение

Abandonment

Finally, when the well no longer produces or produces so poorly that it is a **liability** to its owner, it is abandoned. In this simple process, tubing is removed from the well and sections of well-bore are filled with cement as to isolate the **flow path** between gas and water zones from each other as well as the surface. Completely filling the well-bore with concrete is unnecessary and cost prohibitive.

Abandonment	**Закрытие (ликвидация скважины)**
flow path	путь движения флюидов в породе
liability	обязательство, пассив

(Baker R. "A Primer of Oil Well Drilling", 2001, Austin, Texas)

6. Find the Russian equivalents to the English terms.

1. enhanced recovery methods	A. плохая проницаемость
2. refinery	B. траектория движения, путь движения флюидов
3. formation sands	C. высокая скорость
4. well	D. истощенное месторождение
5. hole	E. эффект скольжения
6. flow path	F. спускной кран, выпускной клапан
7. increased velocity	G. ствол скважины
8. wellbore	H. нефтеперерабатывающий завод
9. abandoned field	I. скважина, выработка малого сечения
10. depleted field	J. способы ремонта скважины в случае аварии
11. sweep effect	K. методы механизированной добычи
12. artificial lift methods	L. эффективные методы добычи
13. well intervention techniques	M. песок из пласта
14. low permeability	N. ликвидированный промысел
15. outlet valve	O. буровая скважина, резервуар, отстойник

7. Match the term with its synonym.

1. repair work	A. tubular
2. subsoil	B. washout
3. failure	C. lateral
4. pulling units	D. hoist
5. side	E. secure(v)
6. elimination	F. subsurface
7. pipe	G. remedial work
8. raise, lift (v)	H. leak
9. tie, fix (v)	I. removal
10. drip, ooze (v)	J. workover rigs

8. Match the words in the right column with the definitions in the left one.

1. well completion	A. cylindrical hole drilled without entering of people and having a diameter significantly less than its length
2. production well	B. well preparation for oil production after drilling that includes such operations as perforation jobs, acid and frac jobs...
3. well	C. pipes run in the hole and cemented during drilling in order to consolidate well bore walls and prevent their collapse
4. well workovers	D. operations to consolidate casing in a well after it was run in the hole during drilling.
5. formation pressure	E. a process of well construction by means of rock destruction with a bit
6. injection well	F. a well drilled in compliance with the plan of formation development to produce oil and gas
7. drilling	G. a well drilled to inject into zones water (air, gas, steam) to maintain formation pressure and prolong flowing period of field development
8. cement job	H. pressure at the bottom of a well that is shut in
9. casing	I. operations to clean out, repair or otherwise work on a well to increase or restore production

9. Compose collocations from the following words.

drilling	rock
flow	flooding
recoverable	pipe
artificial	zone
depleted	recovery
production	rig
drill	path
steel	field
steam	oil
secondary	bit
reservoir	method

10. Fill in the gaps with a suitable preposition.

1. At the end sections of the wellbore are filled ______ cement.
2. Pressure can be lowered _______other producing wells.
3. Casing used ______well integrity should be secured ______cement.
4. Perforations made in the portion of the casing passed _______the production zone provide a path_____oil to flow ______the production tubing.
5. This kind of device provides a redundant barrier ______leaks ________hydrocarbons.
6. These methods are used to increase downhole pressure to push hydrocarbons _______ the reservoir.
7. You can use enhanced recovery methods when you face problems _______ high oil viscosity, etc.

11. Fill in the gaps with the most suitable words or terms from the text.

1. Completion is a stage when a well is prepared for oil or gas _______.
2. A steel pipe is secured with ______ to provide structural _____of the well.
3. _____ are applied to prevent the migration of formation sands into the production tubulars.
4. The better is quality of _____the higher the well operation efficiency.
5. The application of enhanced recovery methods allow reservoir engineers to increase the ultimate ________ ______ .
6. Drilling preparation operations first of all include selection of location for a _______ _____ .
7. Perforations are made in the casing section which passes through the ______ _____.

12. Give English equivalents to the Russian words in brackets.

1. The top of an oil rig **(оснащена)** with a certain set of valves.
2. Such enhanced recovery methods **as (заводнение, нагнетание паром)** are applied to increase reservoir pressure.
3. **(Буровая установка)** is a complex of drilling machines, mechanisms and equipment in the **(буровая площадка).**
4. The well **(ликвидировать)** when it no longer produces oil or gas.
5. A small diameter of the tubing allows increasing the velocity of **(углеводородов).**

6. Injection wells are used for injection into **(продуктивный пласт)** to maintain **(давление в продуктивном пласте).**
7. **(Буровой шлам)** are carried to the surface by the drilling fluid which **(прокачивается)** by special equipment.

13. Read the conversations and underline the process they are talking about.

1. – Roughly how much would it cost?
– In your case, it's better not to waste money at all.

Planning Abandonment Enhanced oil recovery

2. – We have a small problem which can lead to well shut-in.
– It's quite serious. You should contact our service company today.

Completion Workovers Fracturing

3. – How far is it?
– Five hundred kilometers.
– So, we can transport everything in a day.

Planning Casing Drilling

4. – I see we only have large diameters
– Only tomorrow we'll need smaller diameter.
– That's OK. Everything will be ready.

Production Injection Completion

14.
A. Listen to the description of the drilling process and fill in the missing words (no more than THREE words). The first word is given as an example.

The world's **(0)** <u>dependence</u> on oil and gas is a given. Drilling a well is a complex process involving different service companies each one adherent to the clock scheduling, safety and **(1)** __________. The first task is to prepare the location. Next a pilot hole is dug at the precise location marked by the survey crew for the main hole, two other holes, **(2)** __________ and rathole, are also dug. Two shifts of complete crews are assigned to the drill site for

the entire project. Drilling happens in stages: drilling, running and **(3)** ___________. To help keep cuttings from plugging the hole the mud passes through shakers that **(4)** __________ and send them to the bit. The blowout preventer or BOP contains high-pressure safety valves designed to **(5)** __________ of underground gases or fluids in order to prevent blowout from occurring.
The bit is a cutting element used in **(6)** __________. As the bit turns it crushes the rock efficiently. When the hole reaches the designated depth, the derrickhands circulate fluid to condition it for the logging, the process of measuring and **(7)** __________. If everything tests positively the crew inserts the last string of **(8)** __________ that runs the entire length of the hole and cements the casing in the hole.
Next the workover unit trips out of the hole and picks up a **(9)** __________ which the crew lowers into the well to the production depth. An electrical signal is sent down the wireline, firing the gun and igniting explosive charges that create holes connecting the wellbore to the reservoir to **(10)** __________ the flow of hydrocarbons. The final step is to install a pump jack or production well head called a Christmas tree on the well. It is then time to produce the well and plan for any future field development.

B. Listen to the text again and choose the answer – A, B, C or D – that best suits the information from the text.

1. To prepare the well location implies
A. construction of an access road and availability of utilities supply lines.
B. introduction of electricity generation and waste water discharge systems.
C. deforestation and drainage of the area.
D. training of the personnel involved.
2. After being moved and assembled the rig is inspected in order to make sure
A. it is still intact and able to operate.
B. it is equipped and fitted with all necessary up-to-date components.
C. it meets all specifications and safety standards.
D. it looks attractive for investors.
3. Tripping out is performed to
A. remove the entire string of drill pipe.
B. replace a worn-out drill bit.
C. keep the drill crew busy.
D. prolongate the drilling process.
4. An additional mud system used to clean the drilling fluid from cuttings includes

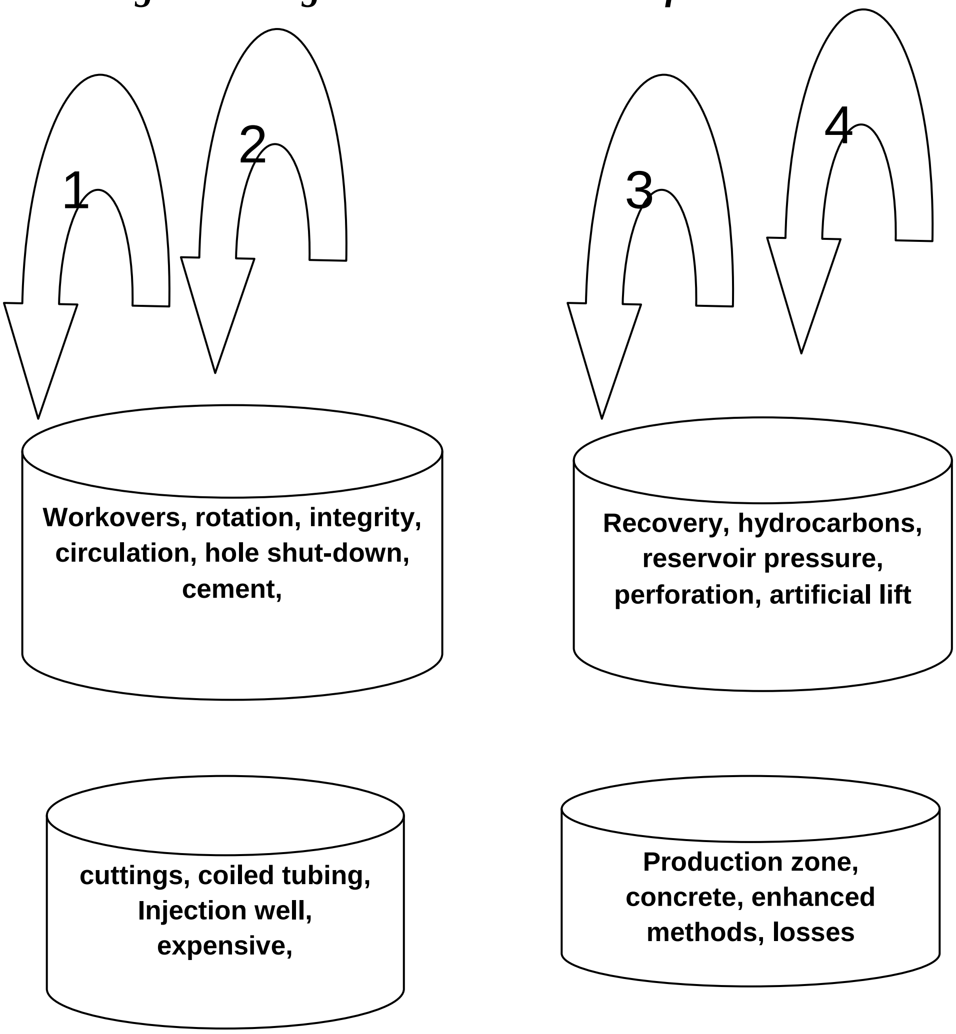
A. desanders, debubblers and desilters
B. decutters, desilters and degassers.
C. degassers, desanders and desilters.
D. descreeners, desanders and descalers.
5. Downhole information obtained by logging allows determining
A. if the well is drilled well enough to produce oil or gas.
B. if the well is plugged with cuttings.
C. if the well is able to meet expectations.
D. if the well is completed or abandoned.
6. The purpose of fracturing a well is to
A. release the pressure and allow oil and gas to flow into the wellbore.
B. pump air, sand and fluid into the wellbore under very high pressure.
C. keep perforations open to prevent them from being plugged.
D. test the walls of the well whether they are solid.
7. The name of the device that controls the flow of hydrocarbons is
A. a monitoring unit.
B. a flow valve.
C. a choke.
D. a tubing.
8. According to the text, drilling for oil and gas helps us
A. make more money and raise the life standards up.
B. meet growing needs for energy.
C. produce high-quality oil-derived products.
D. affect economic ratings on world's stock exchanges.

15. Match the questions about "well life" on the left with the answers on the right.

1. What is the average diameter of a well hole?	A. Well, the diameter of the tubing is small so as to produce hydrocarbons and increase velocity.
2. How is the migration of formation sands controlled?	B. That's difficult to say, but I know that in the Tomsk region flooding is applied.
3. How is hydrostatic effect of water overcome?	C. My best advice is to give it up!
4. What is the nodding donkey?	D. As I know, sand screens or a gravel pack is installed.
5. Is the "Christmas Tree" on the well top the same as the tree we have at Christmas?	E. As far as I know, a "hole" is an opening, but a well is a deep hole.

6. What would you do if reservoir pressure decreases?	F. Hmm, that's hard to say, but as far as I know it is a surface pump jack which could be seen in old oil fields.
7. What must I do (well owner) if the flow rate decreases to 5%?	G. Yes, you are right, but instead of Christmas toys there are different valves.
8. What is the difference between the well and a hole?	H. Well, I think it's about 13–76 cm.

16. The life of a well includes several stages. Put the following key words according to the stages and describe each of them.



WORDLIST

ENGLISH	RUSSIAN
abandonment	закрытие (ликвидация скважины)
acid matrix jobs	кислотная обработка
artificial lift methods	методы механизированной добычи
cased-hole completion	заканчивание скважины посредством обсадной колонны
cement	цементный раствор
circulate fluid	прокачивать буровой раствор по системе
completion	заканчивание скважины
cuttings	буровой шлам
depleted field	истощенное месторождение
downhole pressure	давление в скважине
drill bit	буровое долото, буровая коронка
drilling	бурение
drilling fluid	буровая жидкость
drilling rig	буровая установка
drilling site	буровая площадка
enhanced recovery	повышенная норма добычи
flow path	путь движения флюидов в породе
formation sand	песок из пласта
fracturing fluid	жидкость для гидроразрыва
gravel pack	гравийный фильтр
hoist	подъем
hole	отверстие, выработка малого сечения, скважина
hole completion	заканчивание скважины
injection well	нагнетательная скважина
integrity	целостность
leak (v\n)	утечка, течь
liability	обязательство, пассив
oil rig	нефтяная вышка
oil viscosity	вязкость нефти
perforation	перфорационное отверстие
permeability	проницаемость
produce (v)	добывать
producing well	добывающая скважина
production	выработка, добыча
production tubing	эксплутационная насосно-компрессорная колонна

production tubular	эксплутационная колонна
production zone	продуктивная зона
pulling unit	подъемная установка для капитального ремонта скважин
recoverable oil	промышленные запасы нефти, нефтеотдача пласта
redundant	излишний, избыточный, резервный
refinery	нефтеперерабатывающий завод
remedial	ремонтный
reservoir rock	порода-коллектор
reservoir section	коллекторская порода
scale	твердый осадок на стенах трубопровода
screen	фильтр
secondary recovery	вторичное извлечение
secure (v)	закреплять
shallower reservoir	коллектор на небольших глубинах
steam flooding	нагнетание паром
steel pipe (casing)	обсадная колонна
tertiary recovery	третичное извлечение
unconsolidated sand	неуплотненный песок
washout	размыв, отверстие в бурильной трубе
waterflooding	заводнение (нефтяного месторождения)
workover rig	установка для капитального ремонта скважины
workovers	капитальный ремонт скважины

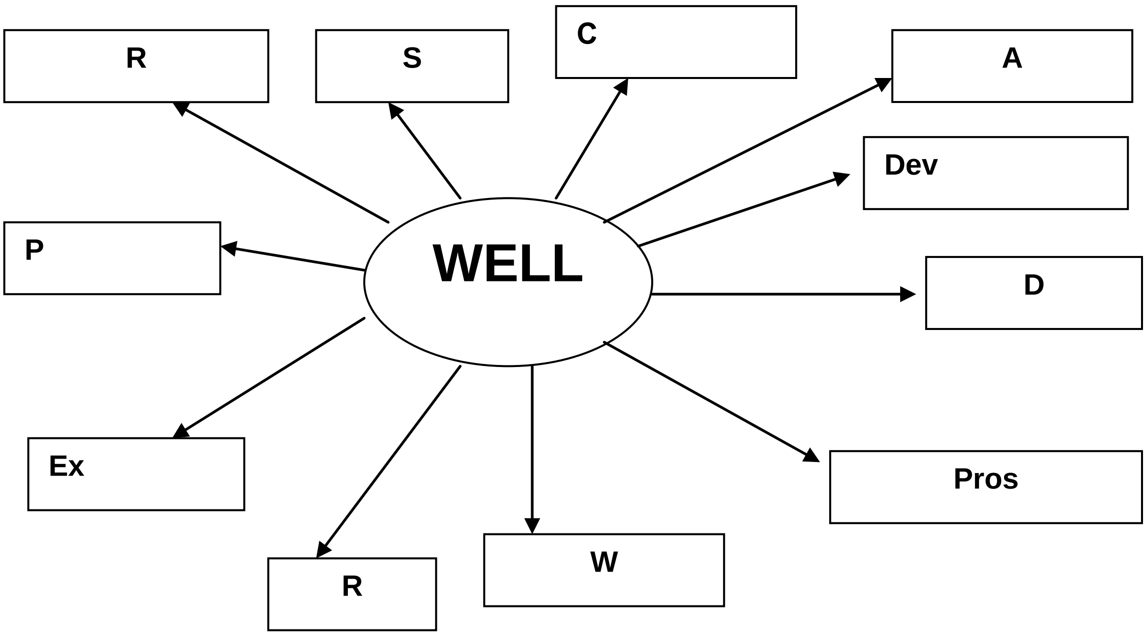
UNIT 2

TYPES OF WELLS

Well is a deep cylindrical hole or shaft sunk drilled without entering of people to obtain water, oil, gas, or brine.

Lead-in

Form the types of wells from the verbs \ nouns given in Terms and Vocabulary



Terms and Vocabulary

recover	добывать
produce	добывать
explore	исследовать, вести разведочные работы
relief	ослабление, разгрузка, сброс
prospect	разведка, производить поиск
discover	обнаруживать, находить
wildcat	рискованное предприятие
develop	развивать, совершенствовать
appraise	оценивать
confirm	подтверждать
step out	выходить, отходить

1. Match the well type with its definition in Russian.

1. development	A. поисковая \ разведочная скважина (бурится для обнаружения ранее неизвестного месторождения новых коллекторов, залегающих на других горизонтах, который был открыт на малоисследованной территории)
2. discovery	B. продуктивная скважина
3. prospect	C. оценочная скважина, пробуренная для подтверждения присутствия \ оценки углеводородов в пласте-коллекторе, который был открыт на малоисследованной территории
4. wildcat	D. эксплуатационная скважина
5. relief	E. вновь пробуренная скважина (при постепенном разбуривании месторождения); отдаленная скважина
6. exploration	F. эксплуатационная скважина, (добывающая)
7. production	G. поисково-разведочная скважина (на новой недостаточно разведанной площади)
8. appraisal	H. поисковая скважина
9. step-out	I.наклонная скважина, пробуренная для глушения другой скважины (в случае открытого фонтанирования пожаров); вспомогательная скважина; разгрузочная скважина
10. confirmation	J. доразведочная скважина, подтверждающая скважина (вторая пробуренная продуктивная скважина на месторождении)
11. recovery	K. скважина, открывшая новое месторождение/вскрывшая новый пласт

2. Pay special attention to the pronunciation of the following words.

appr**ai**sal a**djoi**ning dr**ow**ned d**ua**lly **edg**e **exhau**sted m**argi**nal pr**olif**ic v**irtu**ally ma**ture** [mə´tjuə] s**u**ffi**cie**nt g**aseou**s [´gæsıəs; ´geıʃəs]

3. Pay attention to the underlined stress in the following words.

<u>**aq**</u>uifer <u>**ef**</u>fort sa<u>**line**</u> pro<u>**lific**</u> <u>**bar**</u>ren **o**n<u>**shore**</u> **o**ff<u>**shore**</u>

Terms and Vocabulary

borehole\bore well *(* hole\ wellhole)	буровая скважина
well in operation	действующая скважина
well off	простаивающая скважина
well out of control	скважина, фонтанирование которой не удается закрыть
well under control	скважина с закрытым фонтанированием
abandoned well	ликвидированная скважина
adjoining well	смежная скважина
aquifer	водоносный горизонт, водоносный пласт, законтурная зона пласта
barren (*dry \ non-productive)* well	безрезультативная скважина (не дающая промышленного количества нефти)
beam well	скважина, эксплуатирующаяся глубинным насосом
belching well	пульсирующая скважина \ скважина, периодически выбрасывающая жидкость
brought in well	скважина, вступившая в эксплуатацию
borderline well	краевая скважина
by-product	побочный продукт
cable tool well	скважина, бурящаяся канатным способом
cased well	обсаженная скважина
cased through well	обсаженная до забоя скважина
commercial well	скважина, имеющая промышленное значение
completed well	скважина, законченная бурением \ освоенная скважина
controlled directional well	наклонно-направленная скважина
dead well	заглохшая (истощенная) скважина
disposal	сброс, отведение, утилизация

drowned well	обводненная скважина
dually completed well	двухпластовая скважина
dumping	сброс, утечка
edge well	краевая (приконтурная) скважина
exhausted well	истощенная скважина (дебит которой ниже экономического предела эксплуатации)
gaseous	газовый, газообразный
infill well	скважина, пробуренная при уплотнении первоначальной сетки размещения скважин
injection (input) well	нагнетательная скважина
intake well	нагнетательная скважина (для нагнетания жидкости в пласт)
junked well	скважина, засоренная железным ломом; скважина, заброшенная вследствие безрезультатной ловли оборванного инструмента
key well	опорная скважина; нагнетательная скважина, скважина для нагнетания сжатого воздуха \ газа
line wells	скважины, расположенные вдоль границ участка
marginal well	малодебитная (близкая к истощению) скважина
natural well	скважина, выдающая нефть без кислотной обработки, гидроразрыва, прострела без применения насосов
offset well	соседняя скважина, скважина, пробуренная вблизи другой скважины
offshore well	морская скважина
off-structure well	скважина, пробуренная за пределами нефтеносной структуры
onshore	береговой, прибрежный
on-structure well	скважина, расположенная в нефтеносной структуре
paying well	окупающая себя скважина (экономически выгодная)
pay zone	продуктивная зона, продуктивный интервал
pinch out well	скважина, определяющая границу нефтяной залежи \ малопродуктивная скважина на границе залежи
producing formation	продуктивный пласт

prolific well	малодебитная скважина
saline	соленый, минерализованный
sand (ed) well	скважина, в которой нефтеносным коллектором являются песчаники; скважина, в которую вместе с жидкостью поступает из пласта много песка
service well	вспомогательная скважина
stripper well	малодебитная скважина, дающая менее 1.5м^3/сут нефти
test well	разведочная скважина
twin well	скважина, пробуренная в тех же условия, что и другая скважина того же участка; нефтяная скважина, эксплуатирующая два горизонта; скважина, пробуренная близко к соседней скважине
wellhead	устье скважины
well site	буровая площадка
wild well	некартированная скважина

4. Read the following text and do the exercises.

Types of Oil Wells

Oil wells come in many varieties. By produced fluid, there can be wells that produce oil, wells that produce oil and natural gas, or wells that only produce natural gas. Natural gas is almost always a **by-product** of producing oil, since the small, light gas carbon chains come out of solution as it undergoes pressure reduction from the reservoir to the surface. Unwanted natural gas can actually be quite a disposal problem at the **well site**. If there is not a market for natural gas near the **wellhead** it is virtually valueless since it must be piped to the end user. Until recently, such unwanted gas was burned off at the wellsite, but due to environmental concerns this practice is becoming less and less common. Often, unwanted (or 'stranded'; gas without a market) gas is pumped back into the reservoir with an **'injection' well** for **disposal** or repressurizing the **producing formation**. Another solution is to export the natural gas as a liquid. Of course, in locations such as the United States with a high natural gas demand, pipelines are constructed to take the gas from the wellsite to the end consumer.

Another obvious way to classify oil wells is by land or offshore wells. There really is very little difference in the well itself; an offshore well simply targets a reservoir that also happens to be underneath an ocean. Also, due to logistics, drilling an **offshore well** is far more costly than an **onshore well**. By far the most common type of well is of the onshore variety. Another way to classify oil wells is by their purpose in contributing to the development of a resource. They can be characterized as:

- **production wells** when they are drilled primarily for producing oil or gas, once the\producing structure and characteristics are established
- **appraisal wells** when they are used to assess characteristics (such as flowrate) of a proven hydrocarbon accumulation
- **exploration wells** when they are drilled purely for exploratory (information gathering) purposes in a new area
- **wildcat wells** when a well is drilled, based on a large element of hope, in a frontier area where very little is known about the subsurface. In the early days of oil exploration in Texas, wildcats were common as productive areas were not yet established. In modern times, oil exploration in many areas has reached a very mature phase and the chances of finding oil simply by drilling at random are very low. Therefore, a lot more effort is placed in exploration and appraisal wells.

At a producing well site, active wells may be further categorized as:

- *oil producers* producing predominantly liquid hydrocarbons, but mostly with some associated gas.
- *gas producers* producing virtually entirely **gaseous** hydrocarbons.
- *water injectors* injecting water into the formation either to maintain reservoir pressure or simply to dispose of water produced with the hydrocarbons because even after treatment, it would be too oily and too **saline** to be considered clean for **dumping** overboard let alone into a fresh water source, in the case of onshore wells. Frequently, water injection has an element of reservoir management and produced water disposal.
- *aquifer producers* intentionally producing reservoir water for re-injection to manage pressure. This is in effect moving reservoir water from where it is not as useful, to where it is more useful. These wells will generally only be used if produced water from the oil or gas producers is insufficient for reservoir management purposes. Using **aquifer** produced water rather than sea water is due to the chemistry.
- *gas injectors* injecting gas into the reservoir often as a means of disposal or sequestering for later production, but also to maintain reservoir pressure.

Lahee classification

- *New Field Wildcat* (NFW) – far from other producing fields and on a structure that has not previously produced.
- *New Pool Wildcat* (NPW) – new pools on already producing structure.
- *Deeper Pool Test* (DPT) – on already producing structure and pool, but on a deeper pay zone.
- *Shallower Pool Test* (SPT) – on already producing structure and pool, but on a shallower **pay zone**.
- *Outpost* (OUT) – usually two or more locations from nearest productive area.
- *Development Well* (DEV) – can be on the extension of a pay zone, or between existing wells (*Infill*).

(Baker R. "A Primer of Oil Well Drilling", 2001, Austin, Texas)

5. Match the verb with its synonym.

1. assess	A. corroborate
2. produce	B. finish
3. confirm	C. soak
4. prospect	D. estimate
5. complete	E. empty
6. exhaust	F. recover
7. drown	G. explore

6. Match the terms with the corresponding definitions.

1. production well	A. an interval in the well from where oil and gas are produced
2. appraisal well	B. the point to which a well is drilled
3. injection well	C. a well drilled for oil and gas recovery
4. wellbore	D. a process of oil and gas recovery
5. wellhead	E. a well drilled to identify prospect areas and prepare them for exploration drilling
6. exploratory well	F. a space in subsurface occupied by a well
7. wildcat	G. a well drilled to inject into pay zones water, air, steam, gas in order to maintain formation pressure or prolong flowing period of field development
8. pay zone	H. a pilot well drilled in an area with identified commercial oil and gas bearing capacity to survey

	size and structure of formations, obtain required initial data.
9. production	I. a single well drilled to find new commercial depositions of oil and gas
	J. a set of equipment installed on crossing of the wellbore and the surface line and providing for attachment of downhole strings and equipment and surface pipelines

7. Fill in the gaps with the correct prepositions.

1. Wells can be classified _________ various aspects.
2. Wildcat wells, based __ a large element of hope, are used mainly ______ frontier area.
3. These kinds of wells are used only when produced water ___ oil or gas producers is insufficient______ reservoir management purpose.
4. ________ modern times, a lot more effort is placed _______ exploration and appraisal wells.
5. Wells can be classified __________ their purpose _________contributing __________ the development of a resource.
6. There is low chance to find oil simply ________drilling ___ random.
7. Pipelines are constructed to take crude oil _____ fields __________the terminals.

8. Fill in the gaps with the correct words.

1. Natural gas is considered to be a ____________ of producing oil.
2. Gas is pumped back into the reservoir to repressurize the ____ ______.
3. One can classify oil wells by land or _________ wells.
4. Wildcat wells are used in ________ areas.
5. It's better when the terminal for natural gas is close to the _______.
6. Due to environmental concerns, gas is no longer burned off at the _ _____.
7. Development wells are used for extension of a ______ ____.

9. Compile sentences using the following words.

1. or, wells for, used, oil recovery, are, production, gas, primarily.
2. onshore, is, an, than drilling one, an, offshore well, cheaper.
3. for, hydrocarbons, is producing, gas, gaseous, producer.
4. by, assessment, wells, of, appraisal, made, the formation, is producing.
5. reservoir, help, water, to, pressure, can, maintain, injection.

6. are, based, wells, of, aspects, many, classifications, on, different, there.

10. Read the conversations and underline the types of the wells they are talking about.

1) – Here is all the required information.
– Oh, great! Based on this data, we can plan formation development.

A. Production well B. Twin well C. Exploratory well

2) – What is the flow rate of this well?
– As I know, the average flow rate is 3,5 m^3/day.

A. Wildcat B. Production Well C. Step-out well

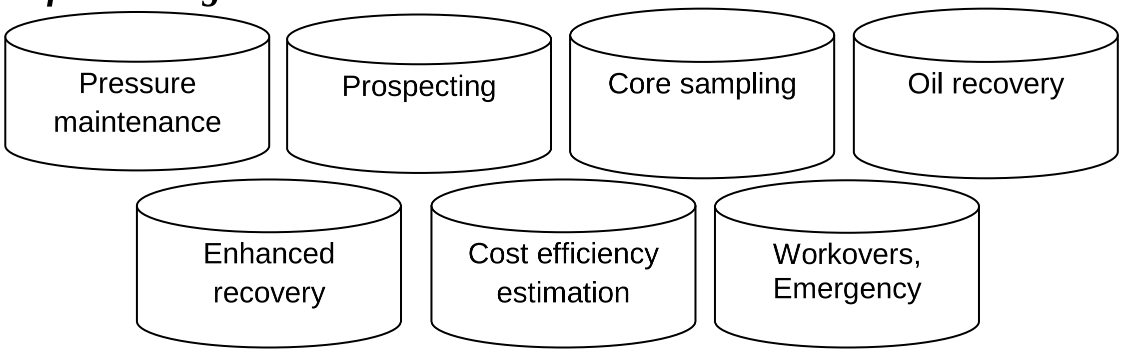
3) – We've defined that the pay zone is about four miles deep in this oilfield.
– Quite good.... But it's not enough. Could you give me the characteristics of hydrocarbons accumulations?

A. Injection well B. Appraisal Well C. Marginal Well

1) – You should take measures as quick as possible! Here is fire hazard!
– Don't worry! All necessary equipment has been already sent.

A. Relief Well B. Dead Well C. Prospect Well

11. Discuss what well types can be applied during the following processes. Define the logical order.



12. Listen to the introduction of the Corn River oil field and mark the statement with T if it is True and with F if it is False.

1. The Corn River field was revealed by chance by two men.
2. In 2002 the Corn River field produced eight billions barrels of oil.
3. To extract oil from the ground a water flooding was used.
4. The field lived through its ups and downs during its history.
5. Nowadays the field produces approximately eighty hundred barrels of oil a day.
6. Computer modeling makes it possible to see down to a thousand feet and deeper.
7. Computer modeling helps target the oil remained behind the production.
8. Operations here are deemed to be successful basing on their environmental impact and efficiency.
9. Water lifted with oil is used as portable water after being cleaned and filtered.
10. The Corn River field is a good example of cooperation of production and consumption.

WORDLIST

ENGLISH	RUSSIAN
abandoned well	ликвидированная скважина
adjoining well	смежная скважина
appraisal well	оценочная скважина, пробуренная для подтверждения присутствия \ оценки углеводородов в пласте- коллекторе, который был открыт на малоисследованной территории
aquifer	водоносный горизонт, водоносный пласт, законтурная зона пласта
barren (dry \ non-productive) well	безрезультативная скважина (не дающая промышленного количества нефти)
beam well	скважина, эксплуатирующаяся глубинным насосом
belching well	пульсирующая скважина \ скважина, периодически выбрасывающая жидкость
borderline well	краевая скважина
borehole \ bore well	буровая скважина
brought in well	скважина, вступившая в эксплуатацию
by-product	побочный продукт
cable tool well	скважина, бурящаяся канатным способом
cased through well	обсаженная до забоя скважина
cased well	обсаженная скважина
commercial well	скважина, имеющая промышленное значение
completed well	скважина, законченная бурением \ освоенная скважина
confirmation well	доразведочная скважина, подтверждающая скважина (вторая пробуренная продуктивная скважина на месторождении)
controlled directional well	наклонно-направленная скважина
dead well	заглохшая (истощенная) скважина
development well	эксплуатационная скважина (добывающая)
discovery well	скважина, открывшая новое месторождение \ вскрывшая новый пласт
disposal	сброс, отведение, утилизация
drowned well	обводненная скважина
dually completed well	двухпластовая скважина
dumping	сброс, утечка
edge well	краевая (приконтурная) скважина

exhausted well	истощенная скважина (дебит которой ниже экономического предела эксплуатации)
exploration well	эксплуатационная скважина
gaseous	газовый, газообразный
infill well	скважина, пробуренная при уплотнении первоначальной сетки размещения скважин
injection (input) well	нагнетательная скважина
intake well	нагнетательная скважина (для нагнетания жидкости в пласт)
junked well	скважина, засоренная железным ломом; скважина, заброшенная вследствие безрезультатной ловли оборванного инструмента
key well	опорная скважина; нагнетательная скважина (скважина для нагнетания сжатого воздуха \ газа)
line wells	скважины, расположенные вдоль границ участка
marginal well	малодебитная (близкая к истощению) скважина
natural well	скважина, выдающая нефть без кислотной обработки, гидроразрыва, прострела без применения насосов
offset well	соседняя скважина, скважина, пробуренная вблизи другой скважины
offshore well	морская скважина
off-structure well	скважина, пробуренная за пределами нефтеносной структуры
onshore	береговой, прибрежный
on-structure well	скважина, расположенная в нефтеносной структуре
pay zone	продуктивная зона, продуктивный интервал
paying well	окупающая себя скважина (экономически выгодная)
pinch out well	скважина, определяющая границу нефтяной залежи \ малопродуктивная скважина на границе залежи
producing formation	продуктивный пласт
production well	продуктивная скважина
prolific well	малодебитная скважина
prospect well	поисковая скважина
recovery well	поисковая \ разведочная скважина (бурится для обнаружения ранее неизвестного месторождения

	новых коллекторов, залегающих на других горизонтах, который был открыт на малоисследованной территории)
relief well	наклонная скважина, пробуренная для глушения другой скважины (в случае открытого фонтанирования пожаров); вспомогательная скважина; разгрузочная скважина
saline	соленый, минерализованный
sand (ed) well	скважина, в которой нефтеносным коллектором являются песчаники; скважина, в которую вместе с жидкостью поступает из пласта много песка
service well	вспомогательная скважина
step-out well	вновь пробуренная скважина (при постепенном разбуривании месторождения); отдаленная скважина
stripper well	малодебитная скважина, дающая менее 1.5м^3/сут нефти
test well	разведочная скважина
twin well	скважина, пробуренная в тех же условия, что и другая скважина того же участка; нефтяная скважина, эксплуатирующая два горизонта скважина, пробуренная близко к соседней скважине
well in operation	действующая скважина
well off	простаивающая скважина
well out of control	скважина, фонтанирование которой не удается закрыть
well site	буровая площадка
well under control	скважина с закрытым фонтанированием
wellhead	устье скважины
wellhole	буровая скважина
wild well	некартированная скважина
wildcat	поисково-разведочная скважина (на новой недостаточно разведанной площади)

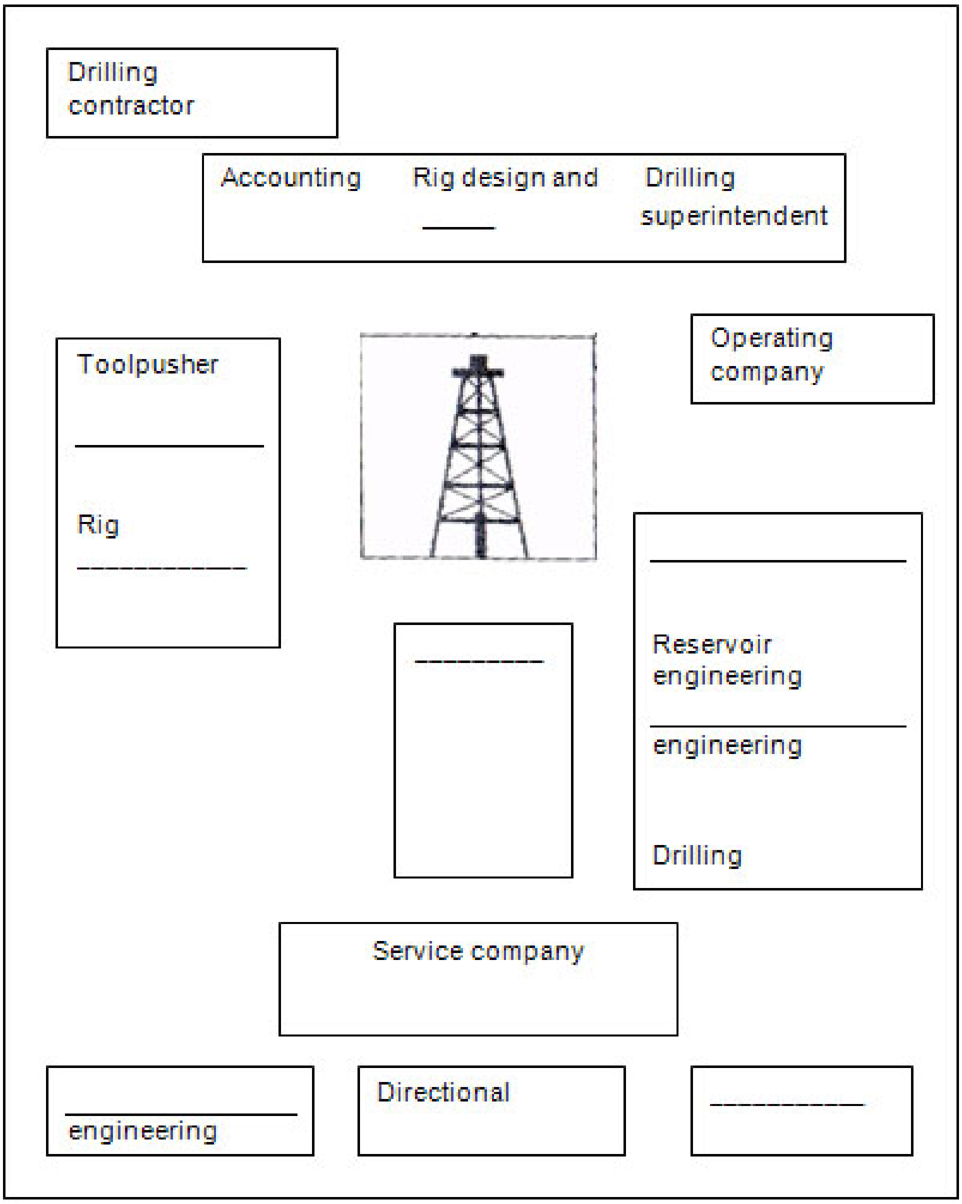
UNIT 3

COMPANIES AND PEOPLE

As **drilling a well** is a complicated job, many **companies** and **individuals** are involved.

Lead-in

Complete the following chart with companies and people involved in a drilling process.



1. Pay special attention to the pronunciation of the following words.

cr**ew** m**ajo**r ex**tingui**sher [ɪk´stɪŋgwɪʃə] **sub**terra**nean** [sʌbtə´reɪnjən] spe**cializ**e s**ophi**sticated f**ue**l cons**um**er re**fine**ry

2. Pay attention to the underlined stress in the following words.

inde**<u>pen</u>**dent **<u>main</u>**tenance com**<u>pon</u>**ent ce**<u>ment</u>**ing trans**<u>port</u>** (v) **<u>trans</u>**port (n)

Terms and Vocabulary

operating company, operator	нефтедобывающая компания
major	монополия, крупная компания
independent	независимая компания
drilling contractor	буровой подрядчик
refine	очищать нефть
process	перерабатывать нефть
service company	специализированная обслуживающая фирма
subterranean	подземный
supply company	компания по снабжению
expendable equipment and material	расходные материалы и детали
maintain(v)	поддерживать, осуществлять техническое обслуживание
pipe	труба
mud	буровой раствор
fire extinguishers	огнетушитель
spare part	запасная деталь
case	обшивка, корпус, крепить ствол скважины обсадными трубами
casing crew	бригада, занимающаяся обсадкой
cementing company	компания, занимающаяся цементированием
cement bond	сцепление цемента
consumer	потребитель
cost-effective	экономически выгодный
formation of interest	продуктивный пласт
logging company	компания, занимающаяся каротажом

well log	диаграмма геофизических исследований скважины, каротажная диаграмма

3. Read the text "Companies" and do the exercises.

Companies

The companies include **operating companies**, **drilling contractors**, and **service** and **supply companies**.

Operating company

An **operating company**, or an **operator**, has the right to drill and produce petroleum at a particular site. The operator buys or leases that right from the owner of the rights to the **subterranean** oil or gas. Rights can be owned by individuals, companies, or, in some cases, by the federal or state government.

An operator can be a **major**, such as Exxon, Mobil, British Petroleum, Shell, Chevron, or Texaco. A major oil company produces oil and gas and transports them from the field to the **refinery** and plant. It also **refines** or **processes** the oil and gas and sells the products to **consumers**.

An operator can also be an **independent**. An independent operator is an individual or a relatively small company that produces and sells, oil and gas but does not transport, refine, or market them. Operating companies, whether major or independent, pay for the drilling of a well. They usually hire a **drilling contractor** to drill it.

Drilling contractors

In the United States and Canada, **drilling contractors** do virtually all the drilling. Operators have found it more **cost-effective** to hire a firm that specializes, in drilling than to **maintain** their own rigs. A drilling company may be small or large; it may drill mainly in one country or it may have rigs working all over the world.

In any case, a drilling company's job is to drill a hole. It must drill the hole to the depth and specifications set by the operating company. An operating company usually bids up several contractors. Often, the operator awards the contract to the lowest bidder, but not always. Sometimes a good work record may override a lower bid.

Service and supply companies

The drilling of any well involves several service and supply companies. **Supply companies** sell **expendable equipment** and **materials,** such as drill bits and **mud**, to the operator and drilling contractor. They also sell items such as **pipes**, **fuel**, **lubricants**, **fire extinguishers**, and spare parts. Moreover, they market safety equipment, **rig components**, paper, water, tools, computers, paint, **grease**, rags, and solvents. Think of any part or commodity that a rig needs to drill a well, and you'll find a supply company on hand to fill it.

Service companies offer special support to the drilling operation. Like supply companies, they exist to nil the special needs of the drilling project. For example, a mud logging company logs, or monitors, the drilling mud as it returns from the well. The returning mud carries cuttings and any formation fluids, such as gas or oil, to the surface. The operator can gain much knowledge about the formations being drilled by analyzing the returning drilling fluid.

Another kind of service company provides **casing crews**. A casing crew runs large pipe into the well to line, or **case**, it . Casing protects formations from contamination and stabilizes the well. After the casing crew runs the casing, another service company— a **cementing company**—cements the casing in the well. Cement bonds the casing to the hole. In many cases, when a well reaches a **formation of interest** (usually, a formation that may contain oil or gas), the operator hires a well **logging company**. The well logging crew runs sophisticated tools into the hole. These instruments measure and record formation properties. By looking at the record, or **well log**, the operator can often determine whether the well will produce oil or gas.

(Baker R. "A Primer of Oil Well Drilling", 2001, Austin, Texas)

4. Compose collocations from the following words.

drilling	company
spare	bond
supply	equipment
hole	part

casing	components
cement	well
rig	logging
safety	contractor
	crew

5. Fill in the gaps with the most suitable words or terms from the text.

1. When a well reaches a formation of interest, the operator hires a __ ____ _____.
2. If the ________ _________ is paid according to the daily costs of operating the rig, it's a daywork contract.
3. When the portion of the hole is drilled, a __________ _________ runs a pipe into the well.
4. A nonintegrated oil company or individual whose operations are in the field of petroleum production is called _______________.
5. ____ ________ help the operating company determine whether the well will produce oil or gas.
6. ________ also transports, refines, and markets oil and its products.
7. An _____ __________does not usually own the land or the minerals lying under the land.
8. The required items, including drill bits are sold by ________ _________.

6. Match the two parts of the sentences.

1. The cement is pumped by company's crew	A. used to ascertain downhole information about a well.
2. I'm not sure but he is responsible for	B. trying to provide logistics support to the rig crew.
3. Try to run any of the various logs	C. preparing and running casing into a well.
4. This company owns a drilling rig or rigs	D. to secure casing in the well.
5. As I know they specialize in	E. a rig needs is delivered by supply company.
6. Our rig manager is in the rig site right now	F. representing the company's interests.
7. All necessary equipment that	G. and contracts services for drilling wells.

Terms and Vocabulary

drilling crew	буровая бригада
driller	бурильщик
derrickhand	верховой рабочий
floorhand	третий помощник бурильщика
motorman	дизелист
mud engineer	инженер по буровым растворам
mud logger	человек, ведущий учет данных о буровом растворе
people	персонал
rig manager	буровой менеджер
rotary helper	помощник бурильщика
roughneck	рабочий на буровой вышке
roustabout	подсобный рабочий
superintendent	руководитель
service	эксплуатация
maintenance	техническое обслуживание
rig floor	рабочая площадка буровой
tripping	спуско-подъемная операция
trip in	опускать буровую колонну
trip out	поднимать буровую колонну
monkeyboard	полати/люлька верхового
stand	свеча
graphic log	описание литографического разреза скважины
well-logging activity	каротаж
logs	буровой журнал, каротажная диаграмма
tongs	машинные ключи, щипцы
work shift	вахта
plan the strategy	планировать стратегию бурения скважины

8. Read the following text and fill in the table below it.

People

While it is true that you can't drill a well without a drilling rig and several companies to back up the rig, it is equally true that you can't drill a well without skilled people. Personnel run the rig and keep it running until the well reaches its objective. Let's look at some of the people involved in drilling.

Drilling crews work for the drilling contractor. Typically, the contractor hires a **rig manager** , or a **superintendent**, for each rig. This rig manager is usually called the **toolpusher**. The toolpusher supervises two or three crews that operate the rig 24 hours a day, 7 days a week. Besides the toolpusher, each rig has **drillers**, **derrickhands**, and **rotary helpers** *(*also called floorhands or roughnecks). Sometimes the driller designates the most experienced rotary helper as a motorhand. The motorhand performs routine service and maintenance on the rig's engines.

The **toolpusher** is the contractor's top hand on the drilling location. This person oversees the drilling crews that work on the **rig floor**, supervises all drilling operations, and coordinates operating company and contractor affairs. During the time the rig is drilling, the toolpusher usually lives in an on-site trailer or portable building and is on call at all times.

Tool pushers are in charge of keeping the rig in all necessary tools and equipment, supplies, etc. They work closely in conjunction with the company man in regards to the actual drilling of the well. In recent times, toolpushers also have taken on somewhat of an administrative role, also, as they frequently do paperwork related to the rig crew regarding payroll, benefits, etc. Usually a tool pusher has started at the bottom and worked his way up and has been in the industry for a number of years.

The **driller** supervises the derrickhand and the rotary helpers with direction from the toolpusher. From a control console on the rig floor, the driller manipulates the controls that keep the drilling operation under way. This person is directly responsible for the drilling of the hole.

The **driller** is in charge of his crew, and running the rig itself. Most of the time, his job is simply to monitor the rig's activity. He is responsible for interpreting the signals the well gives regarding gas and fluids with high pressure. In an emergency he is also responsible for taking the correct counter measures. The driller will watch for gas levels coming out of the hole, how much drilling mud is going in and other information. While **tripping**, the driller will run the floor and work the rig.

When crew members run drill pipe into the hole *(***trip in***)*, or when they pull pipe out of the hole (**trip out***)*, the rig needs a **derrickhand**. The derrickhand handles the upper end of the pipe from the **monkeyboard**. The monkey-board is a small platform in the **derrick**. A drilling crew can trip pipe in or out of the hole one length, or joint, at a time. Usually, however, they trip pipe in **stands** to speed up the process. Since a stand is two or more lengths of pipe, the job goes faster than tripping them one joint at a time. Each stand of pipe is either about 60 feet long or about 90 feet long (about 18 or 27 metres).

The contractor therefore mounts the monkeyboard in the derrick at a height of either 50 or 80 feet (15 or 24 metres), depending on how long the stands are. When the bit is drilling and the pipe is in the hole, the derrickhand climbs down from the monkeyboard and works at ground level on the drilling mud, making sure it meets the specifications for drilling a particular part of the hole.

Mud engineer (sometimes referred to as the "Mud Man", though women also do this job today) works on an oil well drilling rig, and is responsible for the drilling fluid, also known as drilling mud which lubricates the drill bit and clears cuttings from the borehole. It is a well-paid job because of the importance of maintaining the drilling fluid in efficient drilling.

Mudlogger in the modern oil field typically works for a service company contracted by the oil company (or operator) and is tasked primarily with gathering data and collecting samples during the drilling of a well to identify possible indications of hydrocarbons. They then organize this information in the form of a graphic log, showing the data charted on a graphic representation of the wellbore. The oil industry representative or **company man** provides mudloggers their instruction. The mudlogger is told when to start well-logging activity and what services to provide. The mudlogger may also possess **logs** from wells drilled in the surrounding area. This information (known as "offset data") can provide valuable clues as to the characteristics of the particular geo-strata that the rig crew is about to drill through.

Mudloggers observe and interpret the indicators in the mud returns during the drilling process. At regular intervals the mudlogger logs properties such as drilling rate, mud weight, flowline temperature, natural gas content and type, oil indicators, pump pressure, pump rate, lithology (rock type) of the drilled cuttings, and various other items of interest. The job of a mudlogger requires a good deal of diligence and attention. Sampling the drilled cuttings must be performed at predetermined intervals, and can be difficult during rapid drilling. Another important task of the mudlogger is to monitor gas levels and notify other personnel on the rig when gas levels may be reaching dangerous levels, so appropriate steps can be taken to avoid a dangerous well blowout.

Roughneck (or **ruffneck**) is a slang term for an unskilled or slightly skilled laborer in a number of industries. In particular, it is the official name of a semi-skilled role on a North American oil rig. A roughneck's duties could include anything involved with the connecting and "tripping" of pipe down the well bore, and the roughneck is the person when it comes to general work around the rig.

Roustabout is a laborer typically performing temporary, unskilled work. "Roustabout" is also an official classification of oil rig personnel. Roustabouts working in the North American oil fields typically perform various jobs requiring little training. However, they frequently turn out to be long term employees and take on more difficult and sometimes dangerous jobs as they gain experience. Most go on to at least become roughnecks.

Motorman is the person who operates an electrified trolley car, tram, light rail, or rapid transit train. The term refers to the person who is in charge of the motor (of the electric car) in the same sense as a railroad engineer is in charge of the engine. A motorman is the member of the drilling crew who is responsible for the maintenance and operation of the engines on an oil rig.

Floorhand: Works the "make-up" **tongs** on the Driller side of the drilling floor while tripping in the hole.

Depending on the size of the rig, its equipment, and other factors, a contractor usually hires two or three **rotary helpers** for each **work shift**. On small rigs drilling shallow wells, for example, two rotary helpers on a shift can safely and efficiently perform the required duties. On large rigs drilling deep holes, the job may require three rotary helpers, but not always. In any case, rotary helpers handle the lower end of the drill pipe when they are **tripping it in or out** (спускоподъемная операция) of the hole. They also use large wrenches called **tongs** to screw or unscrew (make up or break out*)* the individual stands of pipe. Besides handling pipe, rotary helpers also maintain the rig, help repair it, and keep it clean and painted.

Besides the drilling crew, many other persons work at the rig site. They may, be there during the entire time the well is being drilled, or they may come out only when their expertise or equipment is needed.

The operating company customarily has its own person on the drill site to supervise its interests. The **company representative**, like the toolpusher, usually lives on the rig site in a trailer or, portable building, and is in charge of all the operator's activities on the location. This person helps **plan the strategy** for drilling the well, orders all the needed supplies and services, and makes on-site decisions that affect the well's progress. The company representative and the toolpusher usually work closely together.

(Baker R. "A Primer of Oil Well Drilling", 2001, Austin, Texas)

Position	Position description	Responsibilities	Additional information

9. Match the words in the right column with the definitions in the left one.

1. company man	A. company which carries out an exploration / development
2. derrick man	B. employee of a mud service company whose main responsibility on the rig is to test and maintain the mud properties
3. operator	C. an employee of an operating company whose job is to represent the operator's interests on the drilling rig
4. roustabout	D. a member of the drilling crew whose work station is on the monkey board high up in the derrick. He is responsible for maintaining circulation equipment and direct rig floor activities
5. driller	E. an individual / company that owns the drilling rig and employs the crew required to operate it
6. roughneck	F. the men required to operate the drilling rig on the shift / tour/ This normally comprises a driller, derrick man and 2/3 roughnecks
7. drilling crew	G. an employee of a drilling contractor who is responsible for the drilling rig and the crew
8. drilling contractor	H. The company which carries out an exploration / development programme on a particular area for which they hold a license.
9. tool pusher	I. company which provides specialized skills or equipment; may develop and maintain specialist tools and staff and hire them out to the operator

10. service company	J. general labourer (worker)
11. mud engineer	K. the employee of the drilling contractor who is in charge of the drilling rig and crew. His main duties are to operate the drilling equipment and direct rig floor activities
12. operating company	L. an employee of a drilling contractor who works on a drill floor under te direction of a driller

10. Listen to the description of a reservoir engineer's job and fill in the missing word or words (no more than FOUR words). The first word is given as an example.

The world's demand for oil and **(0)** natural gas is unceasing. To find new supplies of these **(1)** __________ we depend on petroleum engineers. They search the world for reservoirs containing **(2)** __________ and work with geologists and other specialists to extract it. First the team **(3)** __________ of the underground and devices drilling methods, designing equipment and processes for that particular target. To get the most from each reservoir, petroleum engineers also develop **(4)** __________ such as injecting water, steam, chemicals or gases into the reservoir to force out the oil and natural gas. Computer modeling is often used to explore drilling and **(5)** __________ and techniques. This work requires a combination of complex knowledge with a **(6)** __________. The work takes you where oil and gas is found from America's west and south west, overseas to **(7)** __________ and up to the frozen North. You might work for a major oil company, **(8)** __________ or a small consulting firm. To begin with you'll need creative and practical **(9)** __________ and the patience to work with a team on highly detailed plans. A bachelor's degree in Engineering is generally required, two- or four-year technology programs mainly to similar jobs. But the individual can't register as **(10)** __________ under the same terms as graduates with a degree in Engineering.

11. Match the questions about companies, people and their duties on the left with the answers on the right.

1. How much time does it take to fill out the drilling bid proposal?	A. You should know this pretty well! Computers in the field generate special graphs, called well logs.
2. How are certain formation characteristics measured?	B. Sorry, but we're waiting when the operating company accepts the bid.
3. Should we pay the mineral holder?	C. You know, we must do it according to the safety requirements.
4. Has you drawn up the contract yet?	D. The only thing I know is that it is usually mounted at a height ranging from about 15 to 34 meters.
5. How is formation data analyzed?	E. Well, mainly by analyzing the returning drilling fluid.
6. What is a monkeyboard?	F. I don't know, I can help you to repair, clean, and even paint it if it is required.
7. Is it so necessary to hire additional two rotary helpers?	G. Quite an interesting question! I guess they are trying to tighten a drill pipe.
8. What are they doing?	H. Uh-huh, all these sums remained due.
9. Who is responsible for drilling equipment?	I. If I were a contractor I would complete it without any delays.

12. Role game: "Who is guilty? Who should be fired?"

An incident took place in a drilling site which led to well shutdown. A company man should find the guilty one who will be fined and fired.

WORDLIST

ENGLISH	RUSSIAN
case	обшивка, корпус, крепить ствол скважины обсадными трубами
casing crew	бригада, занимающаяся обсадкой
cement bond	сцепление цемента
cementing company	компания, занимающаяся цементированием
consumer	потребитель
cost-effective	экономически выгодный
derrickhand	верховой рабочий
driller	бурильщик
drilling contractor	буровой подрядчик
drilling crew	буровая бригада
expendable equipment and material	расходные материалы и детали
fire extinguishers	огнетушитель
floorhand	третий помощник бурильщика
formation of interest	продуктивный пласт
graphic log	описание литографического разреза скважины
independent	независимая компания
logging company	компания, занимающаяся каротажом
logs	буровой журнал, каротажная диаграмма
maintenance	техническое обслуживание
major	монополия, крупная компания
maintain(v)	поддерживать, осуществлять техническое обслуживание
monkeyboard	полати/люлька верхового
motorman	дизелист
mud	буровой раствор
mud engineer	инженер по буровым растворам
mud logger	человек, ведущий учет данных о буровом растворе
operating company, operator	нефтедобывающая компания
people	персонал
pipe	труба

plan the strategy	планировать стратегию бурения скважины
process	перерабатывать нефть
refine	очищать нефть
rig floor	буровой блок
rig manager	буровой менеджер
rotary helper	помощник бурильщика
roughneck	рабочий на буровой вышке
roustabout	подсобный рабочий
service	эксплуатация
service company	специализированная обслуживающая фирма
spare part	запасная деталь
stand	свеча
subterranean	подземный
superintendent	руководитель
supply company	компания по снабжению
tongs	машинные ключи, щипцы
trip in	опускать буровую колонну
trip out	поднимать буровую колонну
tripping	спуско-подъемная операция
well log	диаграмма геофизических исследований скважины, каротажная диаграмма
well-logging activity	каротаж
work shift	вахта

UNIT 4

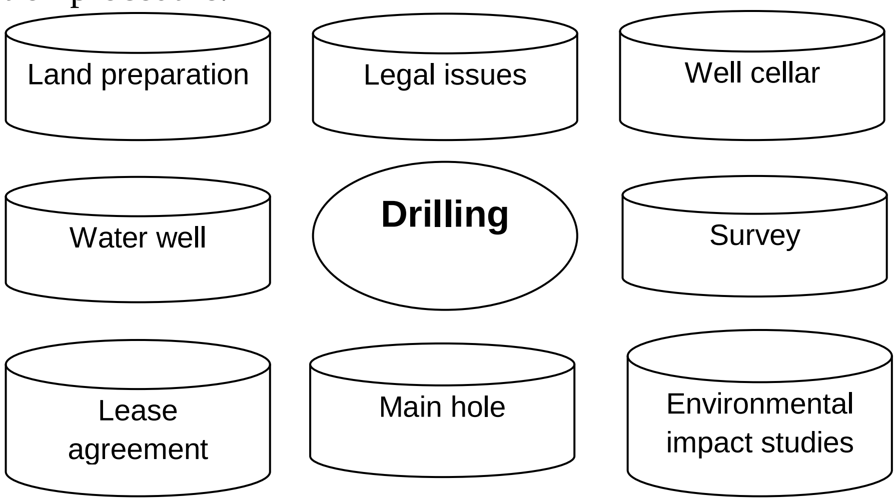
DRILLING

Drilling Rig Components. Rigging Up

If you are interested in **oilwell drilling**, a good way to learn about it is to visit a **drilling rig**.

Lead-in

Looking at the diagram, describe your variant of the oil well drilling preparation procedure.



1 Pay special attention to the pronunciation and stress of the following words.

access [´ækses] **cel**lar [´selə] ac**ces**sory [ək´sesərı]
impact [´ımpækt] e**valua**te [ı´væljueıt] **sur**vey [´sə:veı]

Terms and Vocabulary

access road	подъездной путь
be disposed offsite	быть расположенным за пределами территории
boundary	граница
bring in (v)	приносить
bring in a well	приготовить к эксплуатации
cellar	шахта под вышкой, устьевая шахта
conductor pipe	кондуктор, первая колонна обсадных

	труб
dig off (v)	выкопать, вырыть
dispose (v)	отделять (обломки пород)
drilling accessories	буровая арматура
ecologically sensitive area	экологически уязвимая территория
environmental impact studies	исследование влияния на окружающую среду
evaluate (v)	юридически оценить
go about (v)	приступать к чему-либо; начать работать над чем-то
lease agreement	договор об аренде
level (v)	выравнивать
line smth (v) with	обивать что-либо
marsh	болото
obtain (v)	получать, приобретать
reserve pit	запасной амбар для бурового раствора
right-of-way	доступ к территории
settle the legal issue	урегулировать правовые/ юридические вопросы
store (v)	хранить
survey (v)	исследовать; производить съемку
truck away (v)	увозить на грузовике
wilderness	пустыня, дикая местность

2. Read the text "Prepare to Drill" paying attention to the terms in bold and compare your variant of preparation to drill with that one mentioned in the text.

Prepare to Drill

Once the site has been selected, it must be **surveyed** to determine its **boundaries** and **environmental impact studies** may be done. **Lease agreements**, titles and **right-of-way** accesses for the land must be obtained and evaluated legally. Once the **legal issues** have been settled, the crew goes about preparing the land:

1. the land is cleared and **levelled** and **access roads** may be built;
2. because water is used in drilling, there must be a source of water nearby. If there is no natural source, they drill a water well;
3. they dig a **reserve pit**, which is used to **dispose** rock cuttings and drilling mud during the drilling process, and **line** it with plastic to protect the environment. If the site is an **ecologically sensitive area**,

such as a marsh or wilderness, then the cuttings and mud must be disposed offsite –trucked away instead of placed in a pit.

Once the land has been prepared, several holes must be dug to make way for the rig and the main hole. A rectangular pit, called a **cellar**, is dug around the location of the actual drilling hole. The cellar provides a work space around the hole, for the workers and **drilling accessories**. The crew then begins drilling the main hole, often with a small drill truck rather than the main rig. The first part of the hole is larger and shallower than the main portion and is lined with a large-diameter **conductor pipe**. Additional holes are dug off to the side to temporarily **store** equipment – when these holes are finished, the rig equipment can be brought in and setup.

(Baker R. "A Primer of Oil Well Drilling", 2001, Austin, Texas)

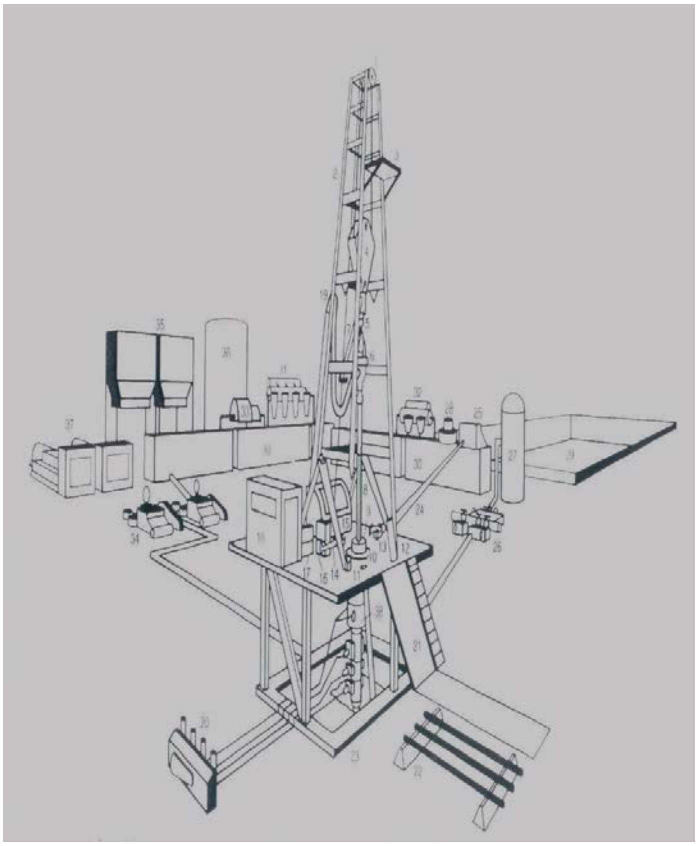


Fig. 1. Drilling rig components

1. crown block
2. mast
3. monkeyboard
4. traveling block
5. hook
6. swivel
7. elevators
8. kelly
9. kelly bushing
10. master bushing
11. mousehole
12. rathole
13. backup tongs
14. drawworks
15. weight indicator
16. driller's console
17. doghouse
18. rotary hose
19. accumulator unit
20. pipe ramp
21. pipe rack
22. substructure
23. mud return line
24. choke manifold
25. mud-gas separator
26. degasser
27. reserve pit
28. mud tanks
29. desilter
30. desander

Terms and Vocabulary (Drilling Components)

accumulator unit	аккумулятор
backup tongs	удерживающий ключ для труб
blowout preventer	противовыбросовое устройство, превентор
casing	крепление скважины обсадными трубами
centrifuge	центрифуга, центрифугировать, очищать (буровой раствор) на центрифуге
choke manifold	штуцерный манифольд (противовыбросового оборудования)
circulation system	система промывки
crown block	кронблок
degasser	устройство для дегазирования бурового раствора, дегазатор
derrick	буровая вышка
desander	пескоотделитель (устройство для очистки бурового раствора от песка)
desilter	ситогидроциклонный илоотделитель
doghouse	будка для переодевания рабочей вахты (на буровой), будка бурового мастера
drawworks	буровая лебедка
driller's console	пульт управления бурильщика
drill string	колонна бурильных труб, бурильная колонна
drilling line	буровой канат, рабочий канат
elevators	элеватор
hook	крюк
hopper	бункер, засыпная воронка, приёмный жёлоб, загрузочный ковш
kelly	«квадрат», ведущая труба
kelly bushing	втулка квадрата
mast	вышка мачтового типа
masterbushing	основной вкладыш ротора
mechanical system	механический привод
monkeyboard	люлька верхового рабочего; полати для верхового рабочего; площадка для верхового рабочего
mousehole	шурф для двухтрубки
mud pit	отстойник, приёмная ёмкость для бурового раствора, амбар для хранения бурового раствора

mud return line	линия для выхода бурового раствора
mud-gas separator	газосепаратор для бурового раствора
pipe rack	приспособление для укладки бурильных труб в штабель (в вышке), мостки для труб (на буровой), стеллаж для труб
pipe ramp	горизонтальные мостки для труб
power system	энергосистема
rathole	шурф для квадрата
rotary hose	буровой шланг
rotating system	система вращения
shale-shaker	вибрационное сито
substructure	подвышечное основание; фундамент; фундаментная рама (буровой мачты)
swivel	вертлюг
traveling block	талевый блок
wire rope	проволочный трос
weight indicator	индикатор нагрузки на буровой инструмент

3. Read the text "Drilling Rig Components" and do the exercises.

Drilling Rig Components

Once the equipment is at the site, the rig is set up. Here are the major systems of a land rig:

1. **Power system**
   - Large diesel engines – burn diesel fuel oil to provide the main source power;
   - Electrical generators – powered by the diesel engines to provide electrical power;
2. **Mechanical system**
   - Hoisting system – used for lifting heavy loads; consists of a mechanical winch (drawworks) with a large steel cable spool, a block-and-tackle pulley and a receiving storage reel for the cable;
   - Turntable – part of the drilling apparatus;
3. **Rotating equipment**
   - Swivel – large handle that holds the weight of the drill string; allows the string to rotate and makes a pressure- tight seal on the hole;
   - Kelly – four\six-sided pipe that transfer rotary motion to the turntable and drill string;

- Turntable (rotary table) – drives the rotating motion using power from electric motors;
- Drill string – consists of drill pipe (connected sections of about 30ft\10m) and drill collars (large diameter, heavier pipe that fits around the drill pipe and places weight on the drill bit);
- Drill bit – end of the drill that actually cuts the rock;

4. **Casing** – large-diameter concrete pipe that lines the drill hole; prevents the hole from collapsing and allows drilling mud to circulate
5. **Circulation system** – pumps drilling mud (mixture of water, clay and weighting material and chemicals; used to lift rock cuttings from the drill bit to the surface) under pressure through the kelly, rotary table drill pipes and drill collars:
   - Pump – sucks mud from the mud pits and pumps it to the drilling apparatus;
   - Pipes and hoses – connects pump to drilling apparatus;
   - Mud-return line – return mud from hole;
   - Shale-shaker – shaker \sieve that separates rock cuttings from the mud;
   - Shale slide – conveys cuttings to the reserve pit;
   - Reserve pit – collects rock cuttings separated from the mud;
   - Mud pits – where drilling mud is mixed and recycled;
   - Mud-mixing hopper – where new mud is mixed and then sent to the mud pits;
6. **Derrick** – support structure that holds the drilling apparatus: tall enough to allow new sections of drill pipe to be added to the drilling apparatus as drilling progresses.
7. **Blowout preventer** – high-pressure valves (located under the land rig) that relieve pressure when necessary to prevent a blowout (uncontrolled gush of gas or oil to the surface, often associated with fire).

(Baker R. "A Primer of Oil Well Drilling", 2001, Austin, Texas)

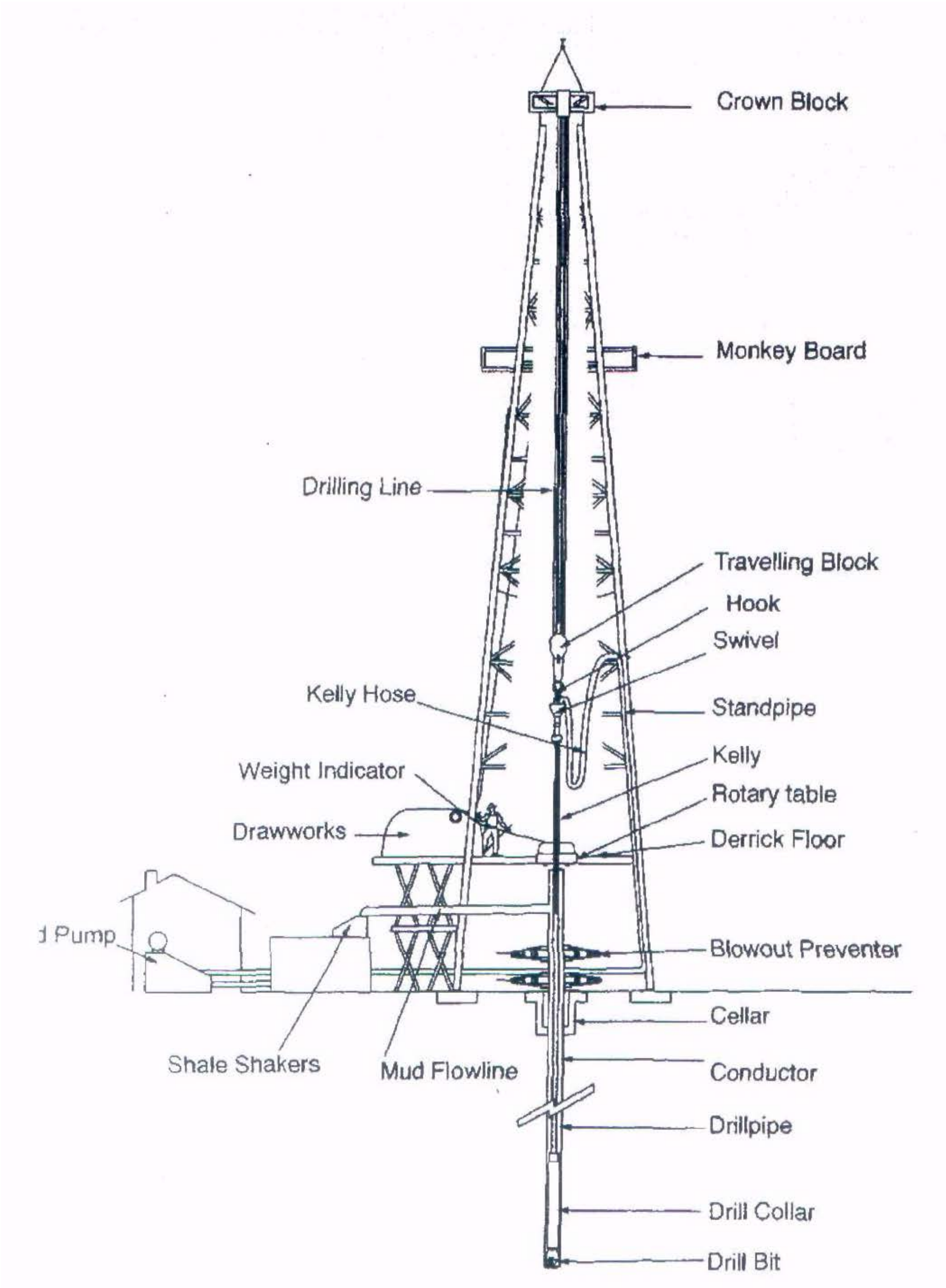


Fig. 2. Drilling rig components

4. Match the words in the left column with the definitions in the right one.

1. traveling block	A. a wire rope made up of a number of strands wound around a steel core, used to lift or lower drill pipe
2. crown block	B. a shallow cased hole close to the rotary table. When making up a string, each single is stood here so that it can be connected quickly and easily to the kelly
3. derrick	C. a device that has several independently mounted sheaves or pulleys and used to lift and lower elevators
4. swivel	D. a piece of equipment designed to mix and prepare drilling mud.
5. elevator	E. a piece of equipment used to transfer rotary motion through a master bushing to the kelly, to drillpipe and, eventually, to the drill bit
6. drill line	F. a piece of equipment used to prevent the rotary motion of the kelly (or drill string) from being transferred to the drilling line
7. shale shaker	G. a device on the top of the derrick that provides means of taking drill line from the hoisting drum to the travelling block
8. kelly bushing	H. a double or a triple, two or three joints connected together.
9. rotary table	I. a structure above the well used for drilling string tripping, location of stands and protection of drilling crew against wind and precipitation.
10. mousehole	J. a device that is attached to the bails of the traveling block and used to grip joints
	K. the part of the drive assembly which transmits motion to the kelly and permits the kelly to move vertically while it is rotating or still.

5. Describe the function of the following elements, using the words given in the right column.

1. kelly	motion, turntable, drill, transfer, rotary, sting, pipe
2. mud pit	drilling mud, recycle, mix, pit
3. derrick	hold, construction, drilling, equipment, support
4. swivel	rotate, string, make, seal, let, hole, handle
5. drill bit	circulating, during, destroy, rock, element, rotation
6. hose	pump, drilling, connect, equipment
7. bottom hole	well, drill, point, which
8. blowout preventer	emergency, shut in, danger, oil, gas, well, device, blowout, when
9. pump	mud, suck, mud pit, drilling, apparatus

6. State whether the following sentences are true or false. Correct the false ones.

1. The kelly is hexagonal. The reason for that is to make it possible for the rotary table to turn the kelly without slipping.
2. Cement job is performed only when quality of casing is poor.
3. Drill pipe is hollow. The reason for this is to make it possible for the mud to pass through it.
4. Elevator is a device for lifting derrickman to the monkey board.
5. Drilling crew members use scratchers to scratch each other and thus clean themselves of oil.
6. Doghouse is a room where security guard and patrol dog live.
7. Drilling cuttings are washed out to the surface with drilling mud made of clay and water.
8. Shale shaker is used for separating fluid from drilling cuttings.
9. Cuttings in a well mean cracks on wellbore walls.
10. Conductor is a person who knows everything at the drilling site. He is in charge of coordinating work of drilling crews.

7. Translate the following sentences into English.

1. При бурении шлам вымывается с забоя скважины буровым раствором.

2. Буровой раствор готовят в вибраситах и закачивают в скважину при помощи бурового насоса.
3. Ротор вращает квадрат, квадрат вращает бурильную колонну, которая в свою очередь вращает бурильное долото.
4. Буровой раствор, выходящий из ствола скважины, проходит через вибросито, где шлам отделяется от раствора.
5. Вертлюг позволяет колонне бурильных труб вращаться и представляет собой шарнирное соединение (swing joint).
6. Талевая система (tackle system) включает кронблок, талевый блок и буровой крюк.
7. При роторном бурении мощность от двигателей передается через лебедку к ротору.
8. Ротор вращает колонну бурильных труб и привинченное к ней долото, которое дробит породу.

8. Think of possible failures which can occur due to damages, breaks and other defects of the following rig components and fill in the fault-finding chart.

Rig component	Failure/ fault	Probable causes	Remedy
Drawworks			
Kelly			
Shale shaker			
Pump			

9. Read the text "Drilling Rig" and fill in the missing words from the box. There is one extra word.

Drilling Rig

A **drilling rig** is a machine which creates **1**. **holes** and/or shafts in the ground. Drilling rigs can be massive structures housing **2.** _________ used to drill **3.** _________,**4.** ___wells, or **5.** _____extraction wells or they can be small enough to be moved manually by one person. They sample sub-surface mineral **6**. ___ ________, test rock, soil and groundwater physical properties, and to install sub-surface fabrications, such as underground utilities, instrumentation, tunnels or wells. Drilling rigs can be **7.** ________ mounted on trucks, tracks or trailers, or more permanent land or marine-based structures (such as oil platforms, commonly called 'offshore oil rigs'). The term "rig" therefore generally refers to the complex of equipment that is used to **8.** __________ the surface of the earth's crust.

Drilling rigs can be:

- Small and portable, such as those used in mineral exploration drilling and environmental investigations.
- Huge, capable of drilling through thousands of meters of the Earth's crust. Large "mud pumps" circulate drilling **9**. ________ through the drill bit and the casing, for cooling and removing the **10**. "________ " while a well is drilled. Hoists in the rig can lift hundreds of tons of pipe. Other equipment can force acid or sand into reservoirs to facilitate extraction of the oil or mineral sample; and permanent living accommodation and catering for **11.** __________ which may be more than a hundred. Marine rigs may operate many hundreds of miles or kilometres offshore with infrequent crew rotation.

Oil and Natural Gas drilling rigs can be used not only to identify geologic reservoirs but also to create holes that allow the extraction of oil or natural gas from those reservoirs. An oil or gas pumping rig, sometimes called a derrick, is used to retrieve oil / gas from a reservoir.

mud; derrick; penetrate; water; crews; natural gas; mobile; cuttings; oil; **holes;** deposits; equipment

(Baker R. "A Primer of Oil Well Drilling", 2001, Austin, Texas)

Terms and Vocabulary

clutch	муфта, соединять
convential	стандартный
deviation	отклонение
grid	батарея, энергетическая система
pipe rack	стеллаж для труб
slant rig	наклонная буровая установка
torque converters	гидротрансформатор

10. Read the following information about foreign drilling rig classification. Fill in the second part of the table about domestic drilling rig classification.

Drilling Rig Classification

There are many types and designs of drilling rigs, with many drilling rigs capable of switching or combining different drilling technologies as needed. Drilling rigs can be described using any of the following attributes:

1. by power used • electric – the rig is connected to a power **grid** usually produced by its own generators and uses electric motors to drive individual components such as drawworks, mud pumps and rotary tables. • mechanical – the rig uses **torque converters**, **clutches**, and transmissions powered by its own engines, often diesel • hydraulic – the rig primarily uses hydraulic power • pneumatic – the rig is primarily powered by pressurized air	**1. by power used**
2. by pipe used • cable – a cable is used to raise and drop the drill bit or drill string • **conventional** – uses metal drill pipe of varying types • coil tubing – uses a giant coil of tube and a downhole drilling motor	**2. by pipe used**
3. by height • single – can drill only single drill pipes, has no vertical **pipe racks** (most small drilling rigs) • double – can store double pipe stands in pipe racks • triple – can store stands composed of three pipes in the **pipe rack** (most large drilling rigs) • quad – can store stands composed of four pipes in the pipe rack	**3. by height**
4. by position of derrick	**4. by position of derrick**

• conventional – derrick is vertical • slant – derrick is at an angle (this is used to achieve **deviation** without an expensive downhole motor)	

11. Discuss the following points.

1. The most high-usage rigs.
2. Foreign drilling rig classification advantages.
3. Domestic drilling rig classification advantages.
4. Disadvantages of both classifications.
5. Modern tendencies in drilling rig development.

Rigging Up

Once the contractor gets the rig to the site, the next step is for the drilling crew to put the rig together, or **rig up**.

12. Put the following rig components and stages in the right rigging up order.

Rig floor

Mast

Substructures

Derrick

Raising the mast or derrick

13. Read the following texts and match them with above-mentioned rig components and rigging up stages. Fill in the chart.

1.

This drilling rig part allows the crew to drill several wells right next to each other on the platform. Crew members can drill one well, shift the crown block and the rotary, drill another well, shift the crown block and the rotary again, drill still another well, and so on, until they have drilled up to nine wells.

2.

It can be of two types: box-on box and the self-elevating, or slingshot.

3.

One of the tallest drilling rig parts are about 200 feet, or 60 metres, high. The shortest are about 65 feet, or 20 metres, high.

4.

It is a framework that rests right over the hole. It raises the rig floor anywhere from about 10 to 40 feet (3 to 12 metres) above the ground. The exact height depends on the space needed to clear this equipment.

5.

An important piece of equipment that is drawworks is placed on this drilling rig part.

6.

Some of them fold, telescope, or even come apart into sections to make them shorter and easier to move. Nevertheless, they retain their integrity as a unitized component.

7.

Its capacities for vertical loads run from 0.25 million up to 1.5 million pounds (over 0.5 million to about 3 million kilograms). In some cases, the drill string alone may weigh as much as a half million pounds, or over one million kilograms.

8.

If the rig has a mast, it is done mainly with the help of drawworks. If the rig has a derrick, crew members bolt it together, one piece at a time, on the substructure.

Rig component	Description	Function	Additional information

Rig Systems

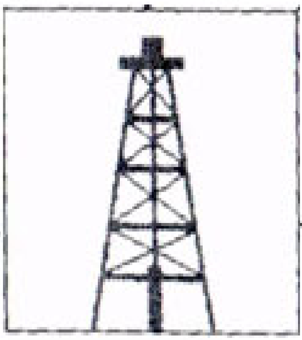
A rotary rig's main job is to make hole. To make hole, the drilling crew places a bit on bottom, then the driller rotates it and pumps drilling mud to it. A rig needs a multitude of equipment to make these operations happen. A first look at all the gear on a drilling rig can overwhelm you. It is, however, easy to understand a rig's components if you divide them into systems: **power, hoisting, rotating,** and **circulating**.

1. Power system

Diesel engine 1
Diesel engine 2
Diesel engine 3
Electric motors

2. Hoisting system

Drawworks
Cathead
Blocks and drilling lines



3. Rotating system

Swivel
Kelly
Rotary table
Top drive
Drill pipe
Drill bit

4. Circulating system

Drilling mud
Mud pits
Mud pumps
Rotary hose
Return line
Shale shaker

1. Read the text "Power system" and fill in the missing words from the box. There is one extra word.

Power system

Without 1. **power** nothing on a rig operates. Machinery must have an energy source to make it go. On virtually every drilling rig, the power comes from internal-combustion engines, which are called prime movers. Further, they often use diesel **2**. _______. Because of the way diesel engines operate, they deliver more turning force, or torque, than gasoline engines. As a result, many industries, including the **3.** ________ industry, use diesels.

A **4.** _______ may need from two to four prime movers, depending on its size. The bigger the rig, the deeper it can drill and the more power it needs. Thus, big rigs have three or four prime movers. Together, they develop 4,500 horsepower (about 3,300 kilowatts) or more. In comparison, a powerful car engine may put out only 300 horsepower (220 kilowatts) or so; most develop even less.

This power must **5.** ________________ to the rig's components to make them work. For example, at the same time as the rotary table needs power to turn the bit, the mud pump needs power to **6**. ______________ drilling mud. What is more, to provide maximum power to a component, the **7.** ________ must also be able to combine the power of two or more engines. Two common methods transfer power on today's rigs and allow the driller to combine engine power: mechanical transmission and electrical transmission.

be transferred; mix; drilling; fuel; circulate; driller; rig; **power**

(Baker R. "A Primer of Oil Well Drilling", 2001, Austin, Texas)

2. Define whether the following sentences are true (T) or false (F).

T / F	1. Diesel engines are used in drilling industry mainly because of its operation regime.
T / F	2. In fact, power is generated by internal-combustion engines almost on all drilling rigs.
T / F	3. The rig height is in proportion to well depth.
T / F	4. There are two main ways of power transmission.
T / F	5. As a rule, big rigs have three prime movers.

3. Lab. Assignment:"Power Systems and Instrumentations".

Terms and Vocabulary

automatic cathead	автоматическая шпилевая катушка
auxiliary	вспомогательный, дополнительный
brake	тормоз
cathead	шпилевая катушка
catline	канат для работ со шпилевой катушкой
clutch	муфта
console	пульт управления
fast line	ходовой конец (талевого каната)
friction cathead	фрикционная шпилевая катушка
makeup cathead, breakout cathead	шпилевая катушка для свинчивания бурильных труб
reeve	оснащать (талевую систему), продевать канат (через блок), надевать (на шкив)
shaft	вал, ось, шток
sheave	шкив; блок; ролик, каротажный ролик, колесо с желобчатым ободом
slip	скольжение, травить канат
spool	шпулька, бобина
winch	лебедка

4. Read the text "Hoisting system components" and do the exercises.

Hoisting system components

The drawworks is one of the largest and heaviest piece of equipment on a rig. It has a spool-shaped revolving drum around which crew members wrap the wire rope they call drilling line. It also has several shafts, clutches, **brakes**, and chain-and-gear drives. The **shafts**, clutches, and drives allow the driller to engage and disengage equipment on the drawworks. The driller can also change the speed with which the drum revolves, thereby varying the speed with which the drawworks raises the traveling block and hook. The driller controls the drawworks from a panel, or **console**, near the drawworks.

The drawworks also has a heavy-duty main brake. Large bands on both rims of the drum stop the drum from turning when the driller engages the brake. When the brake is disengaged, the drawworks drum lets out drilling line to lower the traveling block. An **auxiliary** hydraulic or electric brake assists the main brake when the draw-works is raising or lowering heavy loads. The **auxiliary brake** absorbs some of the **momentum** created by a heavy load. The main brake
thereby works more efficiently.

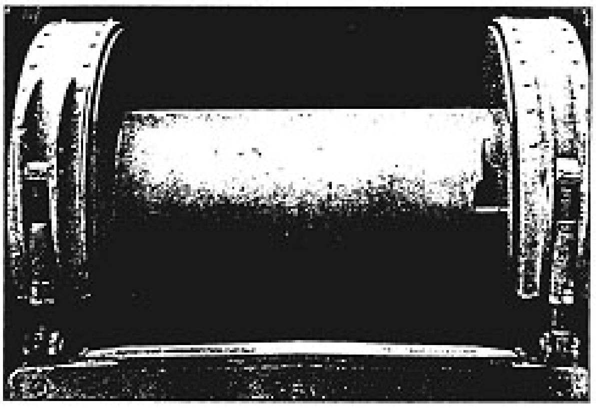


Fig. 3 Drawworks brake has two large bands on each end of the the drawworks

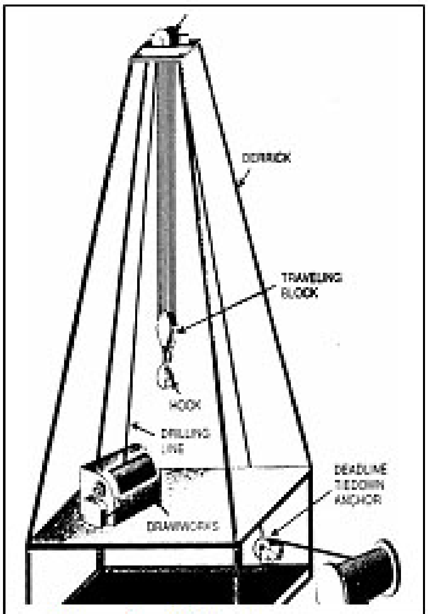


Fig. 4. Hoisting system

A **cathead** is a **winch**, or windlass, on which a line, such as rope, cable, or chain, is coiled. When activated, the cathead reels in the line with great force. Pulling on a rope, cable, or chain is vital to screwing and unscrewing (making up and breaking out) drill pipe.

A **friction cathead** is a steel **spool** a foot (30 centimetres) or so in diameter. It revolves as the catshaft revolves. Crew members used to employ friction catheads and a length of **catline**—a large-diameter rope made out of plant fiber, or hemp—to move heavy equipment around the rig floor. One floorhand rigged up one end of the catline to the object they wished to move. Another wrapped the other end of the catline a couple of times around the cathead. (Rig hands called this operation "taking wraps around the cathead.") This second crew member gripped the line near the turning cathead and, by pulling hard or not so hard on the line, adjusted the amount of friction the cathead applied to the line. When the crew member tightened the line—applied more friction—on the cathead, the cathead pulled on the catline and lifted the object. When the crew member loosened the catline wraps on the cathead— released the friction—the cathead stopped pulling on the catline.

An **automatic cathead** also pulls on a wire rope or, in some cases, on a chain, but in a way very different from a friction cathead. Instead of having to manually adjust tension on a line, the driller simply moves a control lever on the console to engage or disengage an automatic cathead. The automatic cathead on the driller's side of the drawworks is the **makeup cathead**. The automatic cathead on the opposite side of the drawworks is the **breakout cathead**, which looks exactly like the makeup cathead.

Drilling line is wireline, or wire rope. Drilling line is, however, considerably larger than the wire rope on the tongs. Wire rope is what most of the world calls cable. Wire rope manufacturers make drilling line by braiding several steel wires together. It looks like cloth, or fiber, rope except that it is made from steel wire rather than plant or plastic fibers. Drilling line ranges in diameter from ¾ to 2 inches, or about 22 to 51 millimetres.

First, assume that the derrick is lying horizontally in its cradle in the substructure. The drawworks is on the rig floor and the rig's engines are running. To begin, workers take one end of the rope off the supply reel, which is resting on the ground near the substructure. They pull the line from the reel to the top of the derrick. There the rig builders installed a large set of pulleys, or sheaves, termed the **crown block**. Crown blocks have several sheaves over which workers string the drilling line. They thread, or **reeve**, the drilling line over a groove in a crown block sheave. Then they pull the end of the line to another set of sheaves placed near the middle of the derrick. This sheave set is the **traveling block**.

The driller raises and lowers the traveling block in the derrick as drilling progresses. During string-up, however, the traveling block is also stationary until workers complete the string-up job. To continue stringing up, they reeve the end of the drilling line through one of the traveling block sheaves. Then they pull the line back to the crown block. They reeve the line over another sheave in the crown block and pull it back to the traveling block. There, they reeve the line through another traveling block sheave and pull it back to the crown.

The number of times the workers reeve the line through the blocks depends on the weight the line has to support and on the size of the crown and traveling blocks. Crown blocks and traveling blocks vary in the size and the number of sheaves they contain.

After the workers reeve the line for the last time over the crown block **sheaves**, they pull the end of the line to the drawworks. They secure the end of the drilling line to the drum in the drawworks. A worker then powers up the drawworks and takes several wraps of line around the drum, much as an angler reels in fishing line after a cast. Since the traveling block is resting on a support that holds it stationary, the line runs through it without moving it. The part of the drilling line running from the drawworks to the crown block is the **fast line**. It moves when the rig is operating. That is, after the drilling crew readies the rig, the fast line moves on or off the drawworks drum when the driller raises or lowers the traveling block.

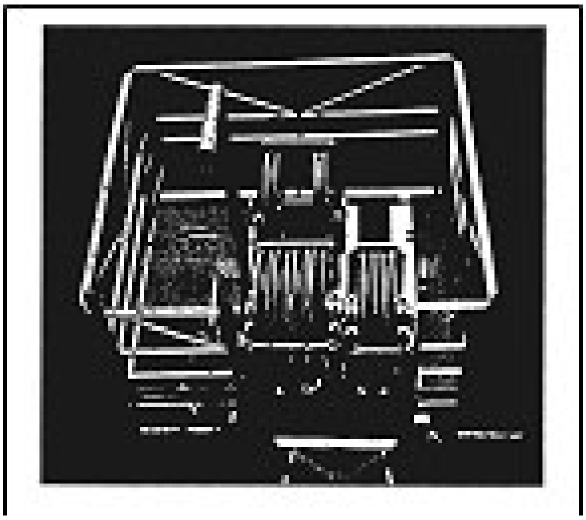


Fig. 5. Several sheaves make up the crown block.

Fig. 6. Travelling block

During the drilling of a well, the drilling line carries many tons of drill pipe and other tools in and out of the hole over a distance of several miles; or it uses many newtons of force moving drill pipe over a distance of thousands of metres. The crew therefore rates drilling line use in ton-miles or megajoules. (When a line has moved 1,000 newtons of load over a distance of 1,000 metres, the line has given i megajoule of service.) The driller keeps careful track of how many ton-miles (megajoules) of wear occur over time. By consulting specially prepared tables, the driller knows when it is time to **slip** the line. Slipping the line places unworn line on the wear points where the line goes through and over sheaves in the traveling and crown blocks. The drilling line also wears where it spools off the drawworks drum.

(Baker R. "A Primer of Oil Well Drilling", 2001, Austin, Texas)

5. Make collocations from the following words.

1. drawworks	A. block
2. auxiliary	B. line
3. crown	C. rope
4. drilling	D. drum
5. makeup	E. load
7. heavy	F. brake
8. wire	G. cathead

6. Fill in the gaps with the most suitable words or terms from the text.

1. Once the last line has been strung over the _________ _________ sheaves, the end of the line goes down to the drawworks drum, where it is firmly __________.
2. The extra sheave is needed for _________ the deadline.
3. The brake is mounted on the end of the _______.
4. A typical hoisting system is made up of the drawworks, a mast or derrick, the crown block, _______ _________, and the wire rope drilling line.
5. You can lift an object on the rig floor wrapping the rope around a ______ ______.
6. For heavier loads, twelve or more ______ could be strung.
7. The main brake is used for _______ and ____________ the drawworks drum.

7. Match the words in the left column with the definitions in the right one.

1. drawworks	A. wedge-shaped pieces of metal with teeth or other gripping elements that are used to prevent pipe from slipping down into the hole.
2. sheave	B. a wire rope used to support the drilling tools
3. spool	C. an assembly of sheaves mounted on beams at the top of the derrick or mast and over which the drilling line is reeved.
4. fastline	D. it is essentially a large winch that spools off or takes in the drilling line and thus raises or lowers the bit.
5. cathead	E. a cylinder around which wire rope is wound in the drawworks.
6. drilling line	F. the end of the drilling line that is affixed to the drum or reel of the drawworks.

7. brake	G. grooved pulley.
8. crown block	H. a device for arresting the motion of a mechanism, usually by means of friction.
9. drum	I. a spool-shaped attachment on the end of the catshaft, around which rope for hoisting and moving heavy equipment on or near the rig floor is wound.
10. bit	J. the drawworks drum.

8. Fill in the chart with the functions of the hoisting system components.

Component	**Composition**	**Function**
Drawworks		
Crown block		
Drilling line		
Cathead		

9. Lab. Assignment:"Hoisting Equipment".

Terms and Vocabulary

die	плашка, оправка
drill collar	воротник бура, утяжелённая штанга; утяжелённая бурильная труба, удлинитель
drill stem	бурильная колонна; бурильная штанга (при роторном бурении); ударная штанга
drill string	бурильная колонна
gooseneck	S-образное колено трубы
kelly bushing	вкладыш под ведущую бурильную трубу
master bushing	постоянная втулка
slips	клин, шлипс
tool joint	бурильный замок
saver sub	переводник с перенарезаемой резьбой в бурильной колонне
threaded	с резьбой
stab (v)	заводить конец верхней трубы в муфту нижней
mate (v)	соединять
drive shaft	приводной вал

10. Read the text "Rotary system components". Define what is IT in bold in each paragraph using the words from the right column.

Rotary system components

Rotating equipment includes the devices that make the bit turn. On a conventional rig, the equipment consists of a **swivel**, an upper **kelly cock**, a special length of pipe called the kelly, a lower kelly cock, a kelly saver sub, the **rotary table**, the **drill pipe**, the **drill collars**, and the **bit**. Some contractors install a special system on their rigs called a top drive. It replaces many parts of the conventional rotating system; top drives are discussed in more detail later.

According to the American Petroleum Institute (API), all the pipe between the swivel and the bit, including the kelly, the drill pipe, and drill collars, is the **drill stem**. (The API is a trade association that sets oilfield standards and specifications.) The **drill string** includes only the drill pipe—not the kelly and the drill collars. Be aware, however, that practically everybody in the oil patch uses "drill string" to mean the drill pipe and the drill collars.

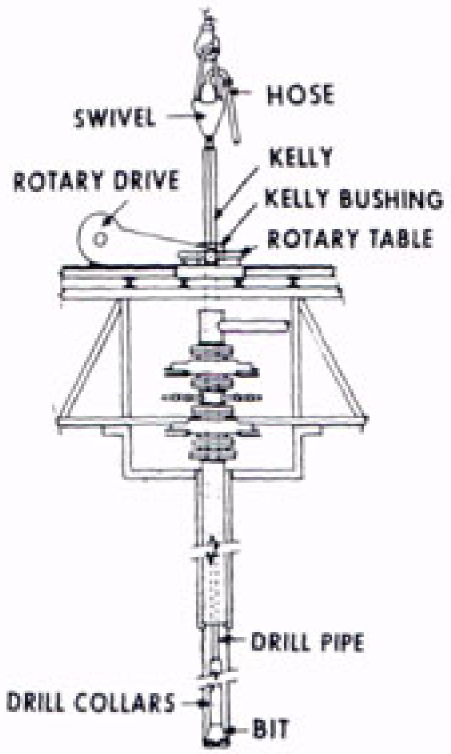


Fig. 7. Schematic of rotary system

<table>
<tr>
<td>1.
IT is a remarkable device. IT sustains the weight of the drill stem, permits it to rotate, and provides a passageway for drilling mud to get into the drill stem. IT also has a large bail, similar to the bail, or handle, on a bucket but much, much larger. IT’s bail fits inside the hook at the bottom of the traveling block. Crew members also attach the rotary, or kelly, hose to ITs side at the gooseneck. The gooseneck is a curved piece of erosion-resistant pipe. Drilling mud enters IT through the rotary hose and the gooseneck.</td>
<td rowspan="2">Rotary table

Drilling stem

Swivel

Diesel engine

Drill string

Drill bit

Kelly

Hose

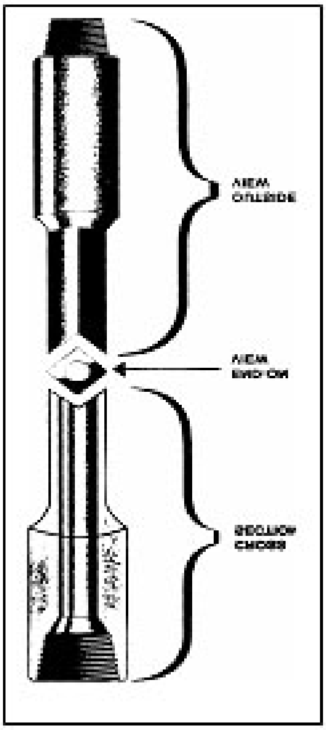
Top drive</td>
</tr>
<tr>
<td>2.
IT is square or hexagonal, instead of round, because the flat sides provide a way to make IT turn. The driller lowers IT inside a corresponding square or hexagonal openng in the kelly bushing. The kelly bushing fits into another rotating component called the master bushing. The master bushing fits inside the rotary table. Thus, as the rotary table rotates, the master bushing and the kelly bushing also rotate. Since the IT mates with the kelly bushing, IT also rotates. The pipe rotates because the crew connects it to the ITs bottom. Finally, the drill collars and the bit rotate because the crew connects them to the drill pipe.

IT passes through the kelly bushing. The master bushing rotates the kelly bushing, which rotates IT. The drill pipe, drill collars, and bit rotate as well. They disappear into the rotary table where you can't see them. At the same time, the mud pump sends mud through the rotary hose and into the swivel. From the swivel, the mud flows inside and down the kelly, the drill pipe, the drill collars, and out the bit. The mud shoots out the bit and lifts cuttings up the hole to the surface.</td>
</tr>
</table>

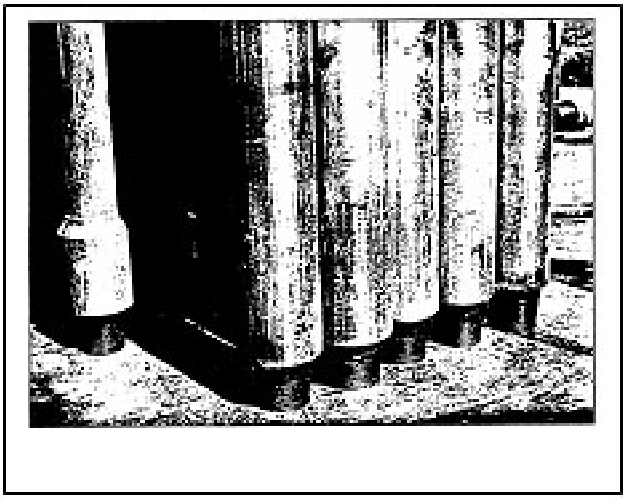
3. The crew fits the master bushing into **IT**. During normal drilling operations, the master bushing drives the kelly bushing. When drilling stops and the kelly bushing is out of the master bushing, the master bushing can hold the **slips.**. Slips have strong, toothlike gripping elements called **dies.** Slips fit around the drill string and suspend it in the hole. With the drill string suspended by the slips, the crew can remove the kelly and the swivel from the drill string. The traveling block and hook no longer suspend the drill string.	**Tool joints**
4. **IT** hangs from the traveling block's hook in place of a conventional swivel. A powerful heavy-duty motor in **IT** turns a threaded drive shaft. The crew stabs, or inserts, the unit's drive shaft directly into the top of the drill stem. When the driller starts **ITs** motor, it rotates the drill stem and the bit. The rig therefore does not use a conventional swivel, a kelly, a rotating rotary table and master bushing, or a kelly bushing. Rigs with **IT** still need, however, a rotary table and master bushing to provide a place for the slips to suspend the pipe.	
5. **IT** consists of the drill pipe and special, heavy-walled pipe called drill collars. Manufacturers make **IT** from steel, but they also use aluminum. **IT** is heavier than drill pipe, however. The drilling crew uses them to put weight on the bit to make it drill. They install them in the drill string below the drill pipe. Number of drill collars depends on how much weight the bit needs and on how much the drill collars weigh.	
6. **IT** is a threaded piece on each end of the pipe . The pipe maker welds **IT** to the pipe. The crew connects the pipe with **IT. IT** adds a significant amount of weight to drill pipe, but not enough to make it weigh anywhere near as much as drill collars.	

7. Manufacturers make two types of **IT** for rotary drilling: roller cone and diamond. Roller cone have steel cone-shaped devices that roll, or turn, as the bit rotates. Most of them have three cones; some have two and some have four, however. **Its** makers mill or forge teeth out of the body of the cones, or they insert very hard tungsten carbide buttons into the cones. The teeth or inserted buttons cut, scrape, or gouge the rock as **IT** rotates.	

11. Label each picture with correct rotary system component and describe its composition.



1.___________



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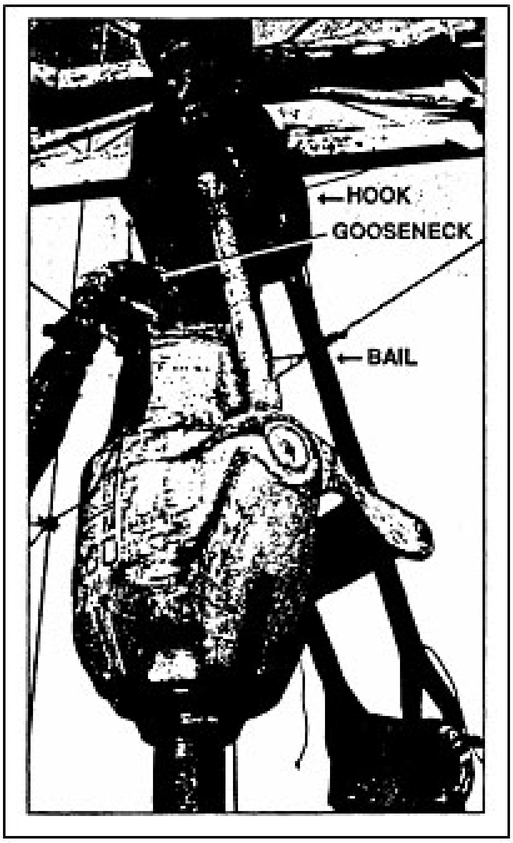
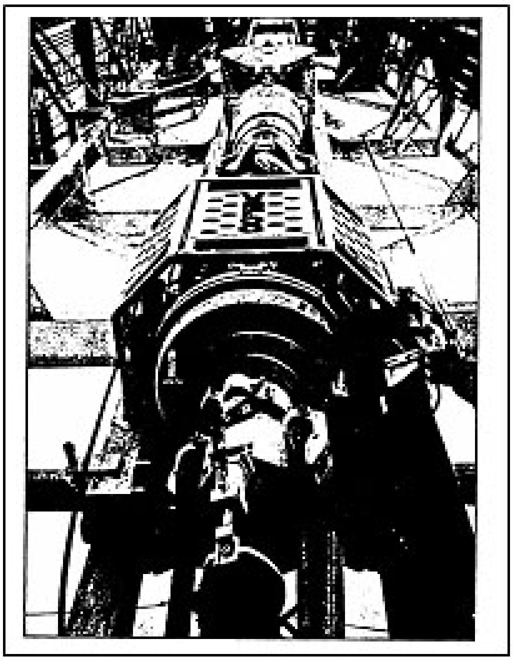
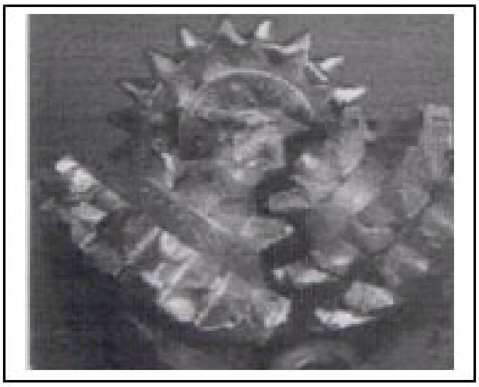
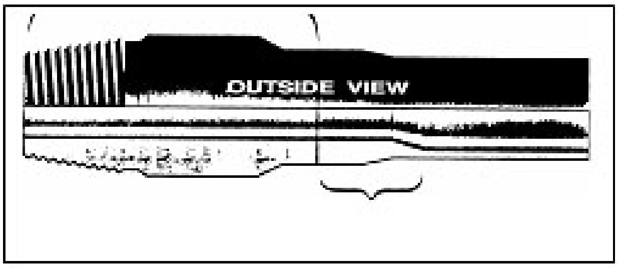




4. ______________

3. ______________





6. ______________________

5.________________

12. Match the words in the left column with the definitions in the right one. There is one extra definition.

1. swivel	A. a device similar to a power swivel that is used in place of the rotary table to turn the drill stem.
2. kelly	B. the column of drill pipe with attached tool joints that transmits fluid and rotational power from the kelly to the drill collars and the bit.
3. rotary table	C. a special device placed around the kelly that mates with the kelly flats and fits into the master bushing of the rotary table.
4. drill stem	D. a rotary tool that is hung from the rotary hook and the traveling block to suspend the drill stem and to permit it to rotate freely.
5. drill string	E. seamless steel or aluminum pipe made up in the drill stem between the kelly or top drive on the surface and the drill collars on the bottom.
6. drill bit	F. a flexible tube for conveying liquids or gases under pressure
7. top drive	G. the principal component of a rotary, or rotary machine, used to turn the drill stem and support the drilling assembly.
8. hose	H. a heavy, thick-walled tube, usually steel, placed between the drill pipe and the bit in the drill stem.
9. drill pipe	I. a heavy coupling element for drill pipe.
10. drill collar	J. the cutting or boring element used for drilling
11. kelly bushing	K. all members in the assembly used for rotary drilling from the swivel to the bit.
	L. the heavy steel tubular device suspended from the swivel through the rotary table and connected to the top joint of drill pipe to turn the drill stem as the rotary table turns.

13. Listen to a top drive system description. Read the questions 1–5 and choose the answer – A,B,C or D – that best suits the information in the text.

1. What rotates the drill string when using a top drive system?

A. Rotary table
B. Drive shaft
C. Guide rails
D. Crew members

2. Which of the following is the advantage of the top drive?

A. It is cheaper to maintain than a rotary table system.
B. It requires less qualification of the driller.
C. It reduces drilling time.
D. It weights lighter that a kelly assembly.

3. According to the text, what helps a top drive system to prevent hole problems?

A. It allows drill string rotation at any hole point due to a wide range of rotating power.
B. It allows moving drilling rigs a short distance.
C. It allows reducing the number of connections of pipes.
D. It allows handling stands of pipes more efficiently.

4. Which of the following was mentioned as a disadvantage of a top drive system?

A. It requires an additional weight on a bit.
B. The drill string should be constantly maintained.
C. A drilling line wears faster.
D. It's difficult to use it in highly deviated holes.

5. Which of the components is NOT included in a top drive system?

A. A rotary hose
B. An integrated swivel
C. A traveling block
D. A kelly

14. Lab. assignment: “Rotating Equipment, Mast and Structure”.

Terms and Vocabulary

annulus	кольцеобразный зазор
bulk storage	хранение в резервуаре
discharge line	нагнетательный трубопровод, выкидная линия, напорный трубопровод
mud pit	отстойник; приёмная ёмкость для бурового раствора; амбар для хранения бурового раствора
return line	возвратная линия, канат
rotary hose	нагнетательный шланг роторной буровой установки, соединяющий стояк с вертлюгом
standpipe	водозаборная колонна
suction line	всасывающая линия, приёмная линия (насоса), всасывающий трубопровод (бурового насоса), впускной трубопровод

15. Read the text “Circulating system” and do the exercises.

Circulating System

Mud circulates through many pieces of equipment, including the mud pump, the discharge line, the standpipe, the rotary hose, the swivel, the kelly (or the top drive), the drill pipe, the drill collars, the drill bit, the annulus, the return line, the shale shaker, the desilter, the desander, the mud pits, and the suction line.

The mud pump draws in mud through a suction line from the mud pits, or tanks, and sends it out a discharge line. From the discharge line, the mud goes into the standpipe. The standpipe runs vertically up one leg of the derrick. Mud exits the standpipe into a strong, flexible, and reinforced rubber hose called the **rotary hose**, or **kelly hose**. The rotary hose joins the swivel at the gooseneck. The mud then flows down the kelly (or through the top drive), drill pipe, and drill collars. It jets out of the bit nozzles and moves cuttings away from the bit. The mud and cuttings then head up the hole in the **annulus**. The annulus, or annular space, is the area between the drill string and the wall of the hole.

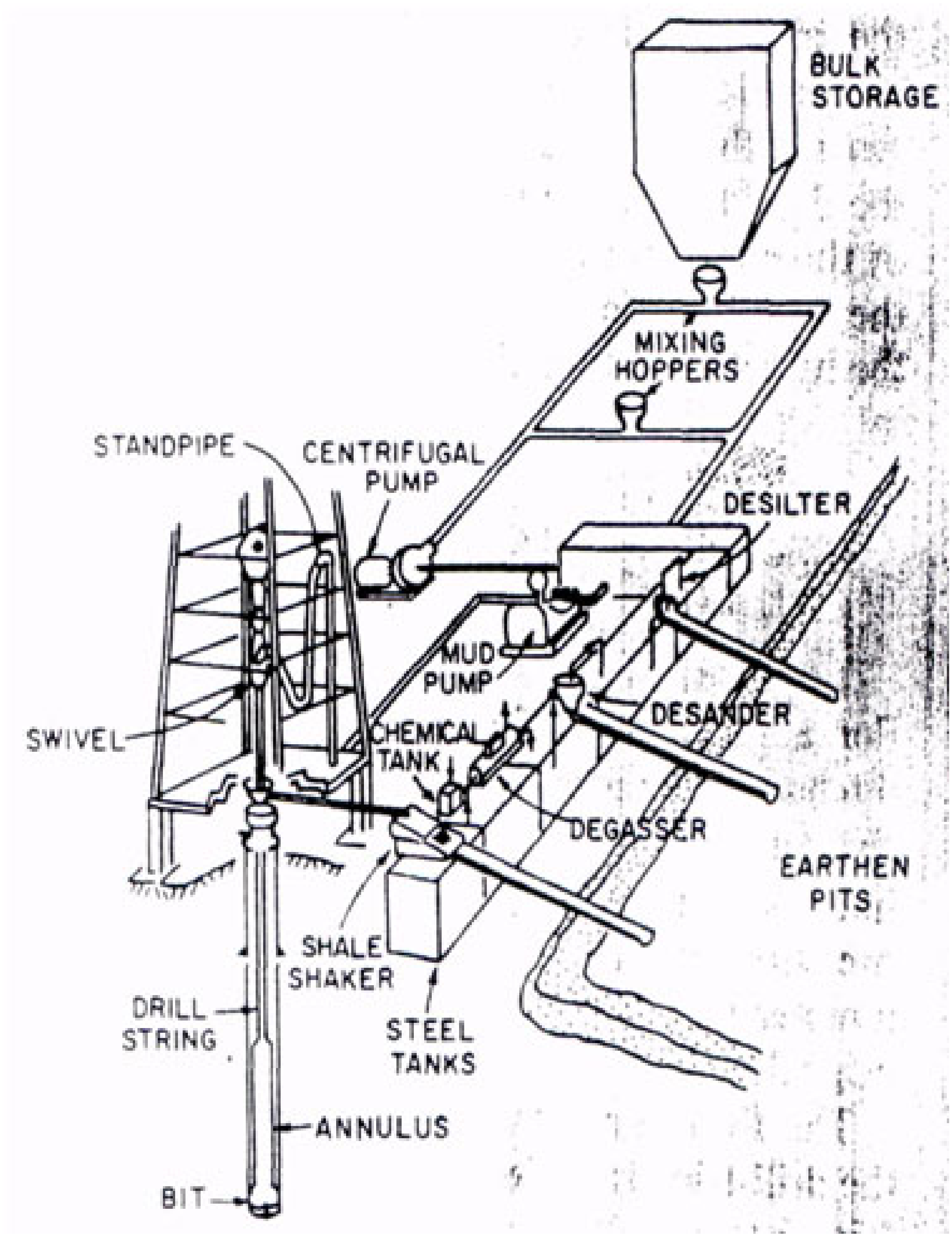


Fig. 8. Schematic of example rig circulating system

The mud leaves the annulus through a steel pipe called the **mud return line**. It falls over a vibrating screen, the **shale shaker**. The shaker screens out the larger cuttings and, in some cases, dump them into the reserve pit. Offshore and in environmentally sensitive areas, however, the shaker dumps the cuttings into a receptacle. Later, the contractor removes the receptacle, washes the cuttings if required, and properly disposes of them. In either case, the clean mud drains back into the mud tanks. The pump then recycles it back down the hole. The mud pump recirculates the mud over and over throughout the drilling of the well. From time to time, the derrickhand adds water, clay, and other materials to make up for downhole losses. This crew member also adjusts the mud's properties as the borehole encounters new and different formations.

16. Define whether the following sentences are true (T) or false (F).

T / F	1. Having flowed through the swivel, mud flows down the top drive.
T / F	2. Shaker screens always dump the cuttings into the reserve pits.
T / F	3. Mud is drained into the mud tanks.
T / F	4. Mud is circulated during the drilling of the well.
T / F	5. The mud properties are changed according to various formation

17. Put the following circulating system components in the right order to make the system work.

Shale shaker | Mud pump | Drill bit | Discharge line

Desander | Centrifugal pump | Standpipe | Suction line

Drill pipe | Swivel | Kelly hose | Earthen pits

Degasser | Desilter | Annulus

18. Listen to the text and mark the statement with T if it is true and with F if it is false.

1. Crew members prepare the mud in mud tanks.
2. Usually a drill rig uses two pumps operating simulatneously.
3. The mud going through the rotary hose carries cuttings with it.
4. Nozzles are special holes in the bit through which the mud jets out and removes cuttings away.
5. The last piece of equipment the mud goes through before returning back into the mud tank and closing the circulation cycle is a shale shaker.

19. Lab. assignment:" Mud circulations and treating equipment".

20. Analyzing the failures, define what drilling rig components are broken and what must be done.

Drilling mud is full of solids, particles, and gas

Mud doesn't flow out of the standpipe

The drill pipe and attached bit don't rotate

Drilling lines being strung between the travelling and the crown blocks are jammed

The drawworks and mud pumps don't run

A square kelly doesn't fit the opening in the kelly drive bushing

The drill string can not be raised

21. You are going to have panel discussion on the following topic – "Drill Bits Chew Rock Formation". It will consist of two parts:

1. Video " Sophisticated Bit technology"
2. Presentations " Bit Technology Development"

WORDLIST

ENGLISH	RUSSIAN
accumulator unit	аккумулятор
annulus	кольцеобразный зазор
automatic cathead	автоматическая шпилевая катушка
auxiliary	вспомогательный, дополнительный
backup tongs	удерживающий ключ для труб
blowout preventer	противовыбросовое устройство, превентор
brake	тормоз
bulk storage	хранение в резервуаре
casing	крепление скважины обсадными трубами
cathead	шпилевая катушка
catline	канат для работ со шпилевой катушкой
centrifuge	центрифуга, центрифугировать, очищать (буровой раствор) на центрифуге
choke manifold	штуцерный манифольд (противовыбросового оборудования)

circulation system	система промывки
clutch	муфта, соединять
console	пульт управления
convential	стандартный
crown block	кронблок
degasser	устройство для дегазирования бурового раствора, дегазатор
derrick	буровая вышка
desander	пескоотделитель (устройство для очистки бурового раствора от песка)
desilter	ситогидроциклонный илоотделитель
deviation	отклонение
die	плашка, оправка
discharge line	нагнетательный трубопровод, выкидная линия, напорный трубопровод
doghouse	будка для переодевания рабочей вахты (на буровой), будка бурового мастера
drawworks	буровая лебедка
drill collar	воротник бура, утяжелённая штанга; утяжелённая бурильная труба, удлинитель
drill stem	бурильная колонна; бурильная штанга (при роторном бурении); ударная штанга
drill string	бурильная колонна
driller’s console	пульт управления бурильщика
drilling line	буровой канат, рабочий канат
elevators	элеватор
fast line	ходовой конец (талевого каната)
friction cathead	фрикционная шпилевая катушка
gooseneck	S-образное колено трубы
grid	батарея, энергетическая система
hook	крюк
kelly bushing	вкладыш под ведущую бурильную трубу
makeup cathead, breakout cathead	шпилевая катушка для свинчивания бурильных труб
master bushing	постоянная втулка
mud pit	отстойник; приёмная ёмкость для бурового раствора; амбар для хранения бурового раствора
pipe rack	стеллаж для труб
reeve	оснащать (талевую систему), продевать

	канат (через блок), надевать (на шкив)
return line	возвратная линия, канат
rotary hose	нагнетательный шланг роторной буровой установки, соединяющий стояк с вертлюгом
shaft	вал, ось, шток
sheave	шкив; блок; ролик, каротажный ролик, колесо с желобчатым ободом
slant rig	наклонная буровая установка
slip	скольжение, травить канат
slips	клин для захвата буровых и обсадных труб, шлипс
spool	шпулька, бобина
standpipe	водозаборная колонна
suction line	всасывающая линия, приёмная линия (насоса), всасывающий трубопровод (бурового насоса), впускной трубопровод
tool joint	бурильный замок
torque converters	гидротрансформатор
winch	лебедка
hopper	бункер, засыпная воронка, приёмный жёлоб, загрузочный ковш
kelly	«квадрат», ведущая труба
kellybushing	втулка квадрата
mast	вышка мачтового типа
masterbushing	основной вкладыш ротора
mechanical system	механический привод
monkeyboard	люлька верхового рабочего; полати для верхового рабочего; площадка для верхового рабочего
mousehole	шурф для двухтрубки
mud pit	отстойник, приёмная ёмкость для бурового раствора, амбар для хранения бурового раствора
mud return line	линия для выхода бурового раствора
mud-gas separator	газосепаратор для бурового раствора
pipe rack	приспособление для укладки бурильных труб в штабель (в вышке), мостки для труб (на буровой), стеллаж для труб
pipe ramp	горизонтальные мостки для труб
power system	энергосистема

rathole	шурф для квадрата
rotary hose	буровой шланг
rotating system	система вращения
shale-shaker	вибрационное сито
substructure	подвышечное основание; фундамент; фундаментная рама (буровой мачты)
swivel	вертлюг
traveling block	талевый блок
wire rope	проволочный трос
weight indicator	индикатор нагрузки на буровой инструмент

UNIT 5

CASING. CEMENTING

It is generally not possible to drill a well through all of the formations from surface to the target depth in one hole section. The well is therefore drilled in sections, with each section of the well being sealed of by lining the inside of the borehole with steel pipes, known as **casing** and filling the annular space between this **casing string** and the borehole with cement, before drilling the subsequent hole section.

Lead-in

Make comments about reasons for casing off formations.

unstable formation zones

high pore pressure

Casing off

well formation zone

lost circulation

selective access

structural support

1. ***Pay special attention to the pronunciation and stress of the following words.***

   conduit [΄kondjuıt, ΄konduıt] thr**ea**ded **an**t**i**ci**pat**ed **li**ner

   subse**que**nt [΄sʌbsıkwənt] **hydrau**lically

2. ***Read the following texts and match them with casing types.***

Casing types: 1. Conductor casing; **2.** Surface casing; **3.** Intermediate casing; **4.** Production casing; **5.** Liner a)

It either runs through the pay zone or sets just above the pay zone. The main function of this casing is to isolate the production interval from other formations. It also provides protection for the environment in the event of failure of the tubing string during production operations and permits the production tubing to be replaced or repaired later in the life of the well.

b)

It generally sets at approximately 1000-1500ft. below the ground level. The main functions: prevents cave-in of unconsolidated, weaker, near-surface sediments and protects the shallow fresh water sands from contamination; supports and protects from corrosion any subsequent casing strings run in the well; supports the wellhead and BOP equipment (in case of kick, surface casing generally allows

c)

It is a short casing string which is suspended from the inside of the previous casing string by a special device known as .... This device is attached to the top joint of the casing in the string. The collar and slips support its weight. The overlap with the previous casing is usually 200ft. –

d)

It is the largest casing. It is generally set at approximately 100ft, below the ground level. Its function is to seal off unconsolidated formations shallow depths. It protects the subsequent casing strings from corrosion and may be used to support structurally some of the wellhead load.

e)

A heavy, flanged steel fitting connected to the first string of casing. It provides a housing for slips and packing assemblies, allows suspension of intermediate and production strings of casing, and supplies the means for the annulus to be sealed off.

f)

It is used to isolate troublesome formations including unstable shales, lost circulation zones, abnormally pressured zones and squeezing salts. When abnormal formation pore pressures are present in the deeper portions of a well, this casing is needed to protect formations from the pressures created by the required high-drilling-fluid density.

Terms and Vocabulary

anticipated load	ожидаемая нагрузка
BOP (blowout preventer)	противовыбросовое устройство, противовыбросовый превентор
casing hanger	клиновой захват для спуска обсадных труб
casing string	колонна обсадных труб
conductor casing	направляющая труба (первая колонна обсадных труб, спускаемая в буровую скважину на сравнительно небольшую глубину для придания скважине правильного направления и перекрытия и пород, склонных к осыпанию)
conduit	трубопровод
guide shoe (casing shoe)	башмак обсадных труб (деталь из твердой стали, прикрепляемая к нижней трубе обсадной колонны, имеющая острый край для срезания грунта)
intermediate casing	промежуточная обсадная колонна (техническая)
liner hanger	подвеска обсадной колонны хвостовика
pay zone	зона с промышленной нефтегазоносностью
production casing	эксплуатационная колонна
production interval	продуктивный интервал
setting	установка; спуск и посадка обсадных труб
setting depth	глубина установки
slip	клин, плашка
surface casing	колонна обсадных труб после кондуктора (кондуктор)
surface string	комплект противовыбросовых превенторов
threaded connection	резьбовое соединение

3. Match the casing with its functions.

1. Conductor casing 2. Surface casing 3. Intermediate casing 4. Production casing 5. Liner	Environmental protection, drilling fluid circulation, corrosion protection, drilling efficiency increase, wellhead load support, BOP equipment support, troublesome formation protection, sediment isolation; to seal off unconsolidated formations, to prevent from formation cave-in, to decrease pressure, to prevent from water pollution, to isolate production zone.

4. Underline the components or functions that are correct.

1. Casing is a strong
a) lead pipe b) steel pipe c) the entire length of all the joints

2. Casing protects the shallow zones from
a) being contaminated b) caving in c) being flooded

3. Intermediate casing is needed for
a) pressure stabilization b) production interval isolation c) wellhead support

4. Liner consists of
a) joints and collars b) catches and slips c) collars and slips

5. Production casing
a) can be replaced b) can be repaired c) protect environment

6. Conductor casing has
a) the largest diameter b) the widest walls c) the smallest diameter

5. Listen to the description of the well completion process. Then read the statements and choose the alternative – A, B, C or D – that best suits the information in the text.

1. To complete the oil or gas well
A. a production casing is used.
B. a surface casing is used.
C. a conductor casing is used.
D. an intermediate casing is used.

2. Primary recovery means that hydrocarbons are forced up to the surface due to
A. primary pressure
B. secondary pressure
C. air pressure
D. natural pressure

3. Even the field is developed professionally,

A. nine per cent of gas and forty five per cent of oil remain behind.
B. ninety per cent of gas and forty five per cent of oil remain behind.
C. fifteen per cent of gas and fifty four per cent of oil remain behind.
D. fifty per cent of gas and fourteen per cent of oil remain behind.

4. The Christmas tree is
A. a wellbottom area fitted with attractive drill bits.
B. a wellhead area fitted with surface casing.
C. a wellbottom area fitted with downhole pumps and valves.
D. a wellhead area fitted with many valves and pipes.

5. It is possible for a well to make a stand up to
A. five kilometers from the production platform.
B. five kilometers from the nearest pipe connection.
C. as many kilometers as necessary.
D. five kilometers from the wellhead.

6. Read the text "Eight Steps Ensure Successful Cement Jobs". Define eight factors the operators must consider for successful cementing jobs.

Drilling mud condition
cement composition selection
proper cementing system selection
spacer and flush use
the casing centralization
pressure optimization
the pipe move
displacement rate maximization
proper temperature slurry design

1. Drilling mud condition

This factor is the most important in achieving good displacement during a cement job. The following measures are necessary to follow:

- determine the hole volume that can be circulated; evaluate the % of wellbore that is actually being circulated (for best results, use a caliper or material balance to determine downhole fluid mobility and check for annular fluid that is not moving);
- circulate the drilling mud to help break the gel structure of the fluid; condition the drilling mud until equilibrium is achieved (after casing is on bottom and before the displacement begins,

circulating the mud decreases its viscosity and increases mobility);

- never allow the drilling mud to set static for extended periods, especially at elevated temperatures. (mud properties coming out of the well are the same as the mud pumped in); continue circulating until displacement program begins;
- modify the flow properties of the drilling fluid to optimize mobility and drilling cuttings removal;
- examine the mud gel strength profile during the job planning stage and just before the cement job (an optimum drilling fluid will have flat, non progressive gel strengths);
- measure the gel strength development during the job planning stage, at downhole temperature and pressure.

2. ______________

They separate the dissimilar drilling mud from the cement. Also they enhance gelled-mud removal and allow better cement bond with the borehole. They are designed to serve various needs: (1) help well control; (2) provide increased mud-removal benefits. The following guidelines should be considered to achieve maximum mud displacement:

- pump the spacer fluid at an optimized rate or as fast as possible without breaking down the formation;
- provide spacer contact time and volume to remove the greatest possible amount of mud;
- make sure the viscosity, yield point and density of both the spacer and the cement slurry, are at least the same as the drilling fluid;
- design the spacer package to water-wet the surface of the pipe and formation thoroughly when using oil-based or synthetic – based drilling fluids.

Flushes are used for thinning and dispersing drilling – fluid particles. These fluids go into turbulence at low rates, helping to clean drilling fluid from the annulus.

3.

- rotating and reciprocating casing before and during cementing breaks up stationary, gelled pockets of drilling mud;
- loosens cuttings trapped the gelled mud;
- allows high displacement efficiency at lower pump rates by keeping the drilling mud flowing.

4.

It helps to optimize drilling –fluid displacement. Good pipe standoff helps ensure uniform flow patterns around the casing. Equalizing the friction loss or force that flowing cement exerts around the annular clearance increases drilling-fluid removal. The best mud displacement at optimum rate is achieved when annular clearance is 1–1.5 in. Pipe movement and displacement are severely restricted. Centralizers and other mechanical cementing aids commonly used in the industry, also serve as inline laminar flow mixers. They change flow patterns and promote better mud displacement and removal.

5.

- high-energy flow in the annulus is most effective to ensure good mud displacement;
- turbulent flow around the full casing circumference is desirable, but not absolutely essential;
- when turbulent flow is not a viable option for the formation or wellbore configuration, the highest pump rate is feasible;
- the best cementing results are obtained when the spacer and cement are pumped at maximum energy, the spacer is appropriately designed to remove mud and good competent cement is used.

6.

One can optimize cost and displacement efficiency by following guidelines:

- design the job on basis of actual wellbore circulating temperatures;
- estimate the bottomhole circulating temperature (BHCT) using the API;
- use the actual downhole temperatures measured;
- include surface mixing time when estimating job time.

7. ____________________

Operators are encouraged to design cement slurry for its specific application, with good properties to allow placement in a normal time period. The ideal cement slurry has no measurable, free water, provides adequate retarder to ensure proper placement and maintains stable density to ensure hydrostatic control. Several criteria affect slurry design:

- well depth
- BHCT
- Bottomhole static temperature (BHST)
- Drilling fluid hydrostatic pressure
- Drilling fluid type
- Slurry density
- Lost circulation
- Gas migration potential
- Pumping time
- Quality of mix water fluid-loss control
- Flow regime
- Quality of cement
- Dry or liquid additives
- Strength development
- Quality of the cement testing laboratory and equipment.

8. _______________

These systems vary in their capability to provide good zone isolation in changing environments. The traditional approach to cement selection has been on the basis that higher compressive strengths result in higher cement sheath quality. One of the most versatile systems to apply is foam cement, which produces a more ductile and resilient cement and withstands the stress associated with casing expansion and contraction.

(Oil &Gas Journal, 1999)

7. Match the two parts of the sentences.

1. Low annular clearance	A. real bottomhole temperature analysis.
2. Drilling mud flow properties are	B. the turbulent flow is required.
3. Displacement efficiency can be achieved by	C. equal the cement slurry density and yield point as well.
4. Drilling fluid density and yield point	D. define the slurry composition.

5. Flow patterns can be changed by	E. influences mud displacement.
6. For displacement rate increase	F. mechanical cementing technologies application.
7. Pumping time can	G. in proportion to drilling cuttings removal rate.

8. Look through the text once again and fill in the chart.

Steps	Objective	Description	Priority
drilling mud condition			
cement composition selection			
proper cementing system selection			
spacer and flush use			
the casing centralization			
the pipe move			
displacement rate maximization			
proper temperature slurry design			

9. You have some money for drilling procedure improvement in the certain oilfield. Unfortunately, the sum is not great and you are to choose four steps for successful cementing jobs. Moderate the whole implementation procedure and be ready to prove your choice.

WORDLIST

ENGLISH	RUSSIAN
annular clearance	затрубный интервал
annular space	затрубное пространство
anticipated load	ожидаемая нагрузка
bond (bonding)	соединение
BOP (blowout preventer)	противовыбросовое устройство, противовыбросовый превентор

bottomhole circulation temperature (BHCT)	динамическая температура на забое
bottomhole static temperature (BHST)	статическая температура на забое
casing circumference	окружность обсадных труб
casing failure	разрушение обсадных труб
casing hanger	клиновой захват для спуска обсадных труб
casing head pressure	давление на устье скважины
casing string	колонна обсадных труб
cement sheath	фильтрационная корка на стенках скважины
centralizer	центратор- для центрирования колонн обсадных труб
compatibility	совместимость
compressive strength	предел прочности при сжатии
conductor casing	направляющая труба (первая колонна обсадных труб, спускаемая в буровую скважину на сравнительно небольшую глубину для придания скважине правильного направления и перекрытия и пород, склонных к осыпанию)
conduit	трубопровод
contact time	время контакта
contaminate	загрязнять
contraction	сжатие
disperse	диспергировать
displacement rate	объемный расход
downhole (bottomhole)	забойное давление
drill cuttings	шлам
drilling fluid	буровой раствор (промывочная буровая жидкость)
ductile	пластичный вязкий
elevated temperature	надземная \ поверхностная температура
equivalent circulating density (ECD)	эквивалент циркуляционной плотности
expansion	расширение
flow path	пути проникновения потока
flow pattern	структура потока
fluid mobility	подвижность жидкости
fluid removal	смещение жидкости (отвод жидкости)
flush(es)	струя жидкости
foam cement	цементная пена

friction loss	потери на трении
gelled mud	густой буровой раствор
guide shoe (casing shoe)	башмак обсадных труб (деталь из твердой стали, прикрепляемая к нижней трубе обсадной колонны, имеющая острый край для срезания грунта)
hole volume	объем скважины
inclination	угол наклона буровой скважины к горизонту
intermediate casing	промежуточная обсадная колонна (техническая)
laminar flow	ламинарное течение
liner hanger	подвеска обсадной колонны хвостовика
pay zone	зона с промышленной нефтегазоносностью
production casing	эксплутационная колонна
production interval	продуктивный интервал
reciprocating	расхаживание труб
resilient	упругий \ эластичный
retarder	замедлитель реакции \ демпфер
set time	установленное время
setting	установка; спуск и посадка обсадных труб
setting depth	глубина установки
slip	клин, плашка
slurry	цементный раствор
spacer(s)	промежуточное кольцо (жидкость с высокой вязкостью и плотностью для удаления бурового раствора)
standoff	степень центрирования (обсадной колонны в стволе)
surface casing	колонна обсадных труб после кондуктора (кондуктор)
surface string	комплект противовыбросовых превенторов
surge pressure	гидравлический удар (давление)
swab (pressure)	поршень для откачки из скважины
thickening time	время загустевания цементного раствора
threaded connection	резьбовое соединение
water wet	смачиваемость
weighted spacer	утяжелитель
yield point	предел текучести

APPENDIX
SELF-ASSIGNMENT TOPICS

1. Sophisticated bits-characteristics and classification
2. Drilling fluid
3. Underbalance drilling
4. Centralizers
5. Horizontal –direction drilling
6. Vertical drilling
7. Side tracking
8. AutoTrack
9. Modernization of downhole turbine motors
10. Completion (types)
11. Completion components
12.Perforation
13. Stimulation
14.Sand control
15. Workovers
16.Environment protection
17. Support –and-alignment mechanisms
18. Piston pumps
19.Turbodrilling

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Chapter 4

PIPELINE ENGINEERING

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UNIT 1

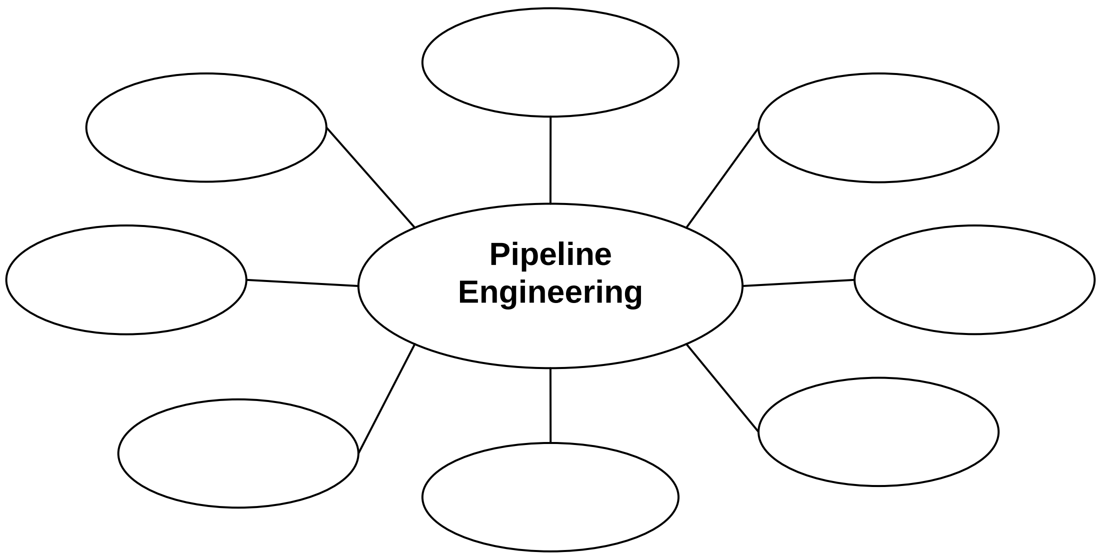
PIPELINE CONSTRUCTION

Pipeline transport is a transportation of goods through a pipe. Most commonly, liquid and gases are sent, but pneumatic tubes that transport solid capsules using compressed air have also been used.

As for gases and liquids, any chemically stable substance can be sent through a pipeline. Therefore, sewage, slurry, water, or even beer pipelines exist; but the most important are those transporting oil and natural gas.

Lead-in

Fill in the spider gram with the words associated with Pipeline Engineering.



Explain your associations.

Terms and Vocabulary

gathering system	система нефтесбора
pump station	насосная станция
crude trunkline	магистральный трубопровод
crude tank farm	резервуарный парк / нефтебаза
tanker	танкер
marine (port) terminal	портовая нефтебаза
refinery	НПЗ – нефтеперерабатывающий завод
petrochemical plant	нефтехимический завод
product line	продуктопровод
processing	переработка
distribution center	распределительная база
oil tankage	нефтехранилище
destination	пункт назначения
gathering	сбор
individual lease	арендованный нефтяной участок
moving	перемещение
transporting	доставка
supply	запас
point	пункт
distributing	распределение

1. Pronounce the following words. Pay special attention to the letters in bold.

l**ea**se indivi**dual** t**er**minal s**up**ply v**arie**ty tank**age** cr**u**de

2. Read the following word formations and learn their pronunciation. Pay special attention to the stress.

distribute – distributing – distribution	deliver – delivering – delivery
process – processing	transport – transporting – transportation
produce – product – production	refine – refinery
locate – location	gather – gathering

3. Read the mini-text "Pipeline System". Look at the diagram and pay attention to the underlined terms in the text.

Pipeline System

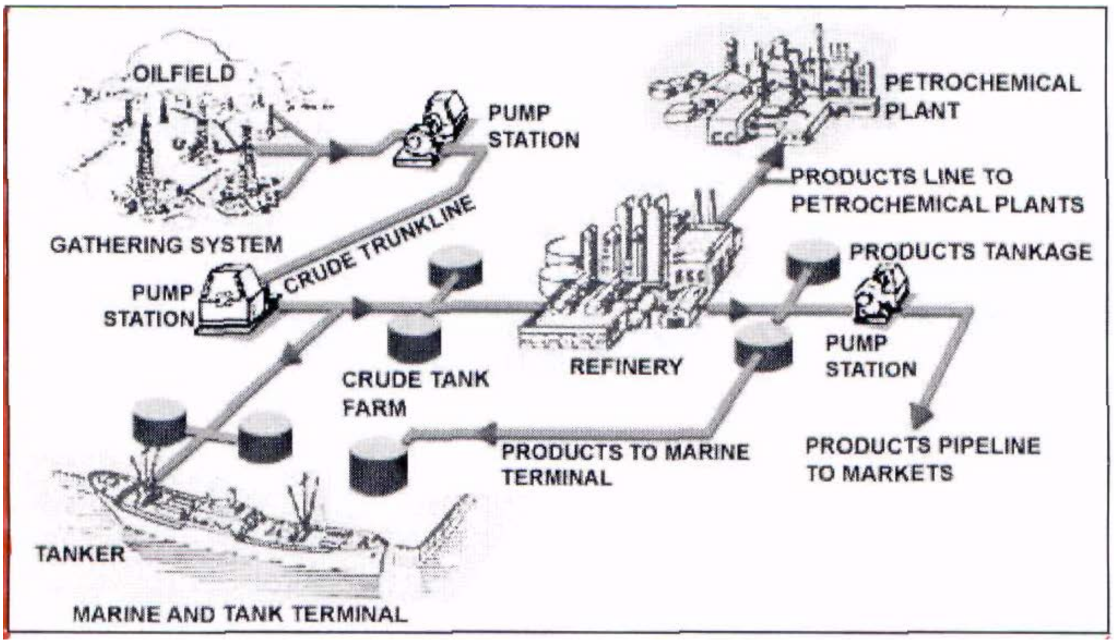


Fig. 1. Pipeline system

In the petroleum industry, pipelines are used for a variety of purposes:

1. ***gathering*** crude oil from ***individual leases*** and delivering it to a central location for ***processing***;
2. ***transporting*** crude oil from fields to ***port terminals*** for tanker transportation;
3. ***moving*** crude oil from processing centers and ***supply points*** to the refineries and other markets;
4. ***moving*** gas from fields to gas processing plants and from these plants to markets;
5. ***distributing*** petroleum products from the refineries to the distribution centers.

(http://www.Wikipedia)

4. Match English terms with Russian ones.

Example: 13. destination – A. пункт назначения

1.	gathering system	A.	распределительная база
2.	pump station	B.	промышленный трубопровод
3.	crude trunkline	C.	портовая нефтебаза
4.	crude tank farm	D.	магистральный трубопровод
5.	tanker	E.	система нефтесбора
6.	marine terminal	F.	нефтехранилище
7.	refinery	G.	распределительная база
8.	petrochemical plant	H.	нефтехимический завод
9.	product line	I.	резервуарный парк / нефтебаза
10.	processing	J.	танкер
11.	distribution center	K.	НПЗ – нефтеперерабатывающий завод
12.	oil tankage	L.	насосная станция
13.	destination	M.	переработка

5. Give the explanation to the following purposes of the pipeline system.

Example: *Moving is gas progresses from the gas field to gas processing plants and from there to the market.*

- Gathering is …
- Transporting is …
- Moving is …
- Distributing is …
- Gathering system is …

6. Here is the diagram of Russian pipeline gathering system. Use the above-mentioned terms and give a short explanation to each element of the pipeline system. (Note the differences).

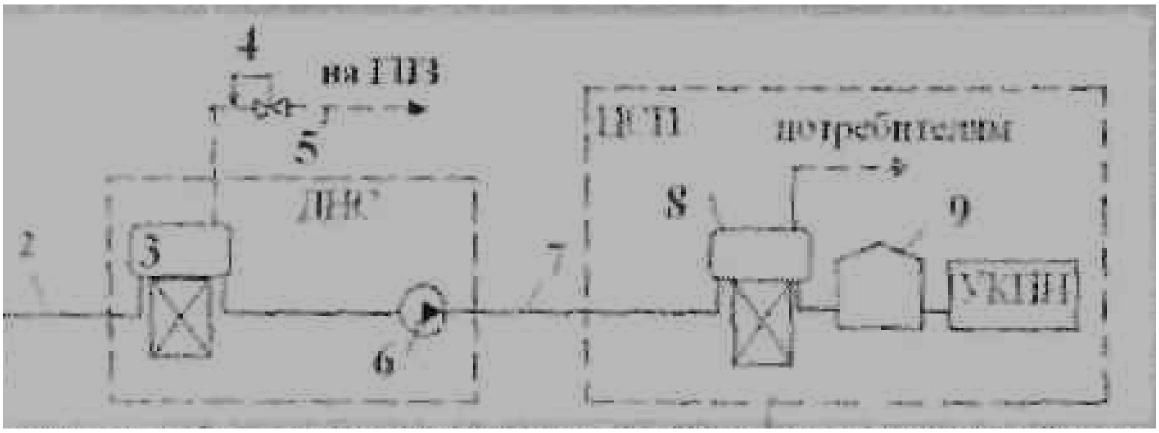


Fig. 2. Pipeline system

Terms and Vocabulary

line pipe	труба
pig trap	камера приема и пуска средства очистки и диагностики
block valve station	аварийный клапан для отключения
ESD (emergency shut-down valve)	аварийный клапан для временного прекращения (предохранительный клапан)
slug catcher	ловушка для конденсата
cathodic protection system	система катодной защиты
pressure protection system	система защиты от избыточного давления
telemetry system	система телеметрии, телемеханика
leak detection system	система определения утечек
corrosion resistant	коррозионно-устойчивый
line	трубопровод
slug	пробка
receiving station	приёмная станция
backup	резервное устройство
coating	изоляция
remote operation	дистанционное управление
carbon steel	сталь
resistant	нержавеющий

alloy	сплав
loading	загрузка
launching	запуск
receiving	прием
retrieval	извлечение
release	выпуск
leak	утечка
rupture	порыв, образование трещин
shut down	временное прекращение
emergency	авария
allowable pressure	допустимое давление
monitoring	текущий контроль

7. Pronounce the following words. Pay special attention to the letters in bold.

all**oy**
corr**osion**
l**au**nching
retr**ie**val
fl**ui**d
phase
ex**cee**d
w**ar**n
rup**ture**
rel**ease**
v**al**ve
em**erge**ncy
automatic
en**sure**
s**ur**face

8. Read the following word formations and learn their pronunciation. Pay special attention to the stress.

resist – resistance – resistant
disrupt – disruption
install – installation
permit – permission
occur – occurring – occurrence(s)
allow – allowing – allowable – allowance

9. You are going to learn some vocabulary to help you understand the text. Study the following dictionary entries, paying attention to specific term definitions. Match the term with the appropriate meaning.

1.	disrupt (v)	A.	afford opportunity or possibility for
2.	install (v)	B.	go beyond the limits of
3.	prevent (v)	C.	interrupt the progress, movement or procedure of
4.	ensure (v)	D.	notify or make aware in advance of something
5.	exceed (v)	E.	connect or set in position and prepare for use
6.	permit (v)	F.	make sure / certain
7.	warn (v)	G.	keep from doing something

10. Read the text "Pipeline Components". Look at the diagram and pay attention to the underlined terms in the text.

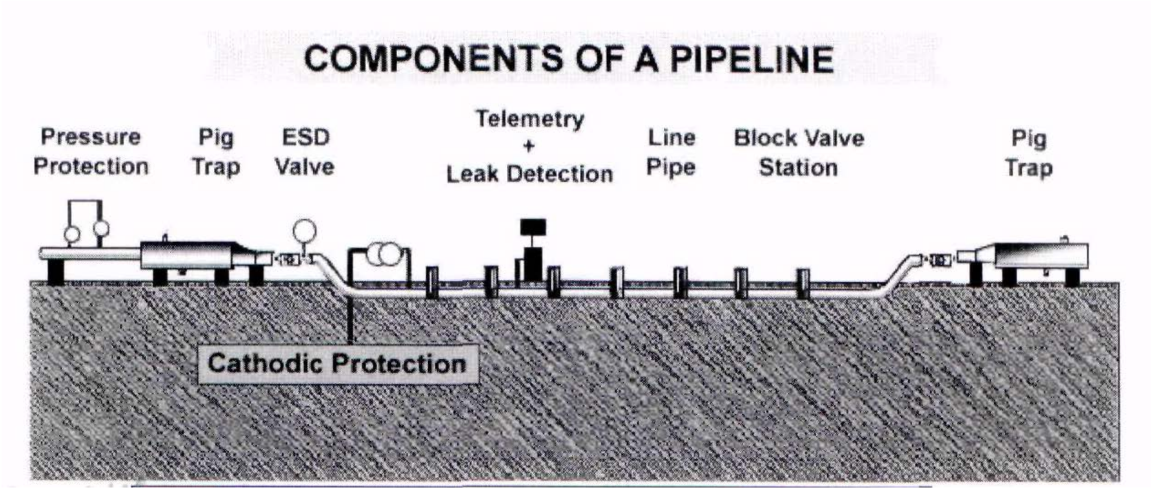


Fig. 3. Components of a pipeline

A pipeline system is comprised of the following components:
1. ***line pipe*** – the main component of every ***pipeline*** and is usually metallic (***carbon steel*** / corrosion ***resistant alloy***);
2. pig traps – allow safe loading, launching, receiving and retrieval of pigs without disrupting the fluid in the pipelines;
3. ***block valve stations*** – isolate section of the pipeline and limit the ***release*** of line contents in case of a ***leak*** or pipeline ***rupture;***
4. ***emergency shut-down valves (ESD)*** – located at both ends of the pipeline and enable automatic ***shut down*** of the line in case of an ***emergency***;
5. ***slug catcher*** – installed at the end of a multi-phase pipeline to prevent ***slugs*** and to ensure a constant gas flow into the ***receiving station***;

6. ***cathodic protection system*** – installed as a ***backup*** to the external ***coating*** to prevent corrosion of the external surface of the pipelines;
7. ***pressure protection system*** – protects a pipeline when the line pressure exceeds**)** the max. ***allowable pressure***;
8. ***telemetry system*** – permits pipeline ***monitoring*** and remote operation from a central location;
9. ***leak detection system*** – installed to warn that a leak occurred.

11. Match the terms with their functions.

Example: *pressure protection system – protects a pipeline when the line pressure exceeds the max. allowable pressure;*

1.	emergency shut-down valves (ESD)	A.	installed to warn that a leak occurred
2.	cathodic protection system	B.	main component of every pipeline
3.	line pipe	C.	isolate section of the pipeline and limit the release of line contents in case of a leak or pipeline rupture
4.	slug catcher	D.	prevent corrosion of the external surface of the pipelines
5.	pig traps	E.	allow safe loading, launching, receiving and retrieval of pigs without disrupting the fluid in the pipelines
6.	telemetry system	F.	prevent slugs and to ensure a constant gas flow into the receiving station;
7.	block valve stations	G.	permits pipeline monitoring and remote operation from a central location;
8.	leak detection system	H.	enable automatic shut down of the line in case of an emergency

12. Give Russian equivalents to the following terms.

Example: rupture – порыв, образование трещин

1.	corrosion resistant	13.	permit
2.	launching	14.	coating
3.	retrieval	15.	allowable pressure
4.	receiving	16.	exceed

5. loading
6. disrupt(ing)
7. shut down
8. emergency
9. leak
10. slug
11. backup
12. alloy
17. monitoring
18. remote operation
19. warn
20. install
21. line pipe
22. pipeline
23. steel
24. prevent

13. Pipeline networks are composed of several pieces of equipment that operate together to move products from location to location. The main elements that conform a pipeline system can be summarized as follows: *Initial Injection Station (Supply or Inlet station), Compressor / Pump Stations, Partial Delivery Station (Intermediate Stations), Block Valve Station, Regulator Station and Final Delivery Station (Outlet stations).* ***Describe the pipeline schematically.***

Example: Initial Injection Station – known also as Supply or Inlet station, is basically the beginning of the system, this is where the product is injected into the line. Storage facilities, such as tank terminals, as well as other devices to push the product through the line, like pumps or compressor are usually located at these locations.

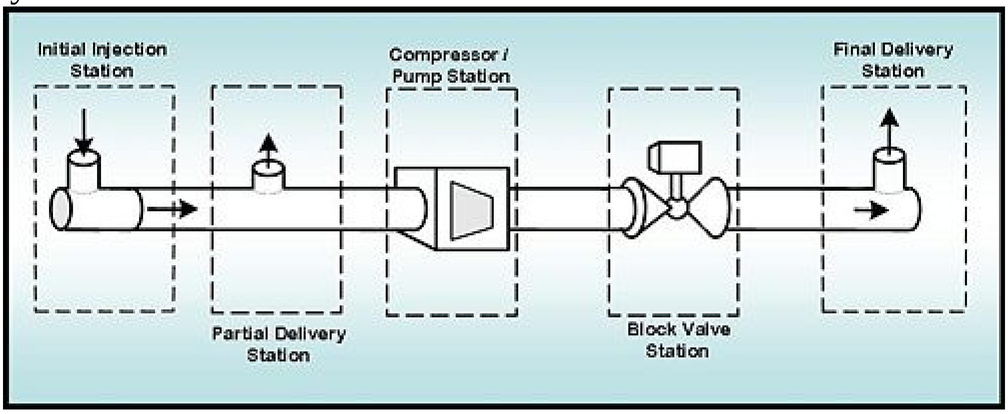


Fig. 4. Pipeline components

14. Solve the following situations.

Example: *<u>Questions</u>:* ***What are slugs? What do slugs in a multi-phase pipeline prevent?***

<u>Answer</u>: the accumulation of a liquid (water, oil or condensate) in a pipeline. Slugs prevent or slow down the flow of fluids in a pipeline.

1. What would happen if a pig trap gets stuck in the pipeline? What solutions must be considered?
2. In case of a leak (pipeline rupture), block valves isolate this pipeline section. What if the block valves are out of order? What will happen? What solutions must be considered?
3. Cathode protection system prevents corrosion on the external surface of a pipeline. Describe other methods.
4. How is a pipeline controlled?
5. When a leak is detected, what are the necessary steps?

15. You will hear a part of advertisement informing listeners about AMPL Multiple Pig Launching System. Put the statements A-G in the right order as they appear in the text.

A	The first pig continues along a pipeline.	
B	The kicker line is opened.	
C	The pig enters a receiver, pig trap isolation valve closes and the trap is drained.	
D	The pig trap isolation valve opens and the kicker line valve reopens.	
E	Product flows into the launcher.	
F	Pigs are preloaded into a simple cassette.	
G	The cassette is inserted into the launcher and a closure door shuts.	

16. Read the text "PIPE (MATERIAL)" and fill in the missing information. The first sentence is done for you.

Pipe is a tube ***1. or hollow cylinder to convey fluid.*** The terms 'pipe' and 'tubing' are almost interchangeable. 'Pipe' is generally specified **2.**________________, whereas 'tube' is usually defined **3.**_________________but may be specified by any combination of dimensions (OD, ID, wall thickness). 'Tube' is often made to custom sizes and may often have **4.**________________. Also the term "tubing" can be applied to tubes of **5.** ________________. The term 'tubing' is more widely used in the USA and 'pipe' elsewhere in the world. Both "pipe" and "tube" imply **6.** _______________. Pipe may be specified by standard pipe size designations, or by **7.**_______________. Many industrial and government standards exist for the production of pipe and tubing.

1. ………… nominal, outside, or inside diameter and wall thickness.
2. ………… more specific sizes and tolerances than pipe
3. …………… by the internal diameter (ID)
4. ………….. a non-cylindrical nature (i.e. square tubing).
5. ………. by the outside diameter (OD)
6. ……… a level of rigidity and permanence.
7. ………. or hollow cylinder to convey fluid.

***17. Fill in the table and record the information from the text according to the following items:* type, material, purpose**

The manufacturing of pipe uses many materials including ceramic, metal, concrete, and plastic. Pipe may be made from a variety of materials. In the past, materials have included wood and lead. Metal pipes are commonly made from unfinished, black, or galvanized steel, brass, and ductile iron. Plastic tubing is widely used for its light weight, chemical resistance, non-corrosive properties, and ease of making connections. Pipe may also be made from concrete or ceramic. These pipes are usually used for low pressure applications such as gravity flow or drainage. Reinforced concrete can be used for large diameter concrete pipes. This pipe material can be used in many types of construction.

TYPE	MATERIAL	PURPOSE
Metal pipes	*Black steel*	*Pipeline construction*

18. Read the text "Pipeline Construction" and pay attention to the underlined terms.

Terms and Vocabulary

survey	разведка
setting out	установка, трассирование
Right-of-way (ROW)	отвод земли
cleaning	расчищение
grading	планирование, выравнивание, планировка
ditching	разработка траншеи
stringing	укладка плетей трубопровода
bending	сгибание труб
road crossing	пересечение дорог
skidding the pipe	опорная рама для сварки трубопровода
welding	сварка
line-up	центровка
internal welding	внутренняя сварка
external welding	наружная сварка
beveling	подготовка кромки
slings	трубный строп – для подвески на тракторе-трубоукладчике
horizontal directional drilling (HDD)	горизонтально-направленное бурение
non-destructive testing (NDT)	неразрушающий контроль
field-joint coating	изоляция сварного шва
padding	наружная присыпка
lowering	спуск трубопровода в траншею
backfilling	засыпка траншей трубопровода
tie-in welding	соединение секции
hydrostatic testing	опрессовка, гидравлические испытания
final tie-in	последнее соединение секции
final clean-up	восстановление
ROW restoration	восстановление
sideboom	трубоукладчик с боковой стрелой
crane	подъёмный кран
pass	проход

Pipeline Construction

Oil pipelines are made from steel or plastic tubes with inner diameter from 30 to 120 cm (about 12 to 47 inches). Where possible, they are built above the surface. However, in more developed, urban, environmentally sensitive or potentially dangerous areas they are buried underground at a typical depth of about 1.3–1.6 meters (about 3 feet). The oil is kept in motion by a system of pump stations built along the pipeline and usually flows at speed of about 1 to 6 m/s. Multi-product pipelines are used to transport two or more different products in sequence in the same pipeline.

Here are the following steps in pipeline construction:
1 Survey, setting out – marking the centerline of the pipeline ditch and edges of the right-of-way.
2 Right-of-way (ROW), clearing, grading – ROW width is determined by the diameter of the pipeline to be installed and includes ***room*** for the pipeline and working space for the construction equipment used to install the pipeline. A ***low silt fence*** protects it against erosion.

3 Ditching – excavated soil (***spoil***) is deposited on the ditch bank. In certain areas, particularly farmland, the ditch will be excavated in two passes with a first pass removing ***topsoil*** and the second ***pass*** excavating the remaining soil to the required pipeline ***burial depth***.

Trenching \ Ditching

4 Stringing – laying sections of pipe along the ROW (stringing) uses pipe in varying lengths (joints). Stringing trucks transport pipe from a ***stockpile*** to the ROW where a pipe layer or crane lays them along the ROW.

Stringing and bending

5 Bending – joints of pipes can be bent to ***accommodate elevation*** changes, horizontal direction changes or both along the ROW. If a change cannot be designed within the field-bending ***constraints*** special ***pipe bends*** (factory bends, hot bends) must be manufactured for the special location.

6 Road crossing – boring beneath a road does not damage the road surface, and traffic flow is not interrupted by the boring activity. Line pipe used for the road crossing has a thicker external coating to provide extra protection during installation. The road crossing pipe is joined to the welded strings of line pipe by a tie-in crew using ***manual welding.***

7 Skidding the pipe before being welded, line pipe is lifted onto ***skids*** made of ***timber*** and stockpiles along the ROW so that the entire ***circumference*** is accessible.

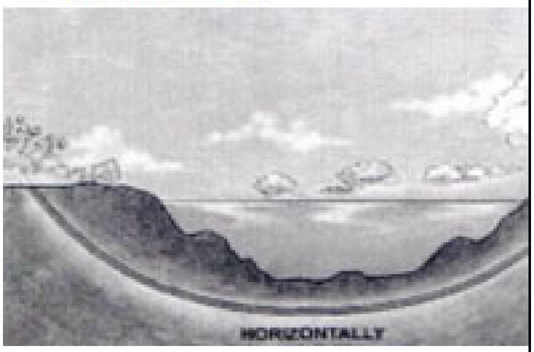
8 Welding – the work here assumes use of automatic welding to join the sections of line pipe, which provides ***consistency, uniform*** welds and fewer repairs. To prepare the line pipe for automatic welding, a beveling and facing machine trims, cuts and grinds the pipe ends with the special edge preparation required by the process. Line pipe comes from the pipe mill with a standard edge preparation or with a plain end if the pipe is specially ordered for automatic welding.

9 Line-up, internal welding – a series of pneumatically operated pistons radially spaced around the internal clamp centers the joints and correctly aligns the pipe ends for welding. The first welding pass is made with the internal welding torches and is called the "***root";*** this is the primary ***strength*** weld that ***fuses*** the two pipes.

10 External welding (firing line back end) – the external torches make the next welding pass (***hot pass***). Together the root and hot passes provide the required fusion and strength to join the pipes permanently. The remainder of the weld passes (fill passes) is made from the outside. The final welding pass (***cap***) completes the weld and forms a cap over the bevel. The number of welding stations for the automatic welding crew varies depending upon the ***wall thickness*** of the line pipe.

11 Horizontal directional drilling (HDD) – is often the preferred method for constructing the pipeline across such obstacles as streams or wetlands.

Horizontal drilling



12 Non-destructive testing (NDT) after welding the joints are inspected by non-destructive methods to verify weld ***integrity***. How many welds are inspected varies depending on the code to which the pipeline is designed, the service of the pipeline (gas or oil products), its location (environmentally sensitive areas, highly populated areas or other risk factors) and the requirements of the pipeline owner. Inspection of 100 % of the welds is not uncommon. Customary inspection is by internal X-ray, external gamma ray or ultrasonics.

13 Field-joint-coating – the factory-applied external coating does not cover a few inches of each pipe to allow for welding. After NDT inspection, field-joint coating is applied to the bare sections at the pipe welds covering the exposed pipe and the weld.

Pipeline coating

14 Padding, lowering and backfilling – welded strings of pipe vary in length depending on the terrain conditions but are typically hundreds of feet long. Before the pipe strings are lowered into the ditch, selected padding, usually sand, is placed on the ditch bottom ***to cushion*** the pipe. In rocky soil, the fill may be placed around and on top of the pipe ***(shading).*** A fleet of sidebooms lifts the string off the timber skids and lowers it into the ditch. The sidebooms use special slings that ***cradle*** the pipe on rollers allowing the ***sideboom*** to travel down the ROW as the pipe slides into the ditch. The ditch spoil is pushed back into the ditch to cover the pipe except for certain sections that must be left uncovered to make tie-in welds and allow for hydrostatic testing.

15 Tie-in welding – individual pipe string ends are cut and trimmed to join the pipe strings with external clamps accurately ***aligning*** the pipe. NDT inspection is performed after the pipe has been welded and the field-joint coating applied. Tie-in welding is also required at road crossings, river crossings and other intersections along the ROW where the main production welding crew cannot access the pipe.

Testing

***16* Hydrostatic testing, final tie-in –** the pipeline is filled with water until the internal pressure in the pipeline exceeds the internal pressure to which the line will be subjected during operation. The elevation profile of the pipeline determines the lengths of the hydrostatic test sections because elevation changes affect the internal pressure. Water for hydrostatic testing is typically taken from rivers and lakes along ROW. Dry areas may require a well to be drilled or water to be delivered by truck along the ROW. After sections have been hydrostatically tested, they are joined with a manual tie-in weld. These final welds are NDT inspected. After hydrostatic testing and final tie-in, open sections of the ditch are filled in.

Backfilling\clean-up

17 Final clean-up, ROW restoration – grading the ROW smooth and clear, placing marker signs to identify the pipeline location, repairing any fences or other structures temporarily removed for construction and seeding the soil to reintroduce vegetation are the final activities. Special attention is paid to drainage and erosion control so that ROW, with time, is restored as closely as possible to its pre-construction while allowing access for regular visual inspections.

19. Match the terms with Russian ones. There is one extra term.

Example: *17. ROW – A. отвод земли*

1 .	survey	**A.**	**Отвод земли**
2.	setting out	B.	планировка, выравнивание
3.	line-up	C.	сгибание труб
4.	clearing	D.	сварка
5.	trenching (ditching)	E.	пересечение дорог
6.	skidding the pipe	F.	горизонтально-направленное бурение
7.	stringing	G.	внутренняя сварка
8.	external welding	H.	восстановление
9.	grading	I.	засыпка траншей трубопровода
10.	padding	J.	подвижной участок фронта нефтепроводных работ
11.	lowering	K.	разведка
12.	welding	L.	центровка
13.	NDT	M.	присыпка
14.	ROW restoration	N.	соединение секции
15.	field-joint-coating	O.	опрессовка

16.	road crossing	P.	спуск трубопровода в траншею
17.	**ROW**	Q.	плетей трубопровода
18.	firing line	R.	наружная сварка
19.	internal welding	S.	опорная рама для сварки трубопровода
20.	HDD	T.	разработка траншеи
21.	land backfilling	U.	изоляция сварного шва
22.	hydrostatic testing	V.	неразрушающие испытания
23.	bending	W.	расчищение
24.	tie-in welding	X.	последнее соединение секции
25.	final tie-in	Y.	установка
		Z.	укладка плетей трубопровода (вдоль трассы)

20. Find Russian equivalents to the following English words and phrases. There is one extra Russian word.

Example: *соединение двух ниток трубопровода – tie-in*

1.	изгородь	A.	room
2.	толщина	B.	low silt
3.	подъём уровня	C.	fence
4.	ручная сварка	D.	thickness
5.	ограничение	E.	pass
6.	сплошной	F.	topsoil
7.	врезка в магистральный трубопровод	G.	burial depth
8.	проход	H.	stockpile
9.	место	I.	elevation
10.	длина окружности	J.	constraints
11.	колено трубопровода	K.	pipe bend
12.	штабель, склад труб	L.	manual welding
13.	илистые отложения	M.	skid
14.	глубина залегания	N.	timber
15.	пахотный слой	O.	circumference
16.	опорная рама для сварки трубопровода	P.	uniform
17.	лотковая опора -трубопровода	Q.	consistency
18.	вершина сварного шва	R.	plain end
19.	прочность	S.	strength
20.	передний край	T.	root
21.	лесоматериал	U.	cap

22.	гладкий конец, ненарезанный конец	V .	bevel
23.	подготавливать кромки	W.	cradle
24.	трубная головка	X.	leading end
25.	устойчивость		

21. Match the verb with the noun and the corresponding translation. There can be several answers.

Example: *cushion (v) – line pipe string (смягчать / уменьшать действие чего-л.)*

1. to deposit	pipe (x 2)	A. выравнивать
2. to lay	pipe end (x2)	B. включать
3. to accommodate	drill string	C. скользить
4. to trim	line pipe	D. обрезать кромки
5. to grind	pipe sections	E. проверять
6. to align	swivel joint	F. зашлифовать
7. to fuse	elevation changes	G. соединяться
8. to lubricate	weld integrity	H. прокладывать
9. to incorporate	two pipes	I. размещать
10. to slide	excavated soil	J. урегулировать
11. to verify		K. смазывать

22. Read the following word formations and translate the sentences that include these words.

Example: *The "root" is the primary strength weld that fuses two pipes. – Вершина сварного шва является основным прочным соединением двух труб.*

excavate (v) – excavation (выемка грунта) – excavated soil (spoil) – (вынутый грунт)
access (v) – accessible (удобный; доступный)
ream (v) – reamer (расширитель) – reaming (расширение ствола скважины)
fuse (v) – fusion (провар шва)
install (v) – installation – installing
inspect (v) – inspection

1. Working space for the construction equipment is used to install the pipeline.
2. Line pipe used for the road crossing has a thicker external coating to provide extra protection during installation.

3. For installing the line pipe, a cap is connected to the leading end of the pipe string.
4. How many welds are inspected varies depending on the code to which the pipeline is designed.
5. NDT inspection is performed after the pipe has been welded and the field-joint coating applied.
6. After NDT inspection, field-joint coating is applied to the bare sections at the pipe welds covering the exposed pipe and the weld.
7. Together the root and hot passes provide the required fusion and strength to join the pipes permanently.
8. The ditch will be excavated in two passes with a first pass removing topsoil and the second pass excavating the remaining soil to the required pipeline burial depth.
9. Line pipe is lifted onto skids made of timber and stockpiles along the ROW so that the entire circumference is accessible.
10. Tie-in welding is also required at road crossings, river crossings and other intersections along the ROW where the main production welding crew cannot access the pipe.
11. The swivel joint is connected to the reamer and the drilling rig again pulls the reamer back through the hole from the pipe side to the rig side, along with the pipe string connected to the reamer.
12. Crews attach a reaming device to enlarge the pilot hole to accommodate the line pipe.

23. Form nouns from the following verbs or nouns -ing and give the definitions to these terms.

Example: *drill – drilling*

set out (v)	skid (v)	trench
clear (v)	weld (v)	string
grade (v)	pad (v)	test (v)
lay (v)	lower (v)	coat (v)
bend (v)	backfill (v)	
cross (v)	ditch (v)	

24. Match the definitions with the following terms.

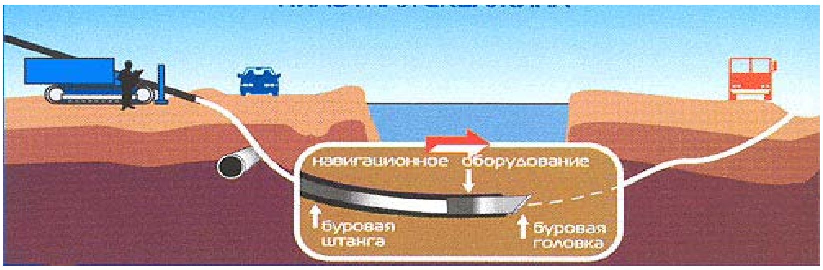
Example: *12. padding – (j) sand placed on the ditch bottom to cushion the pipe.*

1.	ROW	A.	join sections of line pipe providing consistency, uniform welds and fewer repairs.
2.	trenching (ditching)	B.	the primary strength weld that fuses the two pipes
3.	stringing	C.	method for constructing the pipeline across such obstacles as streams or wetlands.
4.	skidding	D.	customary inspection by internal X-ray, external gamma ray or ultrasonics.
5.	welding	E.	bare sections at the pipe welds covering the exposed pipe and the weld.
6.	root	F.	line pipe lifted on skids along the ROW so that the entire circumference is accessible.
7.	HDD	G.	ditch spoil pushed back into the ditch to cover the pipe except for certain sections that must be left uncovered to make tie-in welds and allow for hydrostatic testing.
8.	backfilling	H.	width determined by the diameter of the pipeline to be installed and includes room for the pipeline and working space for the construction equipment used to install the pipeline.
9.	field-joint coating	I.	laying sections of pipe along the ROW
10.	tie-in welding	**J.**	**sand placed on the ditch bottom to cushion the pipe.**
11.	NDT	K.	individual pipe string ends that are cut and trimmed to join the pipe strings with external clamps accurately aligning the pipe.
12.	**padding**	L.	excavated soil (spoil) deposited on the ditch bank.

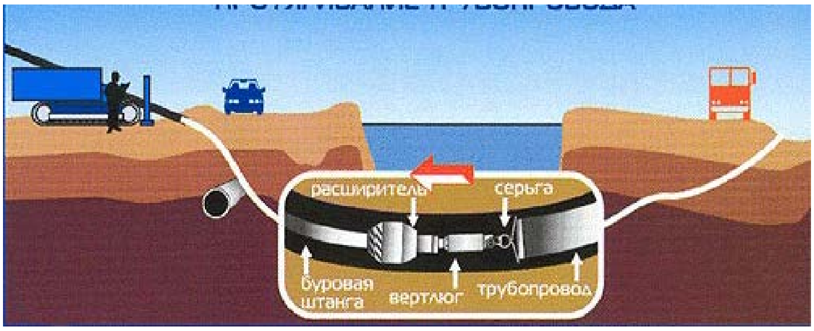
25. Number these instructions for installing a pipeline by HDD (Horizontal Directional Drilling) across a river. Describe this process by putting the statements in the logical order. The first element is done for you.

	A.	It is filled with water to contain and settle the spoil or cuttings that result from the operation.
	B.	The pre-reaming operation pulls the reamer back, cutting and enlarging the opening.
	C.	The trailer-mount is positioned near an excavation on the near side (rig side).
	D.	After the pre-reaming operation is completed, the drill pipe is pulled back from the near side
	E.	Then a reaming device is attached to enlarge the pilot hole to accommodate the line pipe
	F.	A cap with a swivel joint is connected to the leading end of the pipe string.
	G.	The pull-back operation installs the line pipe under the river.
	H.	The drill string contains a survey instrument near the head or cutting end, which guides the cutting head in both vertical and horizontal directions.
	I.	The swivel joint is connected to the reamer.
	J.	This first drill forms the “pilot” hole.
	K.	A mixture of drilling mud and water is pumped into the hole, lubricating the drill string.
	L.	The line pipe string to be installed is welded.
	M.	The drill moves to the opposite bank under the bottom of the river.
1.	**N.**	**Here is a typical river crossing.**
	O.	The drilling rig pulls the reamer back through the hole from the pipe side to the rig side, along with the pipe string connected to the reamer.

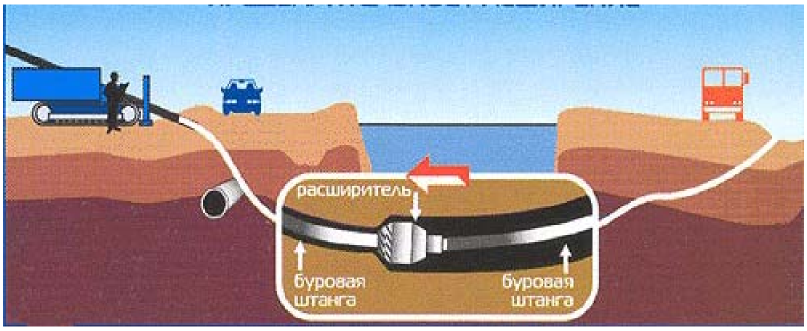
26. Which steps in Ex. 22 (pg. 388–389) do these diagrams show?



______________ ______________ ______________



____________ ____________ ____________



____________ ____________ ____________

27. Refer to the instructions in Ex. 22 (pg. 389–390) again and circle T (True) and F (False).

T / *F* 1. The cuttings settle on the river floor.
T / F 2. A drill pipe with a bit cuts and enlarges the opening.
T / F 3. The line pipe is installed under the river by pull-backing.
T / F 4. There is a survey device to guide the cutting head in vertical and horizontal directions.
T / F 5. The “pilot” hole is formed by a reamer.
T / F 6. Drilling mud and water lubricates the drill string.
T / F 7. The line pipe string is joined by flanges.
T / F 8. The drill moves under the bottom of the river.

28. You will hear a radio report describing the controversy surrounding Chad-Cameroon Pipeline. For questions 1-7, complete the sentences with a word or phrase.

Ekobita’s troubles began with the oil companies’ ___________ (1) for damaged crops.
Villagers used to earn ____________ (2) per year from one tree.

One of the reasons for poor harvest is that top soil _______________ (3) far below.
Nearby villagers say that the cut trees for the ___________________ (4) created a wind tunnel.
Another consequence is a great number of ____________(5) which lead to the death of the crops as the ground is too wet.
The construction crews damaged _________ (6)
Oil companies presented local school ________________(7)

29. Role Play (video: Vermeer Co.: HDD).

Vermeer Co. proclaims the qualities and advantages of their product so as to increase sales.
MOTTO: You don't know we've been there!

PANEL DISCUSSION: «The beauty of HDD is the ability to steer around, under or over obstacles».

1. Building Infrastructure
2. Planning for success
3. Putting it all together

FACTS:

- Reduction of post-construction restoration;
- Benefits to the contractor (easy installation; time);
- Benefits to society (no trenches, little traffic congestion);
- Application of foreign experience (American)

1. Facilities Building Manager
2. International Regional Manager
3. Customers (from several countries)
4. Contractors (companies)

30. Prepare the following presentations.

1. Trenchless technology (including HDD)
2. Restoration (methods)
3. Pipeline construction and its impact on the environment.
4. Equipment and machinery used during pipeline construction.
5. Pipeline construction in different environments (swamps, permafrost, under sea)

6. Pipeline construction and economic evaluation & estimation.

31. Discuss the complete pipeline network, system, construction and engineering.

PIPELINE CONSTRUCTION

- ROW
- Ditching
- Bending
- Skidding
- Welding
- Line-up
- Coating
- Padding / lowering / backfilling
- Testing

Restoration

PIPELINE NETWORK

Initial Injection station

Compressor | Pump station

Partial Delivery (Intermediate) station

Block Valve station

Regulator station

Final Delivery station

PIPELINE SYSTEM

Domestic

Foreign

Gathering
Transporting
Moving
Distributing

PIPELINE ENGINEERING

Areas of specialization

Targets

Jobs and responsibilities

EXAMPLES
Of
PIPELINES

PIPE MATERIAL

Type Material Purpose

WORDLIST

ENGLISH	RUSSIAN
allowable pressure	допустимое давление
alloy	сплав
backfilling	засыпка траншей трубопровода
backup	резервное устройство
bending	сгибание труб
beveling	подготовка кромки
block valve station	аварийный клапан для отключения
carbon steel	углеродистая сталь
cathodic protection system	система катодной защиты
cleaning	расчищение
coating	изоляция
corrosion resistant	коррозионноустойчивый
crane	подъёмный кран
crude tank farm	резервуарный парк / нефтебаза
crude trunkline	магистральный трубопровод
destination	пункт назначения
disrupt (v)	разрушать
distributing	распределение
distribution center	распределительная база
ditching	установка / прокладывание траншей
emergency	авария
ensure (v)	гарантировать / обеспечивать
ESD (emergency shut-down valve)	аварийный клапан для временного прекращения
exceed (v)	превышать / переступать пределы
external welding	наружная сварка
facing	обшивка
field-joint coating	изоляция сварного шва
final clean-up	восстановление
final tie-in	последнее соединение секции
firing line	подвижной участок фронта нефтепроводных работ
gathering	сбор
gathering system	система нефтесбора
grading	планировка, выравнивание
horizontal directional drilling (HDD)	горизонтально-направленное бурение

hydrostatic testing	опрессовка
individual lease	арендованный нефтяной участок
install (v)	монтировать
internal welding	внутренняя сварка
launching	запуск
leak	утечка
leak detection system	система определения утечек
line	трубопровод
line pipe	труба
line-up	центровка
loading	загрузка
lowering	спуск трубопровода в траншею
marine (port) terminal	портовая нефтебаза
monitoring	текущий контроль
moving	перемещение
non-destructive testing (NDT)	неразрушающий контроль
oil tankage	нефтехранилище
padding	присыпка
passes	проход
permit (v)	допускать
petrochemical plant	нефтехимический завод
pig trap	камера приема и пуска средства очистки и диагностики
point	пункт
pressure protection system	система защиты от избыточного давления
prevent (v)	препятствовать
processing	переработка
product line	продуктопровод
pump station	насосная станция
receiving	прием
receiving station	приёмная станция
refinery	НПЗ – нефтеперегонный завод
release	выпуск
remote operation	дистанционное управление
resistant	нержавеющий
retrieval	извлечение
Right-of-way (ROW)	отвод земли
road crossing	пересечение дорог

ROW restoration	восстановление
rupture	порыв, образование трещин
setting out	установка
shut down	временное прекращение
sideboom	трубоукладчик с боковой стрелой
skidding the pipe	опорная рама для сварки трубопровода
slings	трубный строп - для подвески на тракторе-трубоукладчике
slug	пробка
slug catcher	ловушка для конденсата
stringing	укладка плетей трубопровода
supply	запас
survey	разведка
tanker	танкер
telemetry system	система телеметрии, телемеханика
tie-in welding	соединение секции
transporting	доставка
warn (v)	предупреждать
welding	сварка

UNIT 2

FLUID MECHANICS

Fluid mechanics is the discipline concerned with the behavior (movement / conduct) of liquids and gases at rest or in motion.

Lead-in

Free writing: Write down everything that comes to your mind about FLUID MECHANICS. Write only words. If you don't know the English term, write down the Russian one. You have ONLY 1 minute to do it!

1. Pronounce the following words. Pay special attention to the letters in bold.

con**dui**t	lam**in**a**r**
d**uc**t	t**ur**b**u**lent
dev**ice**	r**ough**ness
elb**ow**	prof**il**e
r**e**str**ai**n	fin**ite**
sh**ear**	tran**sie**nt
gradi**e**nt	excessive
pres**sure**	**ch**annel
cavita**tion**	momen**tum**

2. Pay attention to the stress in the following words. □ shows the position of stress.

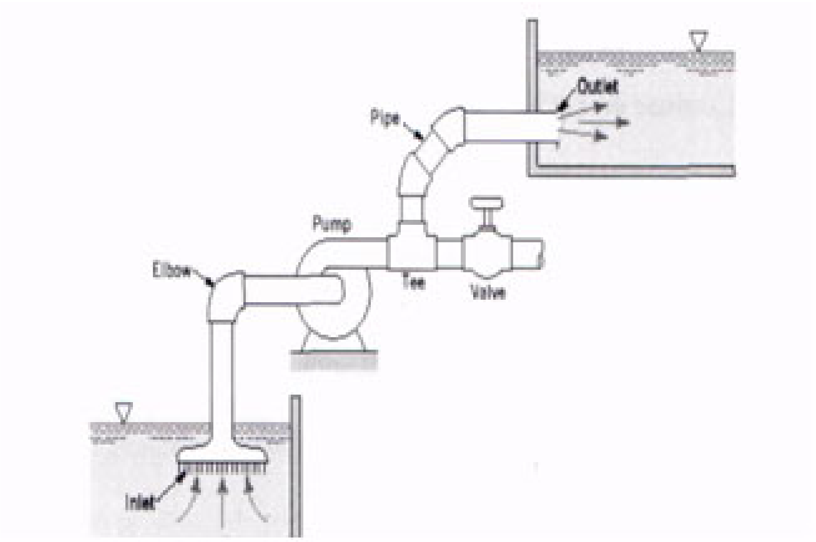
device □ restrain □ laminar□ tur□bulent veloc □ ity pro□file momen □tum mol□ecule cavita□tion repair□ relief□
replace□ment excess□ive expel□ collaps□ing reverse□

3. Read the following mini- texts, do the exercises.

Typical Pipe System Components

The transport of a ***fluid*** (liquid or gas) in a closed ***conduit*** (commonly called a ***pipe***, if it is of round cross section) or ***duct*** (if it is not round) is extremely important.

Some of the basic components of a typical ***pipe system*** are depicted in Fig. 1. They include the pipes themselves, various ***fittings*** used to connect the individual pipes to form the desired system, the ***flow rate control devices*** (valves), and pumps (turbines) that add energy to or remove energy from the fluid.



- Outlet - выпуск
- Pipe - труба
- Valve - клапан
- Tee - тройник (сидинг)
- Elbow - колено
- Inlet - пуск
- Pump - насос

Fig. 1. Typical pipe system components

In general, fluids have a well-known tendency to move or ***flow***. It is very difficult to ***restrain*** fluid from moving. The slightest ***shear stress*** will cause fluid to move. Similarly, appropriate imbalance of normal stresses (pressure) will cause ***fluid motion***.

Terms and Vocabulary

fluid	флюиды
conduit	трубопровод; труба
duct	труба (не с круглым поперечным сечением)
flow (move)	поток; течение

pipe	трубопровод
pipe system	система трубопроводных линий
fitting(s)	фитинг
flow rate control device	регулятор скорости потока
restrain	удерживать
valve	клапан
fluid motion	движение флюидов
shear stress	напряжение сдвига

General Characteristics of Pipe Flow

Although not all conduits used to transport fluid from one location to another are round in cross section. These include typical water pipes, hydraulic hoses and other conduits that are designed to withstand a considerable ***pressure difference***. There are two situations where one pipe is completely filled with the fluid being transported (***pipe flow***) and one through which rainwater flows without completely filling the pipe (***open-channel flow***). The difference between open-channel flow and pipe flow is in the fundamental mechanism that drives the flow. For open-channel flow, gravity alone is the ***driving force***. For pipe flow, gravity may be important, but the main driving force is likely to be a ***pressure gradient*** along the pipe.

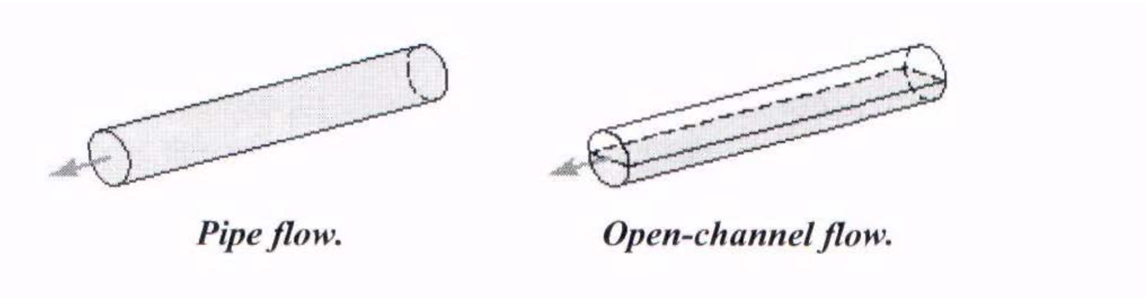


Fig. 2. Pipe Flow

Terms and Vocabulary

pressure difference	разность давлений
pipe flow	поток в трубопроводе (в полностью заполненной трубе)
open-channel flow	поток (в не полностью заполненной трубе)
driving force	движущая сила
pressure gradient	градиент давления

Laminar or Turbulent Flow

The flow of a fluid in a pipe may be ***laminar*** or ***turbulent***. The distinction between laminar and turbulent pipe flow was first pointed out by Osborne Reynolds (1883). The actual ***transition*** or turbulent flow may take place at various Reynolds numbers, depending on how much the flow is disturbed by vibrations of the pipe, ***roughness*** of the entrance region, etc.

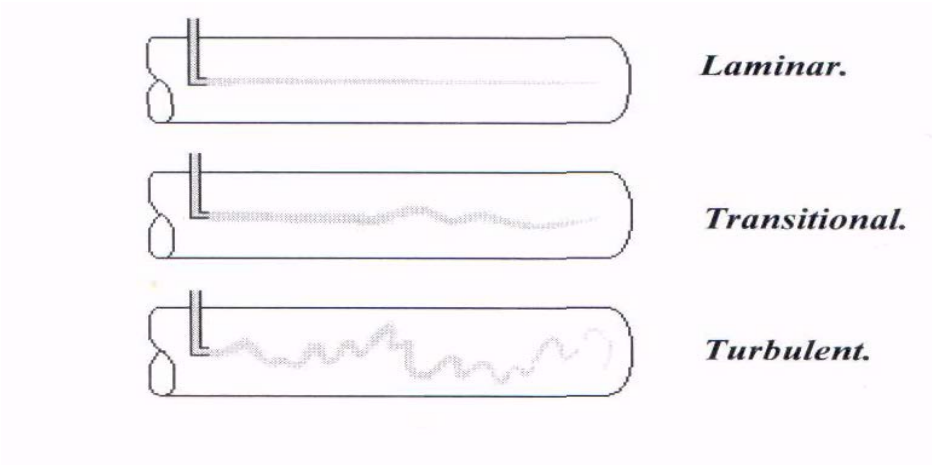


Fig. 3. Fluid Flow in a Pipe

The region of flow near where the fluid enters the pipe is the ***entrance region.*** A ***boundary layer*** is produced along the pipe wall so that the initial ***velocity profile*** changes with distance along the pipe, until the fluid reaches the end of the entrance length. The flow in long, straight constant diameter sections of a pipe becomes ***fully developed***, i.e. the velocity profile is the same at any cross section of the pipe. The details of velocity profile are different for laminar and turbulent flows. The nature of the pipe flow is strongly dependent on whether the flow is laminar or turbulent. This is a direct consequence of the differences in the nature of ***shear stress*** in laminar and turbulent flows. The shear stress in laminar flow is a direct result of ***momentum transfer*** among the randomly moving molecules. The shear stress in turbulent flow is largely a result of momentum transfer among the randomly moving molecules, finite-sized bundles of fluid particles.

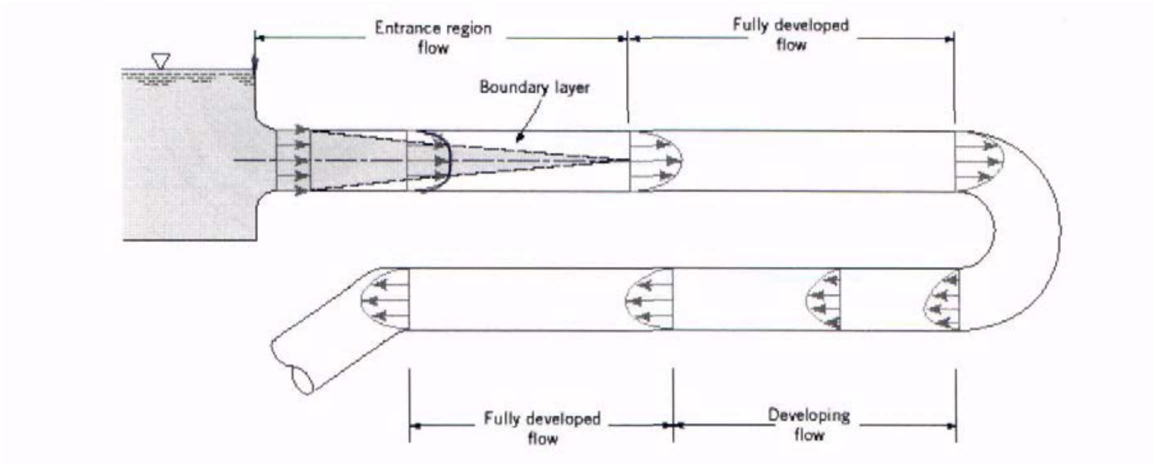


*Fig. 4. Entrance region, **developing flow**, and fully developed flow in a **pipe system***

Terms and Vocabulary

laminar flow	ламинарный поток
turbulent flow	турбулентный поток
transition(al) flow	переходный поток
roughness	шероховатость стенки трубы
entrance region	входной участок
boundary layer	граничный слой
cross section	поперечное сечение
velocity profile	скоростной профиль
fully developed flow	развитый поток
developing flow	развивающийся поток
shear stress	напряжение сдвига
momentum transfer	передача (перенос) импульса
pipe system	система трубопроводных линий, сеть трубопроводов

Valves

Valves are mechanical devices that are installed in pipelines to control flow or pressure. Valves are an important part of piping systems and if not properly selected and operated, they can cause operation problems. The primary valve types, classified by their function, are:

- ***control valves*** – used to control flow, pressure, liquid level, ***cavitation*** and ***pressure transients***;
- ***isolation (block) valves*** – placed on each side of control valves and pumps, allowing them to be removed for ***repair*** or ***replacement***;

- ***check valves*** – used to prevent ***reverse flow***;
- ***relief valves*** – admit air to the pipe while the pipe is being drained to prevent ***excessive*** vacuum pressures and reduce the possibility of ***collapsing*** thin-walled pipes;
- ***air valves –*** designed ***to expel*** large amounts of air at low pressure during filling and release small amounts of pressurized air during operation.

(Kennedy, John L., Oil and Gas Pipeline Fundamentals, USA. 1999)

Terms and Vocabulary

air valve	воздуховыпускной клапан
cavitation	кавитация
check valve	обратный клапан
control valve	распределительный клапан
flow control valve	дроссель, регулятор потока
repair	ремонт
excessive (pressure)	избыточное давление
expel (v)	исключать
operation	работа / процесс
collapsing	разрушающий
replacement	замена
pressure transient	неустановившееся давление / давление в переходном режиме
release valve	выпускной клапан
reverse flow	обратный поток
relief valve	перепускной клапан
isolation (block) valve	стопорный (запорный) клапан

4. Find terms which are used with the following words.

Example: *flow control valve*

- flow
- valve
- fluid

5. Compose collocations from the following words.

Example: *fully developed*

flow entrance velocity developed

region cross mechanic motion fully profile boundary

fluid section reverse layer

laminar turbulent

6. Match the definitions with the following terms.

Example: 11. laminar flow – G. a smooth flow of fluid in which no turbulence or cross flow of fluid particles occurs between adjacent stream line

1.	pipe flow	A.	the speed at which a fluid moves or passes through an object
2.	fluid	B.	nonlinear flow of a fluid, caused by high velocity
3.	flow	C.	a scale of pressure differences in which there is a uniform variation of pressure from point to point
4.	valve	D.	a pipe through which a fluid flows without completely filling the pipe
5.	velocity profile	E.	a pipe is completely filled with the fluid being transported
6.	shear stress	F.	a substance that flows and yields to any force tending to change its shape
7.	turbulent flow	**G.**	**a smooth flow of fluid in which no turbulence or cross flow of fluid particles occurs between adjacent stream line**
8.	fitting	H.	a current or stream of fluid
9.	open-channel flow	I.	a device used to control the rate of flow on a line to open or shut off a line completely or to serve as an automatic / semi-automatic safety device
10.	pressure gradient	J.	a smaller, standardized part (valve, gauge) installed in a larger part (device / apparatus)
11.	**laminar flow**	K.	force applied to a liquid to cause it to flow

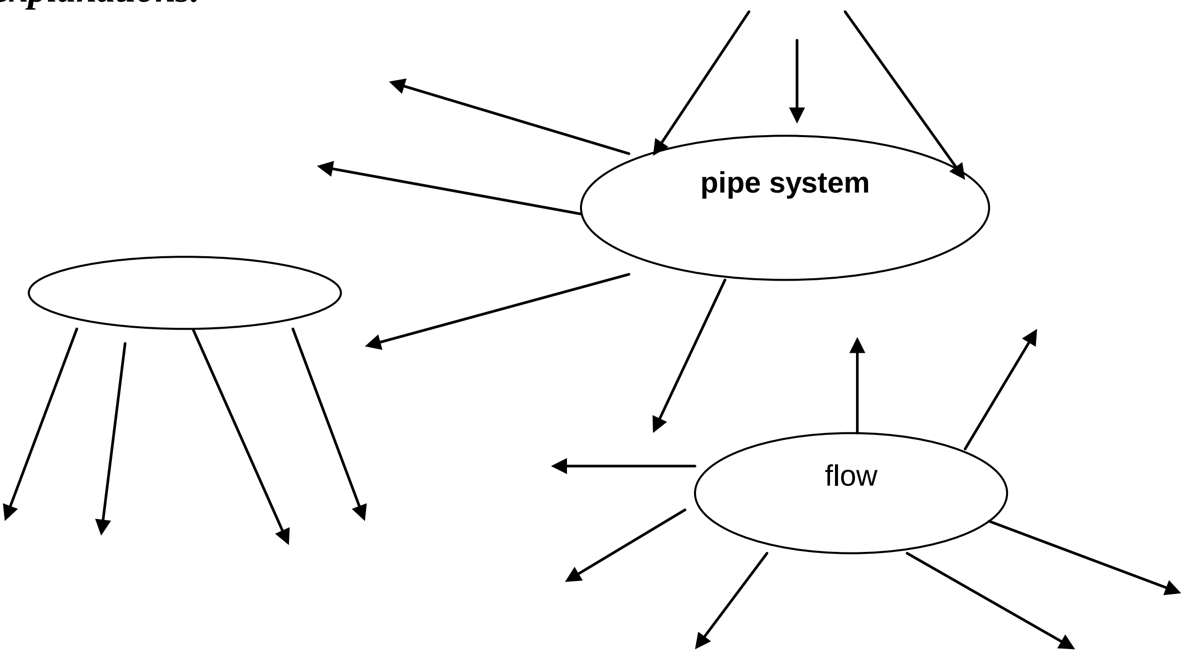
7. Replace the underlined words with a suitable variant from the text.

1. Fluid mechanics is the discipline concerned with **behavior (*the movement or conduct*)** of liquids and gases *in quiescent state* or *when they are moving*.
2. Some of the basic components of a typical pipe system include the pipes themselves, *the various parts which connect the individual pipes* to form the desired system, *the flowrate control devices* and the pumps.
3. For the situation *when the pipe is not completely filled*, gravity alone is the driving force for fluid. For *other situations where the pipe is completely filled with the fluid being transported*, gravity may be important, but the main driving force is likely to be a pressure gradient along the pipe.
4. The region of flow near where the fluid *comes into* the pipe is termed the *inlet area*.
5. The primary valve types are *valves used to regulate flow, pressure, liquid level, cavitation and pressure transients*, *valves placed on each side of valves* and *valves which are designed to prevent reverse flow.*

8. Answer the following questions.

1. What is the difference between the following terms:
   - Pipe
   - Conduit
   - Duct
2. What are the pipe system components and give their definitions?
3. What is the difference between pipe flow and open-channel flow? Give examples.
4. What factors can affect the Reynolds number during the transition fro laminar to turbulent flow?
5. Why is velocity profile important in understanding different flows?
6. What is a valve? Give examples, indicating their functions.
7. What are the most important criteria for control valves?

9. Discussion. ***Complete the following diagrams and give all necessary explanations.***



10. You will hear a part of a lecture series on Fluid Mechanics. For questions 1-10, complete the sentences with a word or phrase.

To discuss the dynamics we have to be able to describe ______ (1)
The description of motion is called _______ (2)
In the contracted flow _____________ (3) have been used to identify pieces of fluid.
In elementary mechanics we are used to describing a position of material time as a ________ (4)
In infinity of mass point it is necessary to pick ______________(5) called initial time.
Velocity is the function of _______________(6)
From the Lagrangian velocity it is easy to calculate _______________ (7)
As Lagrangian measurements are very complicated, it is more convenient to make measurements at points fixed at _____________________ (8)
The fact that velocity at point of laboratory coordinates is not always referred to the same piece of matter leads to _______ (9) between Lagrangian and Eularian representations.
________________ (10) is an advantage of laboratory coordinates.

11. Prepare the following presentations.

1. Laminar and turbulent flows
2. Valve and their functions
3. General Characteristics of Pipe Flow
4. Pipe system components
5. Fluid mechanics

WORDLIST

ENGLISH	RUSSIAN
air valve	воздуховыпускной клапан
cavitation	кавитация
check valve	обратный клапан
collapsing	разрушающий
conduit	трубопровод; труба
control valve	распределительный клапан
developing flow	развивающийся поток
driving force	движущая сила
duct	труба (не с круглым поперечным сечением)
excessive (pressure)	избыточное давление
expel (v)	исключать
flow (move)	поток; течение
flow control valve	дроссель, регулятор потока
fluid	флюиды
fully developed flow	развитый поток
isolation (block) valve	стопорный (запорный) клапан
momentum transfer	передача (перенос) импульса
open-channel flow	поток (в не полностью заполненной трубе)
operation	работа / процесс
pipe	трубопровод
pipe flow	поток в трубопроводе (в полностью заполненной трубе)
pipe system	система трубопроводных линий, сеть трубопроводов
pressure difference	разность давлений
pressure gradient	градиент давления
pressure transient	неустановившееся давление / давление в переходном режиме
release valve	выпускной клапан

relief valve	перепускной клапан
repair	ремонт
replacement	замена
reverse flow	обратный поток
shear stress	напряжение сдвига
velocity profile	скоростной профиль

UNIT 3

JOINING PIPES

Piping refers to the overall network of pipes, fittings, flanges, valves and other components that comprise a conduit system to convey liquids. Whether a piping system is used to convey fluids from one point to another or to process and condition the fluid, piping connections serve an important role in the operation of the system.

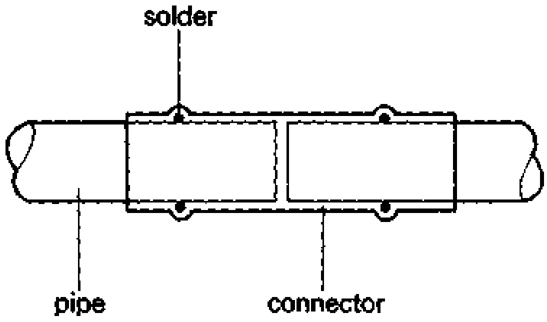
Pipes can conduit fluid under gravity, vacuum, low-pressure, or high pressure in a process, pneumatic or hydraulic system. Depending on the application, pipe connections can take a variety of forms.

Lead-in

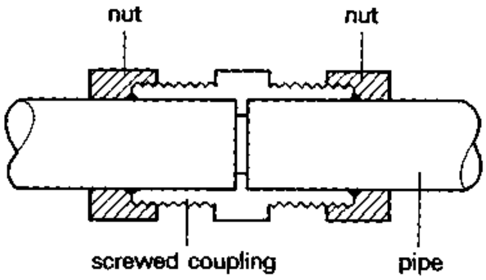
Many different kinds of joint are used to connect pipes. Three types of fittings for small D pipes and three for large D pipes are shown in the below diagrams. Fill in the missing words. Describe pipe joint types (WHAT DO YOU KNOW?)

are pushed	is soldered
is pushed	is screwed

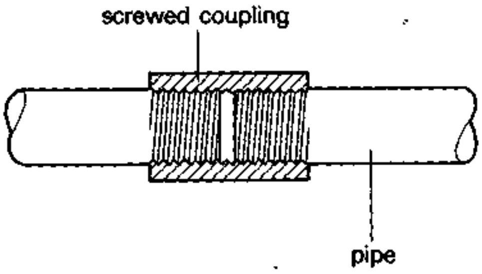
Small diameter pipes



A.Each pipe ___ _______ into the connector;
the connector _____ ________ to the pipes.



B. The pipes _____ _______ into the coupling; then the nuts ___on.

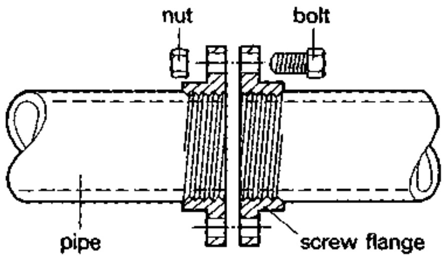


C. Each pipe ______   ________ into the threaded coupling.

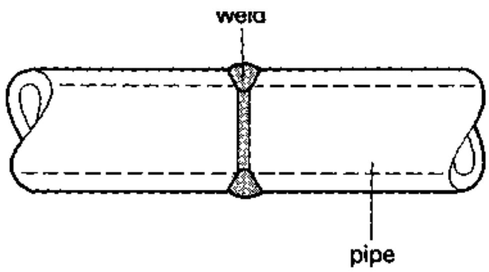
Large diameter pipes

are clamped   are bolted(x3)

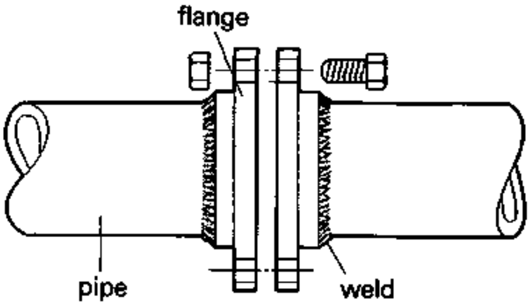
are welded (x2)



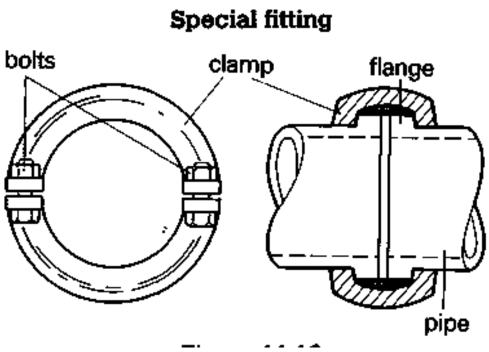
D. The flanges ____ _______ onto the pipe.
Then they ____ _______ together.



E. The ends of the two pipes ____ ____ together.



F. The flanges _____ _______. Then ______ ________.



G. The two flanges _____ ____ together. Then the clamps ______ _________ together.

1. What are the joining processes?
2. What are the joining devices and materials?

(Basic Technical English, Oxford University Press. 2002)

Terms and Vocabulary

flange	фланец
convey (v)	переправлять
ductile or cast iron	чугун с шаровидным графитом (чугун)
malleable iron	ковкий чугун
cast steel	литая сталь
brass	латунь
disconnection	разделение
welding	сварка
crimping	гофрирование
threaded	с резьбой
flanged	ребристый
coupled	сдвоенный
loose	неприкрепленный
tapered male fitting	фитинг с наружной резьбой
tapered	конусообразный/клиновидный/ скошенный/заостренный
female fitting	фитинг с внутренней резьбой
resin	смола
capillary action	капиллярное действие
compression	прокладка / набивка / уплотнение
couplings	соединение (муфта)
(elastometric) gasket	прокладка/набивка/уплотнение/сальник
grooved	гофрированный
vinyl (pipe)	винил
(heat) fusion	плавка
impregnated	пропитанный
adhesive	связывающий
circumferential	периферический
polyolefin	полиолефин
crimped joint	опрессованное соединение
sleeve	рукав / муфта
brazing	пайка твердым припоем
annular space	кольцевое пространство
yielding (metal)	пластичный металл
seal	перемычка
seating surface (seal weld)	монтажный фланец (сварная перемычка)
tightness	герметичность
dismantle	разбирать
union	соединение
prone	свойственный

socket-fitting	муфта (патрубок)-фитинг
fillet welded	сварка угловым швом
butt welded	сваренный встык
butt joint	соединение встык / контактное фланцевое соединение
backing ring	горловое кольцо
soldered joint	паяное соединение
rigid	негибкий

1. Pronounce the following words. Pay special attention to the letters in bold.

th**rea**ded
fl**ang**ed
c**ou**pled
t**a**p**er**ed
w**el**ded
fill**et** welded
s**ol**dered
adhesive
c**rimp**ed
t**igh**tness
gr**oov**ed
ductile
yielding
pr**o**ne
circumferen**tial**
r**igi**d
ann**u**lar
s**ol**vent
vin**y**l
union

2. Pay attention to the stress in the following words. □ shows the position of stress.

elas□ tomet□ ric	impreg□ nated	circum□ ferential	an□ nular	adhe□sive
polyo□lefin	mal□leable	re□sin		

3. Read the text "Pipe Joints and Fittings", do the exercises.

Pipe Joints and Fittings

Pipe and fittings are produced in a wide range of materials including: ***ductile*** or ***cast iron***, ***malleable iron***, ***brass***, copper, ***cast steel***, plastic and fiberglass. Pipe joints can be permanent or mechanically joined, allowing ***disconnection***. Permanent joints involve ***welding*** or ***crimping*** metal pipe and cementing plastic pipe. Joints that can be taken apart include ***threaded***,

flanged and ***coupled*** designs. Flanges can be ***loose,*** threaded or welded to pipe ends and are used on metal and plastic pipe.

Threaded

Threading is one of the most popular and least expensive methods of joining steel pipes. The ***tapered male fitting*** is forced into the ***tapered female fitting***. ***Yielding*** metal creates ***a seal***. Threads other than taper pipe threads can be used for piping connections where ***tightness*** of the joint depends on a ***seal weld*** or ***seating surface*** other than the threads. While threaded joints can be ***dismantled***, it is preferable to use ***unions***. Threaded pipe is available in sizes from 1/16 to 24 in.

Welded

Welded joints are commonly used with steel pipe because these joints are stronger and less ***prone*** to leakage than threaded and flanged joints. Also, this method does not add weight to the piping system as flanges do or require a pipe wall thick enough to be threaded.

Pipe up to 2-in. size is generally ***socket-fitting***, ***fillet welded***. Larger pipe 3-36 in, is usually ***butt welded***. The most common joint is the ***circumferential butt joint***. During the welding procedure, to avoid entrance of welding material into the pipe, ***backing rings*** may be used.

Soldered

A ***soldered joint*** is a ***rigid***, pressure-type joint made with a ***filter metal*** that, when heated to its melting point, is drawn into the ***annular space*** between pipes and fitting by ***capillary action***. This type of joint is generally limited to pipe up to 8 in. because of the difficulty of applying heat evenly to the joint. ***Brazing*** is similar to soldering except higher heat is required for the filler metal. It is used where higher pressure ratings are required.

Compression

Compression couplings usually can be used with all types of pipe and do not require any pipe preparation. They consist of an inner ***elastometric gasket*** and an outer metallic ***sleeve*** with integral bolts for compressing the gasket. They are available for pipe up to 144-in. OD.

<u>Crimped or grooved</u>

The use of mechanical joints in piping systems is becoming popular. A ***crimped joint*** is designed to join light-wall steel and copper pipe, metallic or nonmetallic that is capable of being cut or roll ***grooved*** up to 2-in.

<u>Cemented</u>

Solvent joining can be used on ***vinyl pipe*** and some others, available up to 12-in. ***Polyolefin*** and other pipes require ***heat fusion*** and are available up to 6-i. Fibreglass pipe requires an ***adhesive, resin impregnated*** fabric or threads to make a joint. It is readily available in sizes from 1/2 to 144-in.

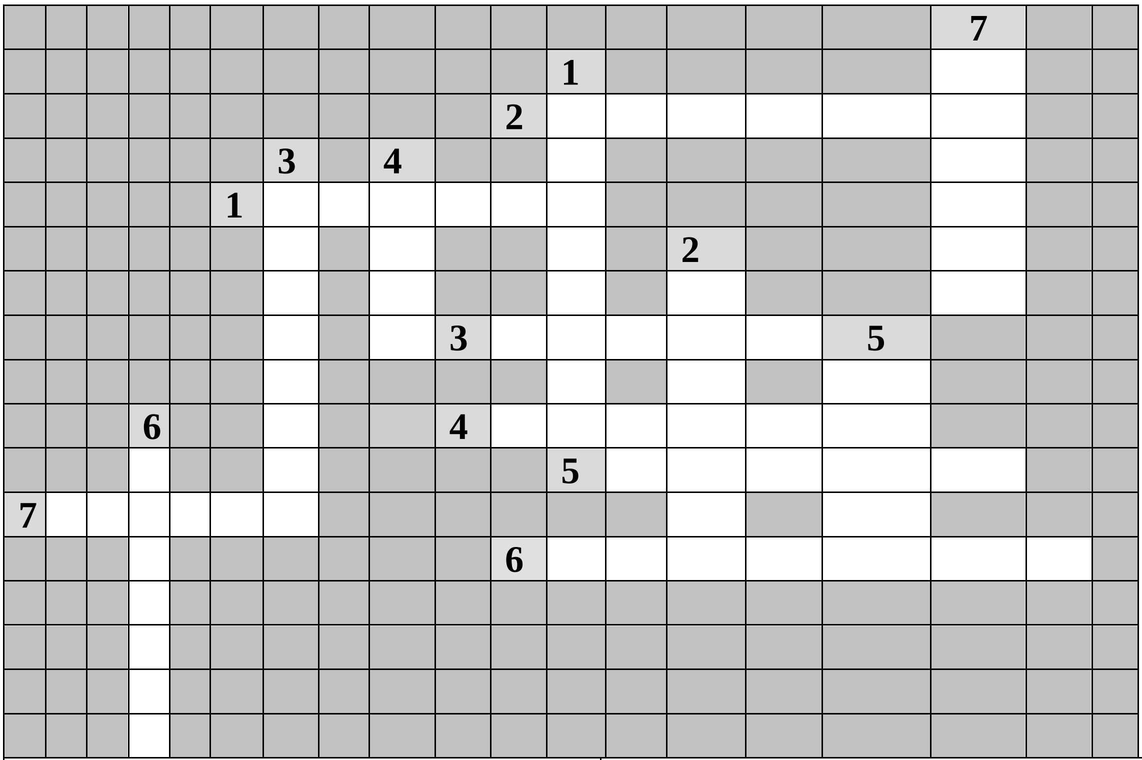
(http://www. Wikipedia.org)

4. Find the synonyms to the following words.

Example: *11. procedure – A. method*

1.	union	**A.**	**method**
2.	prone	B.	tube
3.	circumferential	C.	saturated
4.	rigid	D.	sticky
5.	pipe	E.	adaptable
6.	fusion	F.	hermetic
7.	impregnated	G.	inclined (liable)
8.	adhesive	H.	melting
9.	yielding	I.	hard / inflexible
10.	tightness	J.	peripheral
11.	**procedure**	K.	connection

5. Solve the following crossword.



ACROSS	DOWN
1. a hollow object or open device that fits or holds an object	1. a small, often standardized, part installed in a larger part (device)
2. a projecting rim or edge, usually drilled with holes to allow bolting to other fittings	2. a substance in which another substance is dissolved
3. a coupling device that allows pipes to be connected	3. join metallic parts by fusion alloys
4. a depression on a surface	4. form metal into a particular shape
5. semisolid or solid complex mixture of organic compounds having no definite melting point	5. bend or mold into shape
6. gradual decrease in thickness or width of an object	6. to solder together using a hard alloy with a high melting point
7. a continuous rib as on a pipe	7. hardened by the action of heat

6. Complete the table using the terms and fill in the missing gaps in the following passage.

<table>
<tr><td rowspan="6">Joining methods</td><td rowspan="2">Mechanical</td><td></td></tr>
<tr><td></td></tr>
<tr><td rowspan="3">Thermal</td><td></td></tr>
<tr><td></td></tr>
<tr><td></td></tr>
<tr><td>Adhesive</td><td></td></tr>
</table>

Pipes can be joined by three basic methods: **1. mechanical**, **2.** ______________ and **3.** ___________________. Both the mechanical and **4.** ________________ methods can be further divided. The former method includes **5.** ______________ and **6.** _______________. The latter method can be broken down into
7. _________ and **8.** ______________.

7. Match the methods with the description.

Example: 6 – C

1.	threaded	A.	joining light-wall steel and copper pipe, metallic or nonmetallic that is being cut or rolled
2.	welded	B.	consist of an inner elastometric gasket and an outer metallic sleeve with integral bolts for compressing the gasket.
3.	soldered	**C.**	**a substance that hardens under heat to bond pipes**
4.	crimped (grooved)	D.	pressure-type joint made with a filter metal that, when heated to its melting point, is drawn into the annular space between pipes and fitting by capillary action.
5.	compressed	E.	is a metal-joining process wherein coalescence (соединение) is produced by heating to suitable temperatures with or without the use of filler metal.
6.	**cemented**	F.	a continuous helical (винтовое зубчатое колесо) has threads on each end, making it possible to screw two pieces of pipe together.

8. Read the mini-text "Metal Properties" and complete the table. Use the symbols √ (yes) and x (no). Use the information from Ex. 3.

METAL	PROPERTIES			
	Ductile	Malleable	Corrosion resistant	Good conductor of electricity
cast (ductile) iron				
malleable (wrought) iron				
copper				
lead				
brass				
cast steel				
plastic	√	√	√	

Metal Properties

Metals are used for a variety of engineering purposes, depending on the properties of the metals. Certain common metals have malleable and ductile properties. If a metal is malleable it can be hammered or pressed into a new shape. Copper is a good example of this. It is also can be used for sheaths on electrical cables. Lead, like copper and tin, will resist corrosion.

Tin and wrought iron can be stretched, and also have malleable properties. The former is corrosion resistant, but wrought iron easily corrodes. Wrought iron can be used for chains and crane hooks. Neither of these two metals is a good conductor of electricity.

Cast iron is unlike the other metals because its shape cannot be altered by hammering, pressing or stretching and it is not corrosion resistant.

(Basic Technical English, Oxford University Press. 2002)

9. Complete the table using the information from the text. Compare and analyze.

JOINING PIPES				
Materials	Properties	Method	Method Description	Examples Of Uses

***10. Discussion**: The topic of our discussion is “Pipe Jointings”. The monitoring packet includes four parts. Do the tasks. Afterwards you have 10–15 minutes to make a mini-report and present it.*

Part 1 Checking vocabulary by means of reading comprehension

Fill in the gaps.

1. Pipe and fittings are made of different material ___________.
2. Pipe joints allow ___________________________.
3. Joints can be ________ or _______________.
4. Flanges can be _________, __________ and _________.
5. Joints that can be taken apart include _____________.

Part 2 Detail reading: questions that ask for specific information

Answer the following questions.

1. Which are the most popular and least expensive methods of joining steel pipes?
2. When is threading used? Why?
3. When welded joints are used? What is the advantage of this method?
4. What is the most common joint in the welded method?
5. What is the difference between soldering and brazing?
6. Why can compression couplings be used with all types of pipe?
7. Why is the use of mechanical joints in piping systems becoming popular?
8. What method is used for fibreglass pipes, vinyl pipes and polyolefin pipes?

Part 3 Main idea: checks the student's comprehension of the text.
Fill in the following table.

Method	Pipe type	Pipe size	Function	Description

Part 4 Interpretive questions – analyze and infer the text.
Discuss the following statement and prove your opinion.
Piping connections serve an important role in the operation of the system. Depending on the application, pipe connections can take a variety of forms.

11. 🖭 You will hear a man talking about arc welding process. For questions 1-4, choose the answer (A,B,C, or D) which fits best according to what your hear.

1 MIG stands for
A Metal Inner Gas Welding
B Mild Inert Gas Welding
C Metal Inert Gas Welding
D Metal Inner Gas

2 What is not mentioned as a part of arc welding unit?
A gas shield
B power supply
C strength steel wire
D drive rollers

3 Thickness of wire depends on
A diameter
B usage
C power supply
D MIG gun

4 What is a main constituent of the machine?
A unit
B gas
C gun
D bottle

12. Discuss the following quotation and state your own opinion.

Corrugated pipe is one of the alternatives nowadays. Most importantly, corrugated pipe is durable and flexible enough that it can make it through even in the harshest Alaska winter. The shift in the round here is extreme, our projects need a pipe that can handle it. Corrugated pipe can and does handle it.

(Rick Green)

WORDLIST

ENGLISH	RUSSIAN
adhesive	связывающий
annular space	кольцевое пространство
backing ring	горловое кольцо
brass	латунь
brazing	пайка твердым припоем
butt joint	соединение встык / контактное фланцевое соединение
butt welded	сваренный встык
capillary action	капиллярное действие
cast steel	литая сталь
circumferential	периферический
compression	прокладка / набивка / уплотнение couplings – соединение (муфта)
convey (v)	переправлять
coupled	сдвоенный
crimped joint	опрессованое соединение
crimping	гофрирование
disconnection	разделение
dismantle (v)	разбирать
ductile or cast iron	чугун с шаровидным графитом (чугун)
fillet welded	сварка угловым швом
flanged	ребристый
flange	фланец
fusion(heat)	плавка
gasket (elastometric)	прокладка / набивка / уплотнение / сальник
grooved	гофрированный
impregnated	пропитанный
loose	неприкрепленный

malleable iron	ковкий чугун
polyolefin	полиолефин
prone	свойственный
resin	смола
rigid	негибкий
seal	перемычка
seating surface (seal weld)	монтажный фланец (сварная перемычка)
sleeve	рукав / муфта
socket-fitting	муфта (патрубок)-фитинг
soldered joint	паяное соединение
tapered	(конусообразный / клиновидный / скошенный/ заостренный) female fitting- фитинг с внутренней резьбой
tapered male fitting	фитинг с наружной резьбой
threaded	с резьбой
tightness	герметичность
union	соединение
vinyl (pipe)	винил
welding	сварка
yielding(metal)	пластичный металл

UNIT 4

PIPELINE CORROSION

Corrosion is ***deterioration*** of ***intrinsic*** properties in a material due to reactions with its environment. It is the oxidation of metals reacting with water or oxygen. ***Weakening*** of iron due to oxidation of the iron atoms is a well-known example of electrochemical corrosion. This is commonly known as ***rust.*** This type of damage usually affects metallic materials, and typically produces oxide(s) and/or salt(s) of the original metal. Corrosion also includes the dissolution of ceramic materials and can refer to ***discoloration*** and weakening of polymers by the sun's ultraviolet light.

Lead-in

Pipeline corrosion. Look at this subject from different points of view. Examine the subject from each of the following angles:

- Describe it. (Have you seen it? What does it look like?)
- Compare it. (What is it similar to? What is it different to?)
- Analyze it.
- Associate it. (What does it remind you of? What do you associate it with?)

Terms and Vocabulary

corrosion	коррозия
deterioration	ухудшения характеристик
intrinsic	действительный, подлинный, истинный
weakening	ослабление
rust	ржавчина
discoloration	обесцвечивание, выцветание
to suffer	испытывать
external corrosion	наружная коррозия
coat (v)	покрывать
external surface	внешняя поверхность
impressed current (method)	подаваемый ток (в систему катодной защиты)
sacrificial anode (method)	растворимый (расходуемый) анод
DC (direct current)	постоянный ток
via	через
soil	почва, земля
driving potential	движущий потенциал

corrosion cell	коррозионный элемент
reverse (v)	переворачивать
monitor (by)	контролировать
output voltage	выходное напряжение
readings	данные из таблицы
rely on	основываться, основывать на чём-л
corrode (v)	корродировать, разрушать
be sacrificed	защита (от коррозии) с применением магниевых анодов
arrest (v)	приостановление / приостанавливать
severity	интенсивность
conductivity	(удельная) проводимость
soil condition	грунтовые условия
pH	водородный показатель
fluid velocity	скорость потока
water removal	обезвоживание
water drying	обезвоживание
corrosion allowance	допуск на коррозию
wall thickness	толщина стенки (трубы)
determination	определение
allowable operating pressure	допустимое рабочее давление
yield strength	предел текучести

1. Pronounce the following words. Pay special attention to the letters in bold.

corro**sion** **cu**rrent sacrifi**cial** poten**tial** vol**tage** allow**ance** **yie**ld stren**gth**

2. Pay attention to the underlined stress in the following words.

sever**ity** conductiv**ity** veloc**ity**

3. Read the text "Corrosion", do the exercises.

Corrosion

Corrosion of steel pipelines is a natural process and steel pipes, when buried, invariably ***suffer*** from ***external corrosion*** unless adequately protected. Pipelines are usually ***coated*** to protect the external surfaces of the steel pipe against corrosion.

There are essentially two methods: ***impressed current method*** and ***sacrificial anode method.*** For onshore pipelines it is common to use an impressed current method. In this system, a ***DC*** (direct current) is supplied to the pipeline and is made to flow between the pipe and an ***anode ground bed via*** the ***soil.*** The current is adjusted to generate higher ***driving potentials*** in the pipe than those existing naturally in the ***corrosion cell***. This neutralizes or *reverses* the effects of corrosion. This system requires transformer stations and is usually ***monitored*** by ***output voltage readings***. A sacrificial anode method, on the other hand, ***relies upon*** the installation of anodes on or near the pipeline. The pipeline becomes the cathode of the system and the anodes, which ***corrode*** are ***sacrificed to arrest*** corrosion of the pipeline. When water is present on the transported fluid, corrosion of the internal pipe surfaces can also occur.

Water may be present, either alone, or in combination with CO_2, H_2O, O_2 or other salts. The ***severity*** of corrosion depends upon the operating temperature, pressure, ***conductivity***, ***soil condition***, ***pH*** and ***fluid velocity*** and composition. Corrosion control measures include ***water removal and drying***, chemical injection and ***corrosion allowance*** on ***wall thickness***. Wall thickness – the most important element in pipeline mechanical design is the ***determination*** of pipeline wall thickness. Wall thickness is a function of the pipeline maximum ***allowable operating pressure*** and the ***yield strength*** of the steel pipe used. Operating pressure and wall thickness determine the number and locations of pump or compressor stations along the pipeline. If a higher pipeline operating pressure is chosen, the power at each station can be greater, and the stations can be farther apart.

4. Replace the underlined words with a suitable variant from the text.

***Example:* 6.** *working – operating*

1. Buried steel pipes suffer from outer corrosion.
2. DC flows between the pipe and an anode ground bed through the soil.
3. Transformer stations are controlled by output voltage data.
4. Corrosion control measures include water elimination and drying.
5. A sacrificial anode method depends on the installation of anodes on or near the pipeline.
6. The severity of corrosion depends on the working temperature.

5. Match the terms with Russian equivalents.

Example*:* ***15.*** *deterioration –* ***L.*** *ухудшения характеристик*

1. weakening	A. подаваемый ток
2. rust	B. коррозионный элемент
3. discoloration	C. выходное напряжение
4. impressed current	D. интенсивность
5. direct current	E. (удельная) проводимость
6. corrosion cell	F. ослабление
7. output voltage	G. обезвоживание
8. severity	H. постоянный ток
9. water removal	I. обесцвечивание
10. conductivity	J. ржавчина
11. operating pressure	K. толщина стенки
12. yield strength	**L. ухудшения характеристик**
13. allowance	M. рабочее давление
14. wall thickness	N. предел текучести
15. deterioration	O. допуск

6. Fill in the gaps with the correct term.

Example: 7. <u>relies upon</u>

There are essentially two methods: **1. __________ _____________**and **2. ________________.** For **3.** __________ ___________ it is common to use an impressed current method. In this system, **4.** ___________ ___________ is supplied to the pipeline. The current is adjusted to generate higher **5. ____________ __________.** A **6**. __________ ___________ **7. *<u>relies upon</u>*** the installation of **8.**________ on or near the pipeline. The pipeline becomes the cathode of the system and the anodes **9.________** corrosion of the pipeline. When water is present on the transported fluid, corrosion of the internal pipe surfaces can also occur.

7. Scan through the following short definitions and do the after – task exercises.

Corrosion types

Pitting corrosion results in pits in the metal surface due to localized corrosion. ***Uniform or general corrosion*** proceeds at approximately the same rate over the whole surface being corroded and the extent can be measured as mass loss per unit area.

Crevice corrosion occurs in or immediately around a break in the material.

Intergranular corrosion results in corrosion at or near the grain boundaries of the metal.
Erosion Corrosion involves conjoint erosion and corrosion that typically occurs in fast flowing liquids that have a high level of turbulence.
Environment-induced cracking results from the joint action of mechanical stresses and corrosion.

8. Match the corrosion types in the right column with their Russian equivalents in the left one.

1. crevice	A. сплошная
2. intergranular	B. язвенная (точечная)
3. general	C. наведенный крекинг
4. erosion	D. защитная
5. induced	E. местная
6. pitting	F. сквозная
7. spot	G. нитевидная
8. penetration	H. равномерная
9. isolated	I. эрозионная
10. point	J. межкристаллитная
11. sacrificial	K. щелевая
12. continuous	L. пятнами

9. Look at the photos. Define the corrosion type and describe it.

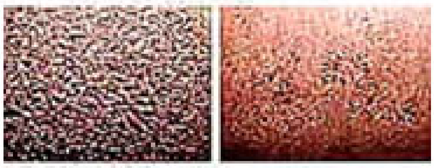
(1)

(2)

(3)

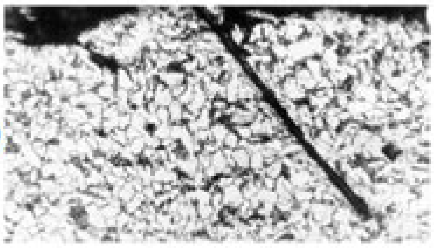
(4)

(5)



(6)

(7)



(8)

10. What is IT in each of these sentences?

1. **IT** occurs in fast flowing liquids that have a high level of turbulence
2. **IT** occurs over the whole surface
3. **IT** occurs in or around a break in the material
4. **IT** occurs as pits in the metal surface
5. **IT** occurs at or near the grain boundaries of the metal
6. **IT** occurs as cracks
7. **IT** occurs as the joint action of mechanical stresses and corrosion

11. Use the definitions to complete the following table. Comment on the items in the table.

FAILURE / FAULT	PROBABLE CAUSES	REMEDY
Pitting corrosion		

12. Match the questions about corrosion on the left with the answers on the right.

1.	Do we have any problems?	A.	That's what I'm doing.
2.	I see, now what can be done?	B.	Somewhere, about 1km. from here.
3.	That's crazy. It's time to work!	C.	H'm, well I think, maybe, like the Moon surface.
4.	What section is damaged?	D.	How can I do it?
5.	Can you identify the area of corrosion on this section?	E.	Maybe, some corrosion.
6.	If you are so eager, tell me what does it look like?	F.	Had I time, even now.
7.	How long do you think it'll take to test and measure it?	G.	Let's paint it.

Now, put the dialogue in the right order and answer the questions.

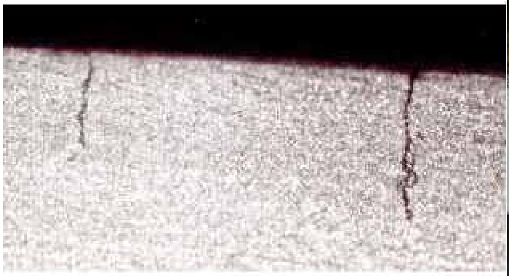
1. Where does this conversation take place?
2. What is the situation?
3. Who is involved?

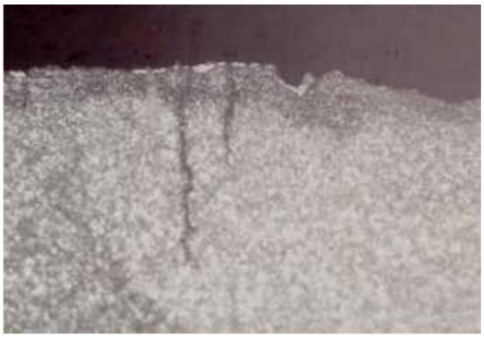
13. Read the following text “Cracks” and answer the questions.

1. What types of cracks exist?
2. What factors cause the formation of cracks?
3. What materials are more affected by cracks?
4. What types of cracks are shown on these photos?
5. What caused their formation?

Cracks

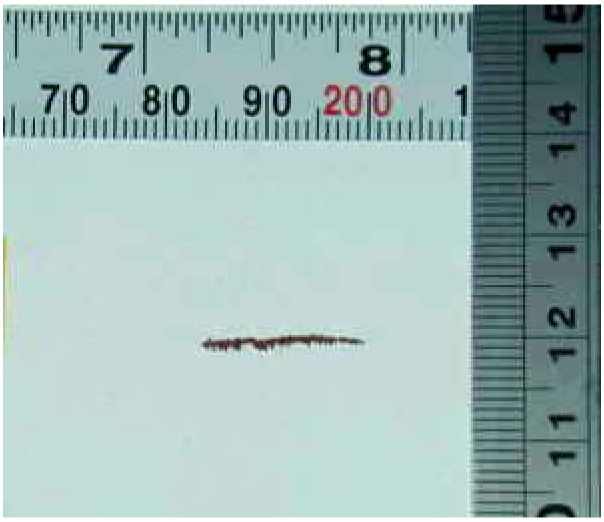
Crack characteristics can vary greatly depending on the cause of the crack, the materials being cracked, and the environment causing the cracking. The following photos show examples of crack profiles.

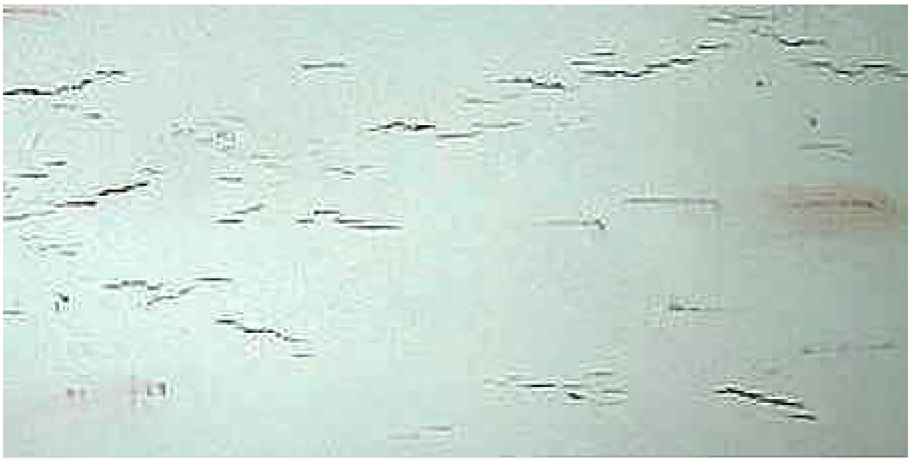




Isolated SCC and Colony SCC

Cracks may form as isolated cracks or within colonies. An example of an isolated crack is shown in the photos. Cracking within colonies may result in the cracks on the periphery of the colony being deeper then the cracks at the center of the colony. This may be observed because the effect of cracking within a colony environment may act as a stress relieving mechanism causing reduced crack growth for cracks located in the center of the colony while the cracks on the periphery continue to grow.





14. Read the information about "Applied coatings" and then the statements and circle T (True) or F (False)

Applied coatings

Plating, painting, and the application of enamel are the most common anti-corrosion treatments. They work by providing a barrier of corrosion-resistant material between the damaging environment and the structural material. Platings usually fail only in small sections. In this case, it is necessary to plate with a more active metal such as zinc or cadmium.

The corrosion control system for an oil and gas pipeline consists of two parts: the external coating on the pipeline and the cathodic protection. The primary purpose of the coating is to protect the pipe surface from its external environment. Coatings are also increasingly used to protect the internal surface of pipelines. Over the years the pipeline has been protected by various polymeric coatings. In the 1950s and 1960s, coal tar or asphalt coatings were applied. In the mid-1950s, mill-applied extruded polyethylene coatings were introduced. From the early 1960s to the early 1980s, polyethylene tape coatings were field applied.

1. Painting is the only anti-corrosion treatment	T	F
2. Anti-corrosion elements are obstacle materials between corroded surface and structural material	T	F
3. Platings are excellent in small sections.	T	F
4. The corrosion control system includes two parts	T	F
5. A coating does not protect the pipe surface.	T	F
6. Coatings protect both external and internal pipeline surfaces.	T	F
7. Polyethylene coatings were first applied in the 70s.	T	F

15. Match the questions about "Cathodic protection" on the left with the answers on the right.

Cathodic protection

If the environment is controlled corrosion inhibitors can often be added to it. These form an electrically insulating and/or chemically impermeable coating on exposed metal surfaces, to suppress electrochemical reactions. Such methods obviously make the system less sensitive to scratches or defects in the coating. Chemicals that inhibit corrosion include some of the salts in hard water, chromates, phosphates.

Cathodic protection (CP) is a technique to control the corrosion of a metal surface by making that surface the cathode of an electrochemical cell. It is a method used to protect metal structures from corrosion. Cathodic protection systems are most commonly used to protect steel, water, and fuel pipelines and tanks and offshore oil platforms.

The application of cathodic protection (CP) for steel gas pipelines started in the 1930s. This technology was rapidly adopted by the oil and gas pipeline industry to protect the pipeline in conjunction with polymeric coatings. For effective CP, the potential of the steel surface is polarized (pushed) more negative until the metal surface has a uniform potential. With a uniform potential, the driving force for the corrosion reaction is halted. For galvanic CP systems, the anode material corrodes under the influence of the steel, and eventually it must be replaced. The polarization is caused by the current flow from the anode to the cathode, driven by the difference in electrochemical potential between the anode and the cathode.

1. When can corrosion inhibitors be applied?
2. What do corrosion inhibitors form?
3. What is the main effect of corrosion inhibitors?
4. What chemicals can be inhibitors?
5. What is CP?
6. What does CP protect?
7. When was CP application first used?

A. salts in hard water, chromates.
B. metal structure-steel pipelines, tanks.
C. 1930s.
D. less sensitive to scratches / defects.
E. if environment is controlled.
F. surface cathode is an electro-chemical cell.
G. an electrically insulating / chemically impermeable coating.

16. Describe the CP application by writing the following sentences in the correct order.

A. driving force for corrosion reaction is stopped.	
B. metal surface becomes uniform potential	
C. steel surface is polarized	
D. current flow is driven by electrochemical potential difference	

17. Complete the following dialogue about corrosion patterns. Use the phrases, terms and photos.

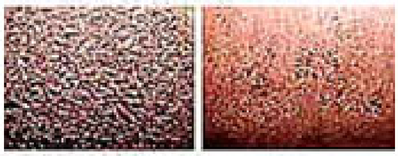
corrosion patterns	
uniform defects	produce
pitted surfaces	
striations (бороздчатость)	include
channel defects	

A: Different corrosion types produce distinct corrosion patterns.
B: Corrosion is a result of low level and pitting corrosion that affects large areas.
A: However, the result is metal loss that compromises the integrity of the pipe.
B: ………….

Fig 1: An example of general deep pitting corrosion with some pits joining to form larger pits and interconnected pitting.

Fig 2: Image presenting the trend towards channel style corrosion. The channels were initially small pits that joined together and continued to grow. This type of corrosion pattern can result in defects with significant depth and length.

18. Describe the following type of corrosion – SCC. Use the terms and phrases and photos.

 *Fig 3: Examples of corrosion striations. This style of corrosion looks like scratch marks and requires special consideration when being inspected using ultrasonic methods, since the striated corrosion surface profile affects the reflected ultrasound signal.*	 *Fig 4: General corrosion patterns range from the image on the left (with little or no good wall) to the image on the right (with only minor corrosion throughout the surface).*

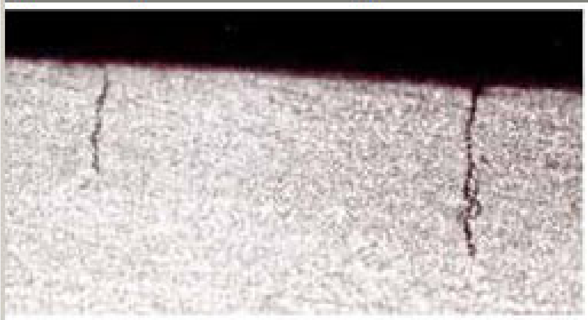
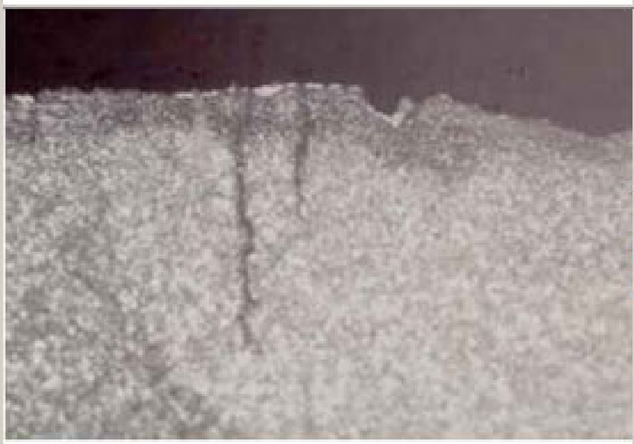



Fig 5: Photomicrograph of a SCC crack in pipeline steel	*Fig 6: Photograph of a SCC crack at the weld fusion line (toe crack). Branching nature that may occur at the crack tip can clearly be seen in this profile.*
	*Fig 7: Photomicrograph of a SCC in a weld. The two indications shown are located adjacent to one another and both occur within the weld material*

cracking	residual stress
pipeline	temperature
be influenced by	load stress
environment stress	bending
water	local stress
come into contact	high pH conditions
steel	cause
create	intergranular cracks
initial corrosion site	low pH conditions
act on	transgranular cracks
crack growth	non-classic SCC
factors	result in

19. Discuss these two problems and state your own ideas and solutions.

1. Consideration of defect initiation mechanisms and the ability to interpret defect styles should enable the NDT technician to choose the best inspection option for the conditions at hand. By providing background knowledge, sample defects, and appropriate calibration blocks the technician will be able to confidently address the requirements of the application.
2. The use of modern computers and automated scanning systems has enabled significant advancements in ultrasonic same side sizing techniques for corrosion and SCC sizing. Corrosion mapping and crack sizing using tip diffraction, angled longitudinal, or shear wave inspection techniques have the potential to offer cost savings by reducing inspection times and providing detailed information about the corrosion feature or crack profile.

20. You will hear an advertisement about Inner Armor Sub-one coating technology. Answer the following questions by saying whether each of the following statements are 1 – True (T) or 2 – False (F).

		1	**2**
1	Inner Armor stops corrosion, minimizes friction, abrasion and fouling.		
2	Inner Armor can be applied in chemical processing, pulp and paper, public utilities and aerospace.		
3	Chrome plates, thermal sprays and polymer lining are superior to CVD made coatings		

4	The coating is applied in three steps.		
5	Inner Armor coatings are subjected standard corrosion tests.		
6	Friction is reduced in 1/10 in comparison with uncoated steel.		
7	There are no any damages on the coating surface after ASTM standard G-76 Abrasive Air Jet Test.		

21. Role play: CONFERENCE ORGANIZATION

You (Conference Director) and group-mates (Conference Partners) are taking active part in the conference program preparation. You will moderate the whole Conference session.

1. Presentations: **Corrosion Types** (selective, contact, isolated, surface, uniform, structural, acid, intergranular, microbal, spot, fretting)
2. Panel Discussion: Agenda – **Corrosion and its Prevention**
3. Prepare the necessary documents using the following plan:
    - Conference program
    - prepare application form for the future participants (sender-receiver)
    - proposals (presentation, poster-presentation, report)
    - invitation (refusal / confirmation)
    - Conference session
    - business card for the Conference

WORDLIST

ENGLISH	RUSSIAN
arrest (v)	приостановление / приостанавливать
coat (v)	покрывать
coating	покрытие
conductivity	(удельная) проводимость
continuous corrosion	сплошная
corrode (v)	корродировать, разрушать
corrosion	коррозия
corrosion cell	коррозионный элемент
crevice corrosion	щелевая
DC (direct current)	постоянный ток
deterioration	ухудшения характеристик
discoloration	обесцвечивание, выцветание
driving potential	движущий потенциал
erosion corrosion	эрозионная
external corrosion	наружная коррозия
external surface	внешняя поверхность
general corrosion	равномерная
impressed current (method)	подаваемый ток (в систему катодной защиты)
induced corrosion	наведенный крекинг
inhibitor	ингибитор (вещество, замедляющее химические реакции или прекращающее их)
intergranular corrosion	межкристаллитная
intrinsic	действительный, подлинный, истинный
isolated corrosion	местная
monitor (by) (v)	контролировать
output voltage	выходное напряжение
penetration corrosion	сквозная
pitting corrosion	нитевидная
plating	гальваническое покрытие
point corrosion	язвенная (точечная)
readings	данные из таблицы
rely on (v)	основываться, основывать на чём-либо
reverse (v)	переворачивать
rust	ржавчина
sacrificed	защита (от коррозии) с применением магниевых анодов
sacrificial corrosion	защитная

sacrificial anode (method)	растворимый (расходуемый) анод
severity	интенсивность
soil	почва, земля
soil condition	грунтовые условия
spot corrosion	пятнами
suffer (v)	испытывать
suppress (v)	сдерживать
via	через
weakening	ослабление

UNIT 5

OIL STORAGE

Every facility involved in the production of petroleum and related products requires some type of storage.

Lead-in

Brainstorming
TOPIC: <u>Extracting the oil from the well and storing temporarily in tanks.</u>
Stage1– Each group discusses the question separately
Stage 2 – Sharing ideas
Stage 3 – Jig-saw plan
Stage 4 – Multi-point conversation

Terms and Vocabulary

oil storage	нефтехранилище
storage tank	резервуар для хранения нефтепродуктов
facility	оборудования
production	добыча
erector	монтажник
installation	монтаж / установка
non-existent	несуществующее
segmental	сегментный
bolted-steel tank	сборный резервуар
welded tank (field)	сварной резервуар
nominal capacity	номинальная мощность
internal pressure	внутреннее давление
dismantle	разборка
erected by hand	установить ручной
meet requirements	отвечать требованиям
sheet	лист
bottom	дно
replace	заменить
connection	соединение
impact wrench	гайковерт
galvanized	оцинковывать
coating	покрытие / грунтовка
fabrication (be fabricated)	изготовление
factory-baked	прокаливать

hot-dip process	пропитка
be furnished (with)	снабжать
expected life	предполагаемый срок службы
leak	утечка
up-ended	опрокидывать
gauge steel	толщина (калибр размер)
cell	камера
atmospheric-type storage	хранение при атмосферного давления
capacity	вместимость
shell	корпус
shop-welded	заводской
fixed roof	фиксированная крыша
frangible	ломкий, хрупкий, слабый
joint	шарнир
design pressure	расчетное давление
dead weight	собственный вес
adequate	соответствующий
capacity	пропускная способность
prevalent (for)	преобладающий
thickness	толщина стенки
excess	превышающий норму
floating roof	плавающая крыша (резервуара)
seal	закупорка
vapour loss	потери от испарения (нефтепродуктов)
operating buoyancy	рабочая плавучесть
aid (in)	способствовать
void	интервал
equivalent pressure	равнозначное давление
safety release	безопасность (выпуск)
drain (off)	спускать; выпускать; сливать
water-cut oil	обводнённая нефть
marketable oil	товарное
vortex breaker	вихреваявыключатель
cone	воронка
treating system, flush (out)	технологическая обработка

1. Pronounce the following words. Pay special attention to the letters in bold.

f**ur**nished	e**qui**valent
n**o**m**i**nal	peri**ph**ery
d**e**sired	**cyl**indrical
erected	appro**xi**mate
afford	a**cc**ess
g**aug**e	act**ua**tor
g**al**vanized	vort**ex**
ad**equat**e	fabri**ca**tion
fran**gi**ble	

2. Read the following word formations and learn their pronunciation. Pay special attention to the stress.

segment	segmental	
fabricate	fabrication	F abricated
install	installation	
erect	erection	re-erect
exist	existence	non-existent

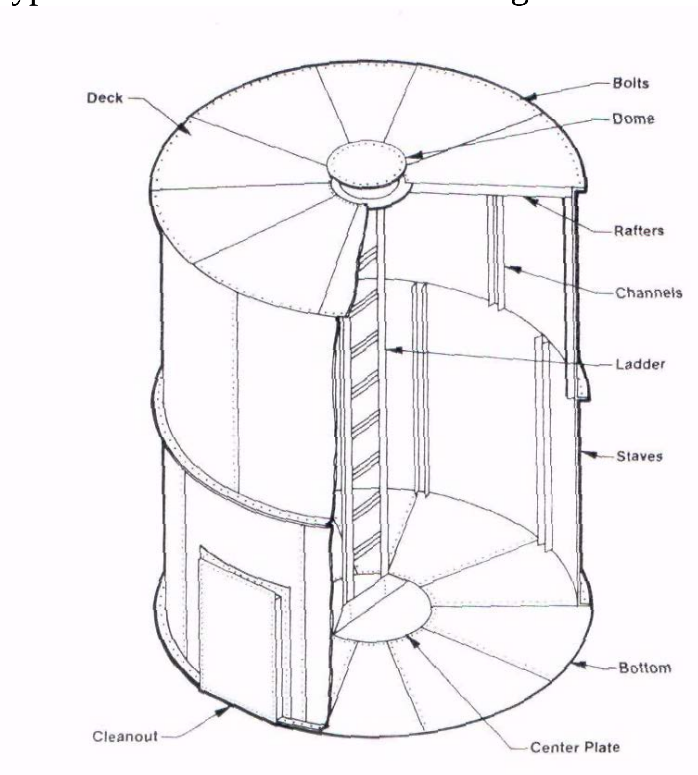
3. Read the following text "Storage Tanks", do the exercises.

Types of Storage Tanks

Every facility involved in the ***production*** of petroleum and related products requires some type of ***storage***. Manufacturers also should be consulted for specific design information on a particular type of storage. During the early days of oil production, the method of storing was almost exclusively white-pine wooden tanks, which were followed by cypress tanks, and then redwood tanks. However, because of the constant and steep rise in the cost of redwood lumber and the ***diminution*** of skilled erectors required, the ***installation*** of new wooden tanks is nearly ***non-existent***. The bolted-steel tank was developed next and replaced the wooden tank.

Bolted-steel tanks

Bolted tanks are designed and furnished as ***segmental*** elements assembled on location to provide complete vertical, cylindrical, above-ground, closed and open-top steel storage tanks. Standard API bolted tanks are available in nominal capacities of 100to 10.000bbl, and are designed for approximately atmospheric internal pressures. Bolted tanks offer the advantage of being easily transported to desired locations and erected by hand. To ***meet*** changing ***requirements*** for capacity of storage, bolted tanks can be easily ***dismantled*** and re-erected at new locations. If a tank develops a hole from corrosion or becomes damaged, a single sheet or more may be replaced. A complete tank bottom may be replaced in the field without dismantling the tank. Also, a section may be removed from the tank, a new ***connection*** installed in the ***sheet*** and the section ***replaced*** without danger. No special equipment is required for the erection of bolted tanks. These tanks are ***erected by*** non-specialized crews using ***hand*** tools and usually an ***impact wrench***. Bolted tanks are available with painted, ***galvanized*** and special coatings, including ***factory-baked*** coatings. Painting on both sides of the sheets during ***fabrication*** gives the inside of the tank some corrosion protection. Galvanizing the sheets and all tank parts by the ***"hot-dip" process*** or applying a factory-baked coating affords high corrosion protection. Generally, bolted tanks are fabricated from 12- or 10-gauge steel, and if not galvanized or ***furnished with*** a protective coating for corrosion protection, they do not have the ***expected life*** of the welded – steel tanks, which are usually constructed of heavier steel. The component parts of a typical bolted tank are shown in Fig. 1.



Deck - крыша резервуара
Cleanout - очистное отверстие
Bolt - болт
Dome - куполообразная крыша
Rafter - балка / стропила
Channel - канал
Ladder - висячая лестница
Stave - планка
Bottom - днище резервуара
Center plate - плита

Fig. 1. Typical bolted tank

<u>Welded – steel Tanks.</u> Shop-fabricated welded, cylindrical-shape tanks are available in a large variety of sizes as ***shop-fabricated*** items. Shop-welded tanks fabricated to API specifications provide the oil production industry with tanks of ***adequate*** safety and reasonable economy for use in the storage of crude petroleum and other liquids commonly handled and stored by the production segment of the industry. Shop-welded tanks are usually fabricated from 3/16-in. or heavier steel and will permit ***internal pressure*** up to 16oz. Shop fabrication permits testing in the shop for ***leaks*** and also provides immediate storage. Tanks are merely ***up-ended*** from a truck on the location.

Field-welded Tanks provide large storage capacities in a single unit. Large field-welded tanks providing storage capacities of 150.000 bbl or more have become ***prevalent for*** use in the storage of oil and petroleum products. Field-welded tanks are designed and erected in accordance with API Standard, which covers material, design, fabrication, erection and testing requirements for welded-steel storage tanks. It also includes an alternative basis for shell design, as well as one for calculating tank-shell ***thickness***.

Fixed Roof are permanently attached to the tank shell. Welded tanks of 50 bbl ***capacity*** and larger may be provided with a frangible roof (designed for ***safety release*** of the welded deck-to-shell joint in the event ***excess*** internal pressure occurs). In this case, the ***design pressure*** should not exceed the ***equivalent pressure*** of the ***dead weight*** of the roof including rafters, if external.

Floating Roof storage tanks may be tank type is used primarily for storage near atmosphere pressure. ***Floating roofs*** are designed to move vertically within the tank shell to provide a constant minimum ***void*** between the surface of the stored product and the roof. Floating roofs normally are designed to provide a constant ***seal*** between the periphery of the floating roof and the tank shell. They can be fabricated in a type that is exposed to the weather or a type that is under a fixed roof. Internal floating-roof tanks, with an external fixed roof, are used in areas of heavy snowfall since accumulations of snow or water on the floating roof affect the ***operating buoyancy***. These can be installed in existing tanks as well as new tanks. Both floating roofs and internal floating roofs are used to reduce ***vapour losses*** and ***to aid in*** conservation programs. Fig. 2 is a schematic of a typical internal floating roof tank.

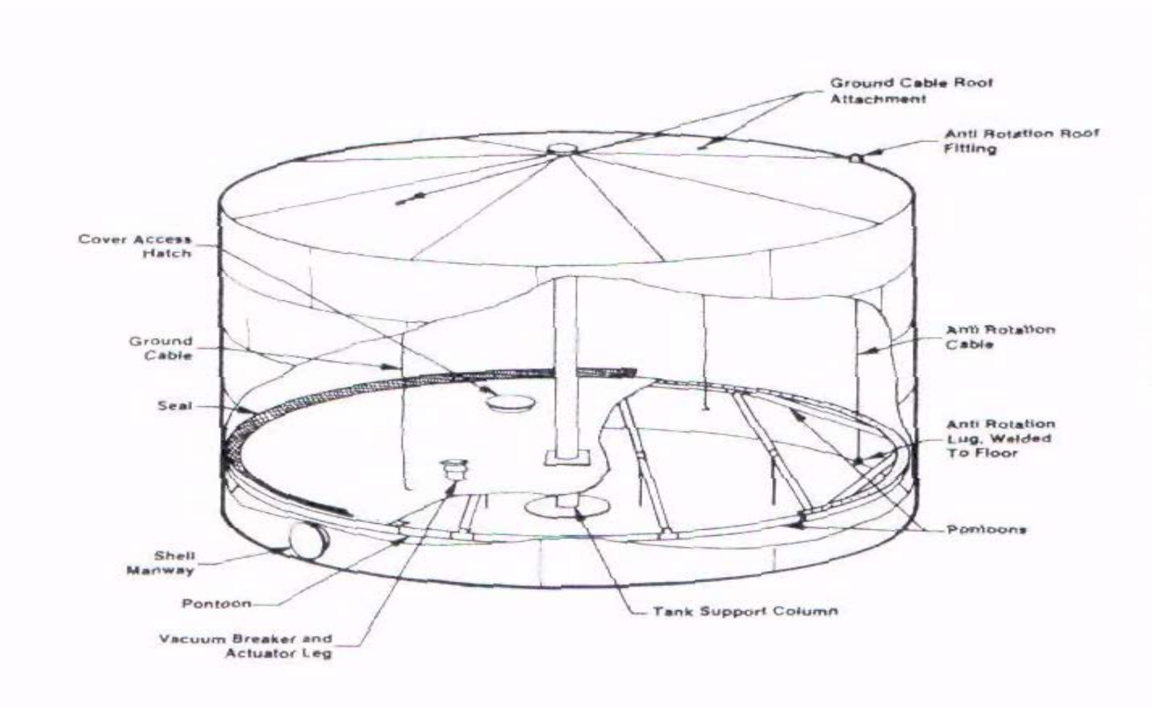


Fig. 2.Typical arrangement of internal floating roof

Cover access hatch – покрышка люка резервуара

Ground cable – кабель заземления

Seal – сальниковое уплотнение

Shell manway – лаз в крыше резервуара

Pontoon – понтон

Vacuum breaker and actuator leg – выключатель / рычаг исполнительного механизма

Tank support column – колонна; стойка (в резервуаре)

Anti–rotation lug, welded to floor – консоль против вращения

Anti–rotation cable – кабель против вращения

Anti–rotation fitting – фитинг против вращения

Ground cable roof attachment – кабель заземления для закрепления крышки

Cone – Bottom Tanks. The cone-bottom in either the bolted or the welded tank offer a means of ***draining*** and ***removing*** water or ***water-cut oil***, from only the bottom of the tank, leaving the ***marketable oil*** above. The drain line from a sump-equipped cone bottom must be equipped with a ***vortex breaker***

to drain off most of the water without ***coning*** oil into the drain. With a flat-bottom tank, some of the marketable oil must be removed if all the water is removed from the tank. Corrosion on the tank bottom is kept to a minimum by keeping all water removed. A cone bottom can be kept clean without having to open the tank if 1 or 2 bbl are drained off once or twice weekly and pumped back through the ***treating system***. If this is not done and the bottom solidifies, the tank must be opened. The cone-bottom tank can be cleaned without entering. A water hose, handled just outside the cleanout opening, can be used ***to flush*** the solids to the centre of the cone and drain connection.

(Petroleum Engineering Handbook, Society of Petroleum engineers, Richardson, TX. USA. 1992)

4. Match the verbs with the corresponding nouns.

Example: *1. erect – F. bolted tanks*

1. erect	A. water
2. flush	B. design pressure
3. provide	C. API specifications
4. reduce	D. tank bottom
5. meet	E. requirements
6. fabricate	**F. bolted tanks**
7. remove	G. protection coating
8. design	H. solids
9. replace	I. fixed roof
10. calculate	J. tank-shell thickness
11. exceed	K. storage capacity
12. attach	L. field-welded tanks
13. furnish	M. vapour loss

5. Compose collocations from the following words.

Example: *1. design – shell design, tank design, fabrication design*

1. design
2. tank
3. roof
4. pressure
5. coating

6. Divide these words into two categories. Give your examples with these words.

Example: *re**l**ease – is not a prefix*

Petroleum industry releases different types of tanks according to the API specifications.

Non prefix <u>re-</u>	**prefix <u>re-</u>**

7. Fill in the gaps using the word formations. Make all necessary changes.

Example: **segment**	**segmental**
1. Every petroleum storage tank consists of several **segments.**	
2. Bolted tanks are designed as **segmental** elements.	
fabricate **fabrication** **fabricated**	
1. The tanks ___________ _______________ according to Standard API specifications.	
2. The internal tank walls are painted during **_______________.**	
3. Shop ___________ permits testing in a sop for leaks.	
erect **erection** **re-erect**	
1. API Standard includes material, design, fabrication and ________________ for welded steel storage tanks.	
2. Bolted steel tanks can be easily dismantled and __________________ in a new location.	
3. Floating roof tanks ______________ ______________ in areas of heavy snowfalls.	
install **installation**	
1. When a tank bottom is damaged, a new connection __________ ___________ without danger.	
2. Tank ____________ is performed in four stages.	
exist **existence** **non-existent**	

1. The installation of wooden tanks is nearly ________________________.	
2. Floating roofs can be installed in _____________________ tanks.	
3. The _________________ of different tanks makes it possible to apply them in various environments.	

8. Complete the text using the words and phrases in the list.

Example: *0 storage*

BOLTED TANKS	
The production of petroleum and its by-products requires **0.** __________________. During the years, tanks developed from wooden to **1.**___________ ___________ tanks. Bolted tanks are **2.** ____________ elements and assembled **3.** _______________. They are designed according to **4.** _________ _________________. Bolted tanks can be easily **5.** ____________ and **6.** ________________ at new locations. The **7.** ___________ ______________ can be replaced in the field. For example, a hole developed from **8.** _____________ or damaged, a single **9.** ____________ may be replaced. No special equipment is required. These tanks can be erected **10.** __________. These tank types include painted, **11.** _____________, and special coatings. Bolted tanks are fabricated from 10-12 in. **12.** _______________.	**0 storage** **1 gauge steel** **2 sheet** **3 bolted –steel** **4 corrosion** **5 API specification** **6 re-erect** **7 manually** **8 segmental** **9 galvanized** **10 tank bottom** **11 on location** **12 ismantle**

9.The pictures show the installation process of tanks. Read the information and number the steps.

Example: *1. – D. tank bottom is assembled on the prefabricated foundation from separate steel plate.*

Tank installation is to be performed in the following sequence:

	A. separate steel plates which are welded to each other
	B. assembled circular belts are installed by the method of top-down construction
	C. tank is to be lowered down on the bottom elements upon assembly of the last belt
1	**D. tank bottom is assembled on the prefabricated foundation from separate steel plates**
	E. then fixed roof is lifted up together with the tank shell
	F. tank wall is assembled of the steel belts up to 3 m wide
	G. the rims are welded to the tank bottom
	H. a fixed roof is installed upon the assembly of the first belts
	I. system of hydraulic lifting jacks forming a conductor is set up around the whole perimeter

10. Answer the following questions.

1. What is top-down construction method?
2. What is chime welding?
3. How many hydraulic lifting jacks are set up around the whole perimeter? What is the maximum distance between the jacks?
4. What are circular belts?
5. Why must the steel belts be up to 3m wide? If not, then state the width of these belts.
6. What are the advantages of top-down construction?

11. Read the statements. Circle T (True) and F (False).

EXAMPLE: ***T*** *1. Cone-bottom tanks can be applied in bolted tanks.*

T \ F	1. Cone-bottom tanks can be applied in bolted tanks.
T \ F	2. Regular drainage keeps the cone-bottom tank clean.
T \ F	3. Cone-bottom tanks only drain water from the tank bottom.
T \ F	4. Floating roof tanks are used for storage above atmosphere pressure.
T \ F	5. There is a seal between the space of floating roof and tank shell.
T \ F	6. Fixed roofs are temporary welded to tank shells.
T \ F	7. Field-welded tanks provide small storage capacities.
T \ F	8. The tank shell thickness can be calculated in designing field-welded tanks.
T \ F	9. Shop-welded tanks are very expensive.
T \ F	10. Welded-steel tanks provide on-the-spot storage.
T \ F	11. Fixed roofs are frangible in case of extra internal pressure.

12. Read the text once more and fill in the chart with the necessary information.

Type	**Capacity**	**Material**	**Application**	**Advantages**	**Disadvan-tages**
Bolted-steel	**100 to 10.000 bbl**				

13. You will hear various people talking about tanker disaster.

Task 1. Look at the types of persons listed below. While listening, decide in what order you hear them speak and complete the table with the appropriate number. Three people will not be used.

A	A Green party campaigner	
B	A member of the public	
C	A central government spokesman	
D	A local inhabitant of a disaster area	
E	A ship-owner spokesman	
F	A radio newsreader	
G	A local official	
H	An insurance broker	

Task 2. Look at the topics listed below. While listening, put the topics in the order in which you hear them mentioned and complete the table with appropriate number. Three topics will not be used.

A	Providing aid for the local people	
B	Offering compensation payments	
C	Preventing future disasters	
D	Describing effect on local people's lives	
E	Tightening international regulations	
F	Criticizing government policies	
G	Keeping transport costs down	
H	Explaining the cause of the accident	

14. Role play: Pipeline engineering department is discussing the possible variants of steel tanks with fixed roofs or floating roofs for the East Siberia Pacific Pipeline System project. (Appendix 3).

Agenda:

1. Reports (different opinions)
2. Comparison analysis
3. Results and conclusions

15. Label and describe the following diagrams. Read the necessary information in Appendix 4.

Reservoir Walls

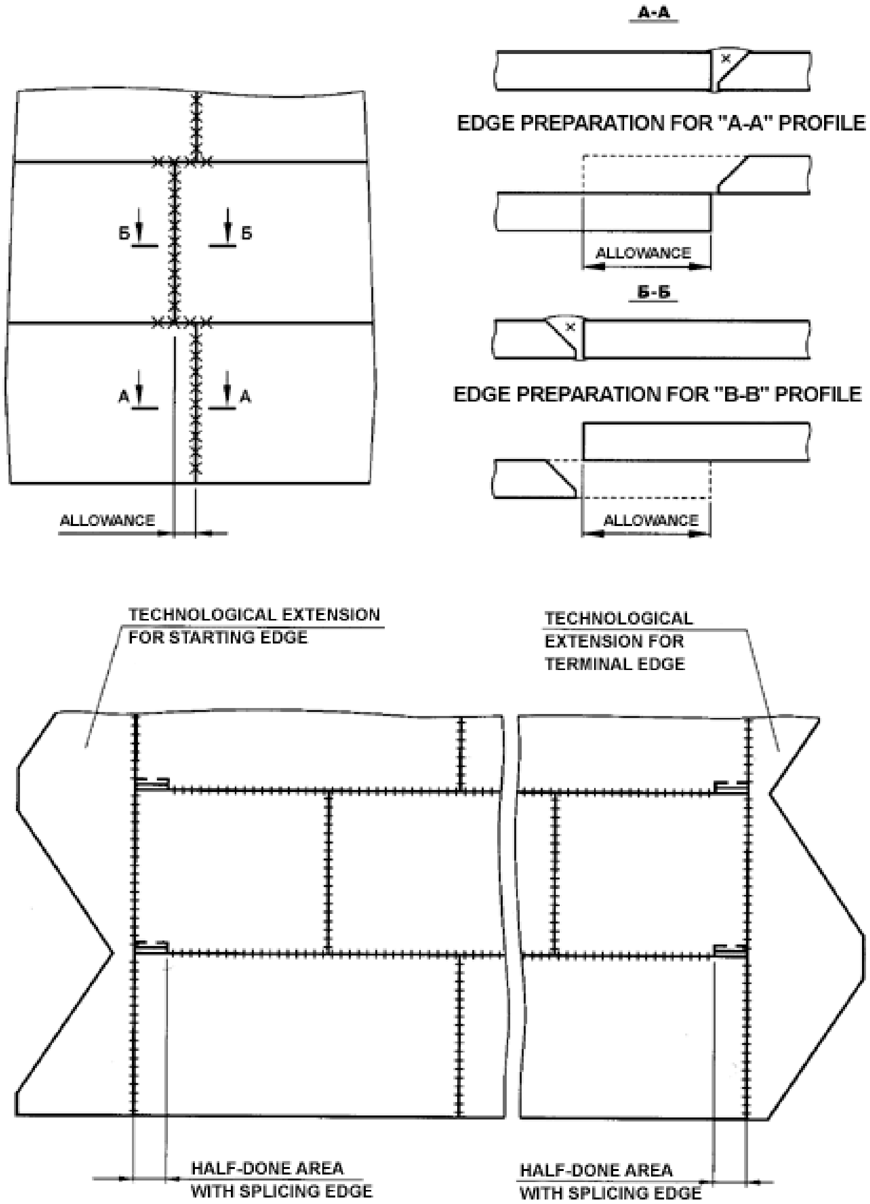


Fig. 3. Wall panels (reservoirs volume over 5000 cub. cm.)

Reservoir Bottoms

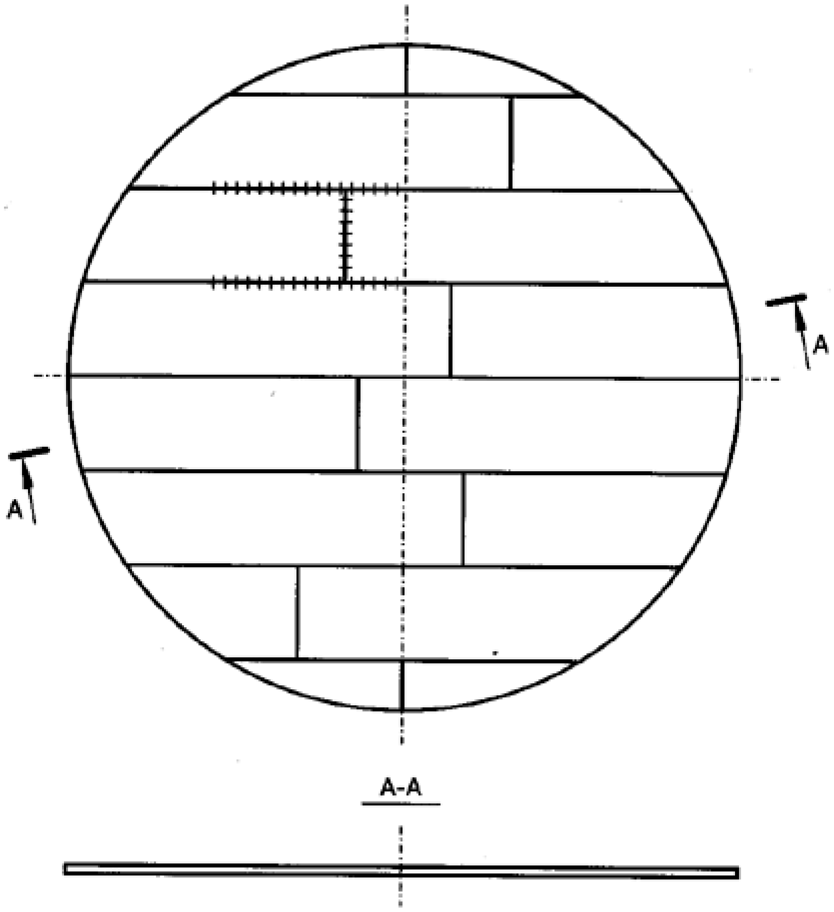


Fig. 4. Flat selvageless bottom

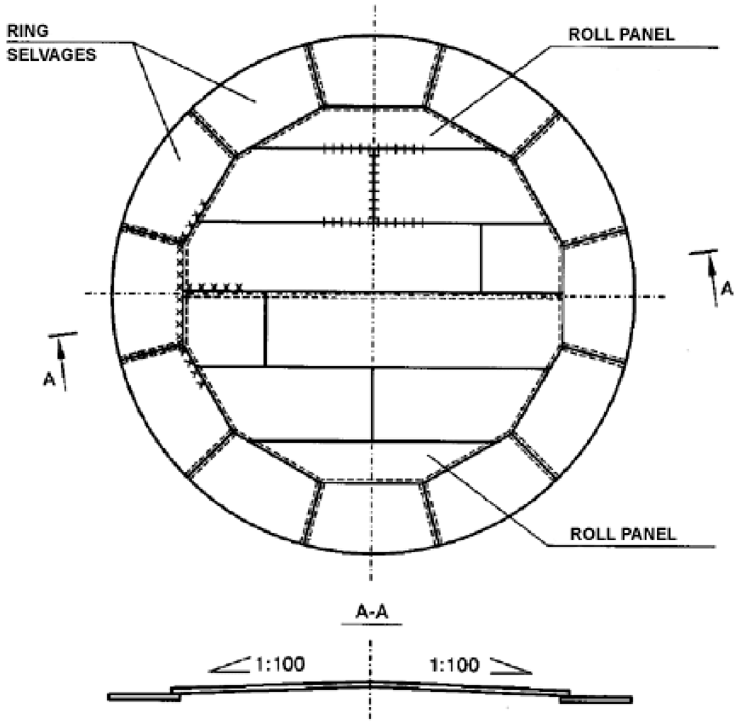


Fig. 5. Conical selvaged bottom

Roofs

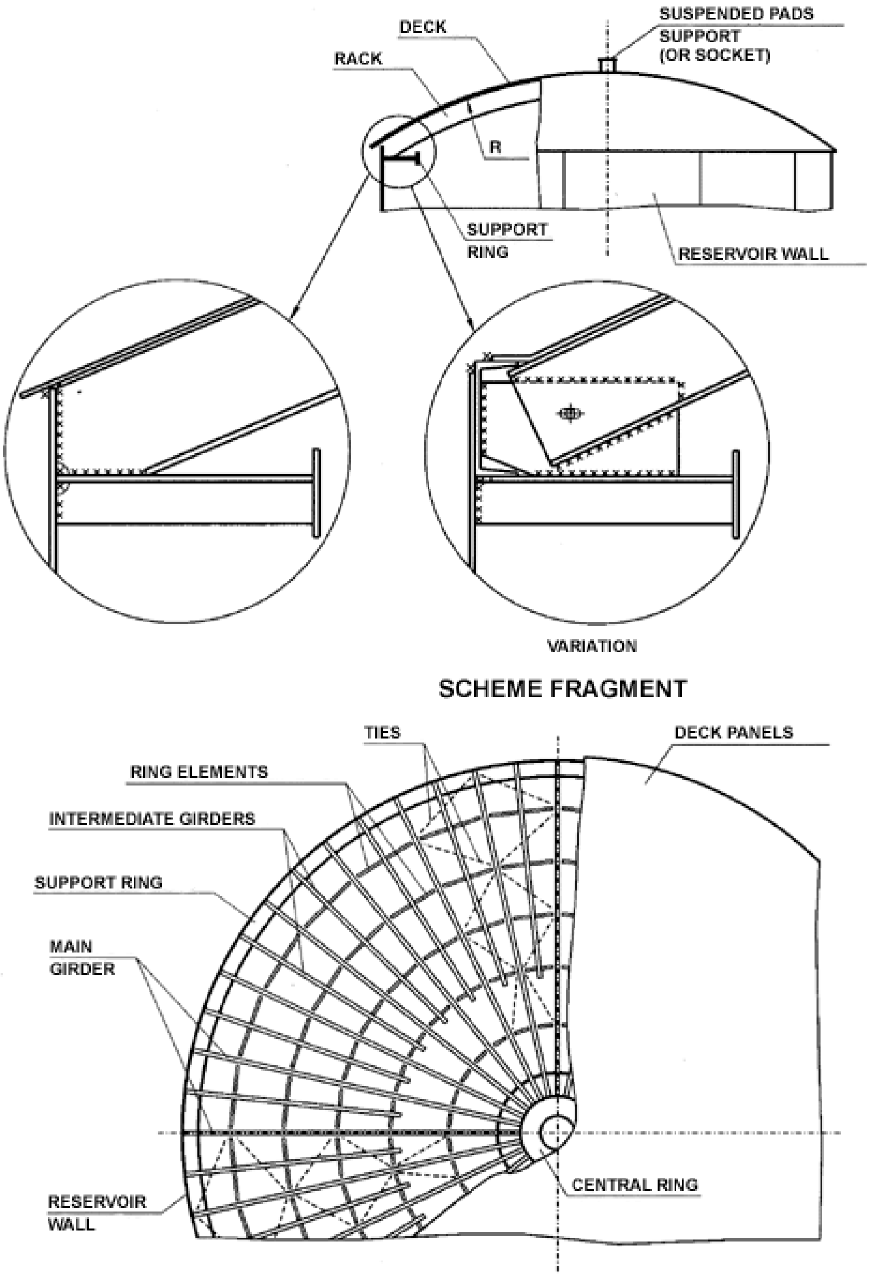


Fig. 6. Scheme fragment

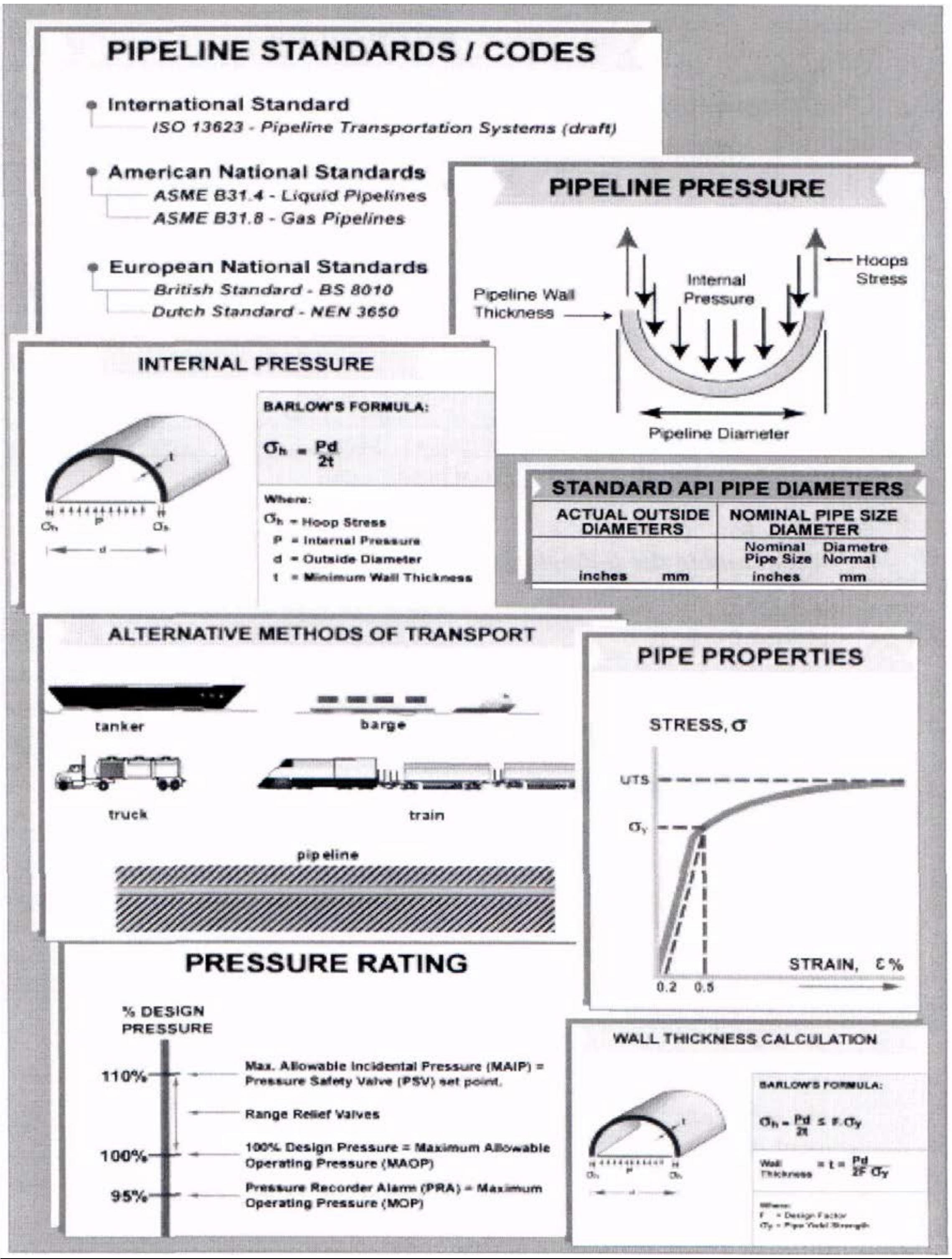
WORDLIST

ENGLISH	RUSSIAN
adequate	соответствующий
aid (in)	способствовать
anti-rotation cable	кабель против вращения
anti-rotation fitting	фитинг против вращения
anti-rotation lug, welded to floor	консоль против вращения
atmospheric-type storage	хранение при атмосферного давления
bolt	болт
bolted-steel tank	сборный резервуар
bottom	дно, днище резервуара
capacity	вместимость, пропускная способность
cell	камера
center plate	плита
channel	канал
cleanout	очистное отверстие
coating	покрытие / грунтовка
cone	воронка
connection	соединение
cover access hatch	покрышка люка резервуара
dead weight	собственный вес
deck	крыша резервуара
design pressure	расчетное давление
dismantle	разборка
dome	куполообразная крыша
drain (off)	спускать; выпускать; сливать
equivalent pressure	равнозначное давление
erected by hand	установить ручной
erector	монтажник
excess	превышающий норму
expected life	предполагаемый срок службы
fabrication (be fabricated)	изготовление
facility	оборудования
factory-baked	прокаливать
fixed roof	фиксированная крыша
floating roof	плавающая крыша (резервуара)
flush (out)	технологическая обработка
frangible	ломкий, хрупкий, слабый

furnished (with)	снабжать
galvanized	оцинковывать
gauge steel	толщина (калибр размер)
ground cable	кабель заземления
ground cable roof attachment	кабель заземления для закрепления крышки
hot-dip process	пропитка
impact wrench	гайковерт
installation	монтаж / установка
internal pressure	внутреннее давление
joint	шарнир
ladder	висячая лестница
leak	утечка
marketable oil	товарное
meet requirements	отвечать требования
nominal capacity	номинальная мощность
non-existent	несуществующий
oil storage	нефтехранилище
operating buoyancy	рабочая плавучесть
pontoon	понтон
prevalent (for)	преобладающий;
production	добыча
rafter	балка / стропила
replace	заменить
safety release	безопасность (выпуск)
seal	закупорка
seal	сальниковое уплотнение
segmental	сегментный
sheet	лист
shell	корпус
shell manway	лаз в крыше резервуар
shop-welded	заводской
stave	планка
storage tank	резервуар для хранения нефтепродуктов
tank support column	колонна; стойка (в резервуаре)
thickness	толщина стенки
treating system	технологическая обработка
up-ended	опрокидывать

vacuum breaker and actuator leg	выключатель / рычаг исполнительного механизма
vapour loss	потери от испарения (нефтепродуктов)
void	интервал
vortex breaker	вихревой выключатель
water-cut oil	обводнённая нефть
welded tank (field)	сварной резервуар

APPENDIX 1


PIPELINE STANDARDS / CODES
International Standard
ISO 13623 - Pipeline Transportation Systems (draft)
American National Standards
ASME B31.4 - Liquid Pipelines
ASME B31.8 - Gas Pipelines
European National Standards
British Standard - BS 8010
Dutch Standard - NEN 3650
PIPELINE PRESSURE
Hoops Stress
Internal Pressure
Pipeline Wall Thickness
Pipeline Diameter
INTERNAL PRESSURE
BARLOW'S FORMULA:
$\sigma_h = \frac{Pd}{2t}$
Where:
σ_h = Hoop Stress
P = Internal Pressure
d = Outside Diameter
t = Minimum Wall Thickness
STANDARD API PIPE DIAMETERS
ACTUAL OUTSIDE DIAMETERS
NOMINAL PIPE SIZE DIAMETER
Nominal Pipe Size
Diametre Normal
inches mm
inches mm
ALTERNATIVE METHODS OF TRANSPORT
tanker
barge
truck
train
pipeline
PIPE PROPERTIES
STRESS, σ
UTS
σ_y
STRAIN, ε %
0.2
0.5
PRESSURE RATING
% DESIGN PRESSURE
110%
100%
95%
Max. Allowable Incidental Pressure (MAIP) = Pressure Safety Valve (PSV) set point.
Range Relief Valves
100% Design Pressure = Maximum Allowable Operating Pressure (MAOP)
Pressure Recorder Alarm (PRA) = Maximum Operating Pressure (MOP)
WALL THICKNESS CALCULATION
BARLOW'S FORMULA:
$\sigma_h = \frac{Pd}{2t} \le F \cdot \sigma_y$
Wall Thickness $= t = \frac{Pd}{2F\sigma_y}$

APPENDIX 2
SELF-ASSIGNMENT TOPICS

1. Repair and Maintenance
2. Tank Repair
3. Welding
4. Pigging and pigs
5. Oil refinery
6. Environmental problems and their solutions
7. Sophisticated pipeline coatings
8. Underground tank storage
9. Corrosion cracking types
10. Pipeline construction in different environments (swamps, undersea, etc.)
11. Valves-construction, application and engineering design
12. Pipeline repair procedures (muffs, sleeves, etc.)
13. Underwater pipeline routing
14. On-line, non-intrusive diagnostic techniques for pipeline inspection and flow assurance
15. Stress conditions in oil tanks
16. Pipeline repair considerations
17. Flow regimes in pipelines
18. Gas and condensate transportation
19. Tank fire safety
20. Pipeline inspection gauges
21. Oil spills and their elimination methods
22. Oil spill formation
23. Restoration procedures
24. Construction standards of PVC underground burying
25. Technical conditions of construction and operation of pipelines on sea bottom

APPENDIX 3

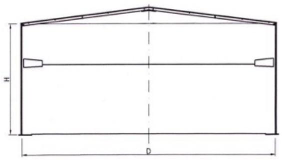
STEEL TANKS WITH FIXED ROOFS

Fixed roofs are used for tanks with low and middle storage volumes. The most of them are for tanks with diameter ***D*** from 6,0 to 60,0 m but there are not any obstacles to be used for bigger diameters.

Fixed roofs could be used in these cases:
a) of all kinds of products (crude oil, gasoline, benzene, fuel oil, water, beer, molasses, etc.);
b) when the temperatures are raised (asphalt, liquid silphur, etc.) by normal and lower temperatures (when liquefied gases are stored in the tank);
c) when there are serious loads from snow and ice there and when ambient conditions are very severe;
d) when requirements about internal hygiene in the tank are exacting. Then roof structure will be placed over the roof plates. Steel plates will be painted with special covers.

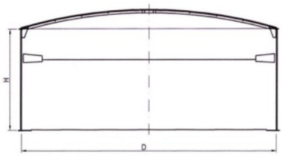
1. According to used materials fixed roofs are:
a) aluminum roofs - they begin to be more popular around the world. Their advantages are:
– decreased self weight. They are very light and beautiful structures;
– it is not necessary to be painted;
– aluminum roofs have better resistance to any products that are used in chemical industry;
– they could cover cylindrical tanks with diameter ***D*** up to 120,0 m.
b) steel roofs – the most predominate kind of roofs in the world and only one type in Bulgaria by the moment. Their advantages are:
– they have lower basic price;
– they are more convenient to prefabrication and mounting;
– the steel has bigger strength than aluminum and clear pronounced yield strength. When a element of structure is overloaded it receives large displacement and re-distribute loads to another members of steel roof structure.

2. According to type (shape) of fixed roof:
a) cone roof;
b) dome roof – it is necessary radial girders to be bended;
c) hanging roofs;
d) fixed roofs (dome or cone) with internal floating roof.



Cone roof with internal floating roof

The advantages of using of internal floating roofs are as follow:
– level of evaporation of storaged product is decreased;
– risk of fire is lower – there almost are not cases of fire in the world practice;
– internal floating roof could be aluminum. It has low height and storage capacity is increased;
– the internal floating roof is protected from ambient climatic conditions and they could be used in various earth regions;
– it is not necessary mounting of roof drain.



Dome roof with internal floating roof

Tanks with cone or dome roofs and internal floating roofs have reduction loss of evaporation of the product. When the internal pressure is increased the loss is less.
Internal floating roofs could be:
– made of steel – they are similar to external floating roof, but roof drain is not necessary;
– made of aluminum – they are the most popular in the world;
– synthetic – they could not be used when fire is extinguished under layer product.

STEEL TANKS WITH FLOATING ROOF

The tanks with floating roof are most widespread method for decrease the loss when volatile oil products are stored in them. They can be used when the tanks are open on top or they can be constructed inside in the tanks with fixed roofs. They can be used also when the tanks are closed and it is not admissible any product leak in the environment.

Floating roofs are strongly dependent on the good geometry of the shell, from vertical position of the anti-rotation device and the roof itself must not have a slope. The cases of discrepancy from the project condition of the tanks elements in the tanks lead to the key on the floating roof and to danger from fires. Big part from tanks with floating roofs that are in exploitation in Bulgaria are constructed in the end of 70 years and in the beginning of the 80 years. One of the most important problems is to find out whether these facilities are good for further use.

The main advantages of the tanks with floating roofs are as follow:

1. Minimizing of the loss of the stored product due to its evaporations. The factors influencing the product evaporation are:
a) temperature of the liquid;
b) the presence and the dimension of the vapor space above the liquid;
c) the possibility for ventilating of the vapor space;
d) the presence of the free surface of the product.
2. As a result of the decreased evaporating of the product the corrosion activity in the upper part shell courses is decreased too.
3. The safety from fire is increased which is a result of the decreased evaporation of the volatile stuff hence the lower risk from compound between the air and evaporating product which can be easily detonated.
4. Comparing with the tanks with fixed roofs there are smaller spaces inside the tanks with floating roofs which must be used for foam extinguish and it allows fitting fire extinguished installations with smaller power and their pipes to have smaller diameters.
5. The floating roof almost does not transmit the vertical longitudinal efforts to the shell. The risk from loss of stability is decreased.

The correct choice of the type of floating roof can decrease the risks during the exploitation. The factors which influence the tank construction and kind of the floating roof are as follow:
– characteristic of the stored product;
– climate conditions and conditions on the site;
– volume of the stored product;
– the requirements toward of the tank as a facility as a whole.

The floating roofs may be separated in the different groups depending on the different criteria. According to the presence of the fixed roof in the tank:

- **external floating roofs.**

The floating roofs projected and used for open on the top tanks.
They are made from steel and are welded. They must bear loadings from:
a) weather conditions (rain, snow, wind);
– 250 mm rain water for the period of 24 hours.
With tank owner agreement the real values for geographical area can be accepted for calculating the rain loading;
– the normal snow loading for Bulgaria is $\mathbf{s_t = 2{,}0\ kN/m^2}$. The coefficient for snow overloading is accepted to be equal to $\boldsymbol{\gamma_f = 1{,}4}$. In this case the snow loading may be valid condition depend on area where the tank is situated. Snow load can be irregularly distributed on the roof.
b) live loading on the roof;

– **2,2 kN** movable concentrated loading of two persons upon 0,1 m^2, who can stay on each one point on the roof, which is floating or is in the lower position upon its supports;

c) loading from rolling ladder and supporting truss;

d) loading from additional manholes, nozzles, roof drain, and seal;

e) loading of the product upon the roof;

f) single deck roof – membrane and two neighboring compartments are punctured.

double deck roof – two neighboring compartments are punctured. During this check, independently from the kind of the roof, there are not water and mobile load.

- **internal floating roofs.**

They appear because of the increased requirements of environment safety and to decrease the loss of oil product. These floating roofs are fit inside under the fixed roof itself. They can be fit even in the tanks with supported cone roof.

They can be made from steel, aluminum, or synthetic materials. They must bear the loading from:

a) **2,2 kN** live concentrated load from two persons upon the 0,1m^2, who can stay upon any point on the roof, when it is floating or is in its lower position supported by its supports;

b) if there are not other conditions, all project calculation must be done when the product density is 0,7t/m^3. According to the kind of the construction, the floating roofs must be separated into the following groups.

a) simplicity for execution, erecting and maintenance;

Disadvantages:

a) this kind of roof has not positive buoyancy and if its membrane be punctured it will sink;

b) the wind can push the accumulated water upon the roof toward one board and it will cause the bending and probably sinking.

Criteria for determining the type of the floating roof

The purpose of the tank, kind and the characteristics of the stored product, the conditions of the site must be taken into account when the type of floating roof is being chosen. The correct determination of its kind and the facilities connected with it can assures easer maintenance and quick return of the investments.

a) stability of the floating roof

It is one of the most important conditions for the correct work. Moving loads which are not balanced upon the roof can cause inclination of the roof and floating with slope. There is the higher risk for the roof to sink there. It is necessary to assure the work of the roof in the projected position by means of correct constructing.

b) product

– aggressiveness of the stored product. It is necessary to take care of chemical characteristic of the liquid and the possibility to damage the roof equipment which is not metal. Some chemical products can destroy the seals of the roof in several weeks of exploitation;

– density of the product. According to the API Std. 650 volume weight of the product which are used when the calculations for the buoyancy are made is ρ_f = 0,7 t/m^3. It is not likely to store product with smaller density but it is possible to happen. The information for the minimal values of the $\boldsymbol{\rho_f}$ allows the designer to determine the sinking of the roof;

– steam pressure of the product. It is one of the most important characteristic of the roof when the kind of the roof is being determined. According to the NFPA the use of the floating roofs in the tanks for storage of oil and oil products is recommended when the steam pressure of the liquid bigger or equal to 1,5 psia (78 mm Hg), but not bigger than 11,1 psia (570 mm Hg). If the steam pressure exceeds 11–12 psia the heating during the day will causes the considerable increase of the steams under the floating roof. The inflation of the central part as balloon is possible. The cooling of the product during the night will decrease the pressure and will allow to the roof to restore its previous form with slope toward the center. It is possible when there is the combination of the considerably inflated membrane by insider pressure, which slope is from the center toward the periphery and the water upon the roof, the correct drain of the water to be difficult.

When the steam pressure of the liquid is high, approaching 11,1 psia or higher then it is better to use double deck floating roof. Its rigid construction keeps it in the projected form, even when there are the steam under it and it assure uninterrupted drain. On the other side the double deck roofs protect the roof from excessive heating.

c) technological process
It is necessary to measure the speed of filling/emptying. When we do not consider this speed and it do not correspond to the erected technological facilities it is possible damage and even destroying of the roof.
In order to fix the floating roof according to its designed position (for avoiding its rotation), the antirotation devices must be put inside in the tank, parallel to the shell.
In the past the number of antirotation devices usually was two per tank. Now during the repairing works one of the antirotation devices can be removed and only one antirotation device can left. It must be done in order to neutralize of the inclinations of the autorotation devices from their designed position during the erections and during the exploitation. When the antirotation devices are not vertical it is possible to key of the floating roof with all consequences connected with it. It is necessary that the anti-rotation device supports all horizontal efforts which were supported before by two devices.
3. Constructive requirements
a) approximately 200 mm free space must have between external floating roofs and the shell, where the seal will be mounted. The modern seals assure good jam and normal work when the distance between shell and roof is from 100 to 300 mm;
b) minimal thickness of the steels in the pontoons in the membrane is 5mm ($t_r \geq 5$ mm);
c) the maximal distance between the roof supports of the floating roof must not be bigger than 1000 x t_r (thickness of the membrane);
d) distance from roof supports to welding joint in the membrane is not smaller than 300 mm;
e) when there are the girders stiffening the membrane, roof supports must be put in the area in this stiffening;
f) the length of the supports is deferent depending on its status:
– during the exploitation – minimal height must grant the tank filling without the liquid jet to touch the vertical board. It is unacceptable that the floating roof in its lowest position to lie upon the technological facilities;
– during the repairing works on the tank – the minimal distance depends on considerations for easy doing of the repairing works. It is assumed to be 1800 mm in the lowest point of the roof;
g) the floating roof , stepped through its supporting constructions on the bottom or when floats on the liquid must have the slope toward the roof drain not less than 1:100. For insider roofs this slope have not be considered;

h) upon the floating roofs must be constructed foam dam which height must not be less than 300 mm at 1 m from shell of the tank;
i) for fixing the roof according to the design conditions the antirotation devices must be considered. They do not allow the rotation of the roof. They must bear the horizontal forces, caused by the rolling ladder, by the uneven load from snow, by wind and by rotation of the stored product when it is mixed or the tank fills;
j) the drain pipe must have the diameter not smaller than **3”** for the tank which have the diameter $\boldsymbol{D \leq 36}$ **m**. The drain pipe must have the diameter not smaller than **4”** for the tanks which have the diameter $\boldsymbol{D > 36}$ **m**;
k) the pontoons situated on the periphery must be separated by waterproofed barriers and every pontoon must have manhole for inspection;
l) in the central part of the roof must have one manhole for inspection, through which people can go to the roof when the roof is in its lower position and the tank is empty.

METHODS OF ERECTION OF CYLINDRICAL STEEL TANKS

There are three general ways for erection of the Aboveground Steel Tanks (AST): by rolls; sheet by sheet and lifting method. These methods will be described briefly there.

a) rolls method – when the bottom and shell are made from rolled sheets, and roof (cone and spherical, self supported and supported) – made from shields. The advantages of this method are as follow:

– relatively quick method for erection, because the composite elements are biggest, made in special plants for metal constriction (i.e. ZMLK – “Septemvri”);

– input and output control of the production is easier and quicker, which make the terms shorter;

– increase the quality of the execution because bigger part of weld joints are made in a plant and welding of the elements is automated with special machines;

– the number of the workers needed for this operation is small.

A disadvantage of this method to some extent or limited appliance is that there is a maximum of the thickness of the sheets, which will be used for rolls making. Maximum thickness can not exceed 14 mm for ordinary low carbon steel (S235) and 18 mm for low stainless steel with increased strength. The theoretical grounding for limits is made by B.V. Popovskiy. Therefore the tanks which have volume up to $V_1 \leq 20000 m^3$ can be made using the rolls method. In addition, for bigger volumes the dimension ***D*** and ***H*** of the tank must be took into account, because the facility of the KZU in NHK – Bourgas for instance can produce roll with height $\boldsymbol{H} \leq 12{,}0$ m. Maximal height of the shell $\boldsymbol{H}$ made only by the rolls method can not exceed 18,0 m, which is due to the limit of the facility in ZMLK – "Septemvri".

Other important disadvantages of the classical rolls method are:

– line placed crossing welds of vertical joints of the shell;

– whole uninterrupted vertical joint, made on the site, where are – inside picking;

– the use of the heavy and expensive facilities during the erection work;

– when the tanks are made according to the rolls method it is very difficult to achieve as good geometrical form as when the tanks which are made by sheet by sheet method.

b) sheet by sheet (classical) method. The whole sheet construction and section for bottom, shell and roof are cut and bend preliminary after the precise dimensions.

Advantages of the sheet by sheet method are:

– the expensive and complicated facilities such as when the rolls need, are not necessary for the sheet by sheet method;

– the erection works need relatively not so heavy facility and the facility could be applied for all the volumes of the tanks and the site;

– all vertical joints have length equal to the one course. So the crossing welds have been avoided which made the tank secure for exploitation;

– the shell and bottom shape is closer to the designed one;

– the tanks with every volumes and height can be made using the sheet by sheet method.

Disadvantages of the sheet by sheet method:

– relatively longer term for erection is needed;

– the number of the weld joints and the necessary control on the site is increased;

– more qualified workers are needed for this operation.

c) lifting method – it is kind of the sheet by sheet erection method. First must be done erection and welding of the bottom and the first (lower) course. The shell must be collected course by course on the insider part of the first course and only the vertical weld joints between sheets must be made. After the welding of the last course, the roof must be mounted and welded to the last one. The access for coming in the tank must be assured through one or two part of the roof cover plates by means of use of erecting stairs inside and outside.

The lifting began from the last course together with the roof. The jacking system type "Laterna" (10–15 t) must be used or hydraulic jacking system evenly positioned on the perimeter of the shell. The insider course must be lift up to the level in which the horizontal lap joint between upper course and the next one to be 60 mm of the entire perimeter.

It is necessary to be made double lap joint with minimum 2 layers per weld. First lap weld must be made outside in bottom position and then inside in ceiling position. The whole shell of the tank is executed as consecutive lifting and welding of the erecting horizontal joints. The correct lifting of the course must be controlled (the different courses must have the same axis) and every bending of the shell as a whole must be avoided.

This type of lifting method, with lap welds on horizontal joints, is not in application now. According all standards around the world every one shell joint have to be made as but, with full penetration and fusion.

d) mixed method. This is a method which is combination from sheet by sheet method and the rolls method, where the bottom is made by rolled sheets, the 6shell is made by sheet by sheet method and the roof is made by shields. This method combines the advantages of the rolls, sheet by sheet methods. This technology allows the acceleration of the erection and the use of the relatively light mechanization.

APPENDIX 4

Reservoir Walls

Reservoir walls are manufactured via rolling or sheeted assembly. Sheeted assembly is usually applied in cases of reservoir's lower belt wall thickness over 18 mm, but upon the customer's request this method can be used to produce reservoir of any size. Basically, for sheeted assembly roll metal from 1.8 to 3 m thick and up to 12 m long is used. Sheet selvage refinement is committed mechanically, through milling or plasma cutting. Sheet rolling is done via three- and four-roll apparatus. It is recommended that reservoirs with lower belt wall thickness up to 18 mm should be manufactured via rolling method. Wall plates are rectangular in shape and have tolerance areas at factory seams along with rectilinear starting and terminal edges. Longitudinal seams in these edges have raw spaces ready for melding. The cogged assembly edge is created by cutting the technological tolerance area (usually 150 300 mm) of the plate lengthwise. To ensure quality roll forming of reservoirs with volume over 5 000 m^3, triangular technological insets are applied at starting and terminal edges.

Reservoir Bottoms

Flat bottoms (for reservoirs with volume up to 1 000 m^3) consist of sheets of the same thickness. Conical bottoms (for reservoirs with volume over 1000 m^3) have a central part and thickened ring selvages. It is recommended to take bottom inclination off centre, thus affording to compensate the possible unevenness of base immersions. When manufacturing flat bottoms and central parts of conical bottoms with metal thickness up to 7 mm the rolling method is applied, while for metal thickness 8 mm and over – sheeted technology is used. For geometrical shape improvement of bottoms (reduction of “poppers” which can appear in the process of sheet rolling and can increase due to melding deformation) a minimum bottom thickness of at least 5 mm is recommended, including 1 mm allowance for corrosion.

Roofs

Spherical racked roofs are used at reservoirs with volume over 5000 m^3. The roofs consist of rolled radial girders, main and intermediate, rack ring elements, central and deck plates, based on rack elements. Along the wall perimeter there's a support ring, receiving thrust pressure of the sphere and ensuring fixation and stability of the geometrical shape of the walls during the assembly. Implosion protection measures are identical to those for the conical racked roofs.

APPENDIX 5

Dictionary of Pipeliner's Terms (SLANGS)

Back End
Those crews behind the welding crew
Backfill
The dirt / sand material used to cover the pipe in the ditch
Bead
The root pass of the weld
Beaver tail
The extreme rear sloped, fabricated steel portion of a lowbed trailer used to facilitate a tractor mounting the trailer from the rear
Bell hole
A widened and sloped section of the ditch where welders will work when doing a tie in
Bender
Machine for bending pipe
Berm
A dyke of earth material formed to contain fluid, such as fuel, in case of a spill or leak, or to diver water on a slope in the prevention of erosion.
Blacktop
Tar sealed road
Bladder
Sack like container for storing water, diesel or other liquids
Blasting mats
Large mats fabricated of tires secured tightly together with bolts and chains. Used to prevent projectiles of rock (fly-rock) from becoming airborne out of the blasting site.
Bone Yard
Lay down area for equipment adjacent to the pipeline area, usually either at kick Off or the end of the line.
Boxing a sag
Squaring off the R.O.W. at a creek / river crossing
Breakers
On hillsides and inclined slopes, the placement of sand bags or spraying of foam to surround the pipe, as a dam, to the top of the ditch, to prevent water flow and subsequent erosion around the pipe. Water breakers are berms built at an angle across the ROW to divert ground water and prevent ROW erosion.
Buckles

A deformity in the pipe resulting in an inward protruding bend, often caused by ditch rock, bending mistakes
Buddy system
An arrangement by which two workers work together to ensure the health and safety of each other.
Buffing
Grinding the pipe with a wire brush
Bug
The automatic welding machine that welds inside or outside the pipe on a track
Cap
The top pass of the weld
Carry back
On setup and pipe gang, the distance the pipe section is brought back to a "start stake" to ensure that after the pipe section is lowered in, it will overlap the following section, necessitating the removal of a "pup". The start stake is placed by the engineering crew to ensure a sufficient overlap.
Chainage
The accumulated length of the pipeline from Kickoff marked in kilometers and meters
Cheater
A length of pipe used to lengthen the handle of another tool for the purpose of increasing leverage and power
Cherry Picker
Truck mounted crane
Choker
A wire rope or synthetic sling used to encircle the pipe by passing one end through a loop in the other end thereby providing an attachment which can pull laterally as well as vertically
Choking pipe
Wood skids, wedges or rock material used to stop pipe from rolling on a flat surface
Clam
Excavating equipment
Cold-wrapping
Applying tape type coatings that do not require the application of heat
Combination
A bend incorporating a sidebend and a sag or overbend
Coming-in-side
The upstream side of a section or tie in.
Coupons

Sections of cut pipe, used for practicing welding
Crumbing the ditch
Ahead of Lower-in removing material from the ditch that might damage the coating or cause a buckle in the pipe.
Danger Zone
A location within 6 meters of a piece of heavy equipment
Daylighting
Exposing a utility that was previously buried
Deadman tractor
A tractor used as an anchor for a pipe section (such as on lowering-in) or when winching equipment on steep slopes
Ditch line
Centerline of ditch, marked by red stakes, stones or markers along the right of way
Ditch side
The side of the right of way on the opposite side of the ditch line from the work side, where the spoil pile is placed
Dog it
Stop heavy equipment operation
Dogleg
An irregularity in a straight line – in a pipe section, lay of the right of way, etc.
Dolly
A trailer converter dolly that is towed from a single hitch located on the centerline of the towing unit.
Donut
Internal brace used in bending operation when end of pipe is near the die.Used to prevent egging of pipe
Downstream
The direction the product will flow when in the pipeline is in service
Drag up
To quit or resign
Dragup Tank
A large tank built into the deck of a welders rig
Drawbar
Structural member of a sled, full trailer, pony trailer or trailer converter dolly that includes a device for the purpose of coupling with a trailer hitch, fifth wheel or hook on a sling
Egging
Pipe becoming out of round, during bending process
Eye balling

Judging by sight rather than using an instrument
Fill line
Small inch light wall pipe 6–10 inches diameter used to carry water from a water source to a fill point, during testing operations
Fill point
A test point used to fill a pipe section with water for testing
Fly-rock
Rock projectiles ejected skyward from a blasting zone
Foreign line
A pipeline that crosses the centerline of the new pipeline under construction
Front End
Those crews ahead of and including the welding crew
Going-out-side
The downstream side of a section or tie in
Goose
Internal hydraulically operated internal clamp used by pipe gang welding crew
Goose
Internal clamp on front end welding crew
Grousers
Horizontal lugs on tracks of tracked equipment
Hand
Pipeline worker
Headache Rack
Strong (reinforced steel) barrier mounted on the back of the cab of a truck to prevent the load sliding forward and breaching the rear cabin wall injuring the driver
High boy
A conventional truck trailer with deck approximately 5 foot off the ground
Hoarding
Plastic over a wood frame used at a test point to maintain temperature of exposed test section
Holiday
Hole or gap in pipeline coating
Hot Dope
Old method of coating pipe with hot melted tar like substance
Hot-wrapping
Applying tape type coatings that require the application of heat
Hot pass
The filler pass of the weld
Hustle skids

The work involved in the loading / unloading of skids, building cradles to support the pipe etc.
Jeep (Holiday detector)
Electrical device used to detect abnormalities / holidays in pipeline coating
Kick Off
Where the work starts on a pipeline project. The work site at the very beginning of a pipeline mainline or looping project.
Lathe
A stake, sharpened on one end, driven into the ground and used to mark centerline of ditch, chainage, or other purpose
Line pipe
The mainline pipeline pipe
Load line hook
The hook that supports the weight
Loop
A parallel section of pipeline
Looping
Work on a section of pipeline that parallels an existing pipeline system.
Loose end
The free, open end of a longer section of pipe
Low Boy / Low Bed
A low slung trailer used to haul heavy equipment
Mormon Board
Backfilling implement
MSDS Sheets
Material Safety Data Sheets - Sheets providing the worker with information of hazardous products so he may protect himself
Mud board
A wooden elevated (4–5 inches) platform for welders to lie on when welding under the pipe
Nightcap
Caps made out of material, plastic, wood etc to fit over and close off the end of the pipe to prevent entry of foreign material
P.I.
Change in the direction of the right of way centerline, usually identified by a stake / lathe with the chainage written on it
Pig
Internal pipeline cleaning or inspection device
Pig Catcher
A device for receiving a pig
Powder man

The worker on a blasting crew whose job is to load explosives in the bore holes
Pulling head
A heavy reinforced end cap for a pipe section with a towing eye, for sustained lateral pulling of that section, used on road bores and river / creek sections
Pup
Short length of pipe
Quad
Welding machines mounted on a tractor
Reach Rod
Long rod with wheel on end which is used to control the mandrel inside the pipe when bending pipe
Reamer
A cutting head that increases the bore hole size
Ripper
A vertical earth / rock cutting blade mounted on the back of a dozer
Roach
A berm (mound of earth) over the pipeline
ROW
Pipeline night-of-way
Rubber boot seal
The seal between the casing and pipe on either ends of a road / river bore
Sag
A bend in the pipe that is concave - high on the ends and low in the middle
Setup
The phase of pipe handling which immediately follows bending. This crew positions the pipe advantageously for the welding crew to ensure minimum required handling by the front-end pipegang crew. It is also laid out as per carry back and other stakes left by the engineering crew
Sho-Fly
Access road to pipeline construction ROW
Shoot a bend
To calculate the degrees of a bend with a transit
Shotrock
Blasted shards of rock
Silk screen
Fine mesh plastic screening used to filter sediment out of flowing water for environmental purposes
Slider
A simple type of skid support for pipe joints/sections

Sneaky
A manned internal pipe repair vehicle A pipeline construction project
Sourman
Equipment used to yoyo a drag bucket at a river crossing
Splitter
A length of safety fuse which notches at 50 millimeter (two inch) intervals and is used to ignite safety fuses
Spoil pile
The excavated ditch material
Spoons
Long handled (12–15 foot) shovels used ahead of lower-in cradles to remove rock from the centerline of the ditch, under the pipe, which could cause buckles, when regulations prohibit workers entering unsafe ditch.
Spotter
A worker designated to identify the appropriate location on the right of way to drop a load, park a vehicle etc. to a driver or operator
Spread
A pipeline construction project
Spread Man
Construction Superintendent
Squeeze iron
Iron from squeeze pump to test head
Stabber
Employee who helps line-up pipe for welding
Stinger
Welding rod and holder
Straw Boss
Crew foreman's lead worker
Swabbing
Using a ring of pipe cut to a slightly smaller diameter than the line pipe with an outer layer of soft rubber which is pulled through a joint of pipe to clean out the inside of the pipe
Tack Rig
Welding tractor
Test head
A short section of pipe with a convex end cap and valves, welded to the end of a section. Used in the filling of pipe and controlling pressure during testing operations.
Test point
A location in a pipe section chosen to be used as a work site for testing operations, where the welders have left two loose ends.

To the house
Going home after shift
Tow cat
Tractor used to pull any equipment or vehicles stuck on the right of way.
Train
A combination of vehicles composed of a tractor, a semitrailer and either an A Dolly and a semitrailer or a full trailer attached to the lead semitrailer in a like manner as if an A Dolly were used.
Upstream
The direction from which the product will come from when in service
Utility
Any pipeline, buried or overhead powerline, fiber optic cable, sewer, etc.
Wobble
A strike. Workers collectively refuse to go to work in support of some demand
Work side
The side of the right of way on which the equipment and vehicular traffic move
Yoyo
Using bucket on a drag line to get ditch depth at a river crossing

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Chapter 5

ECONOMICS AND MANAGEMENT IN PETROLEUM ENGINEERING

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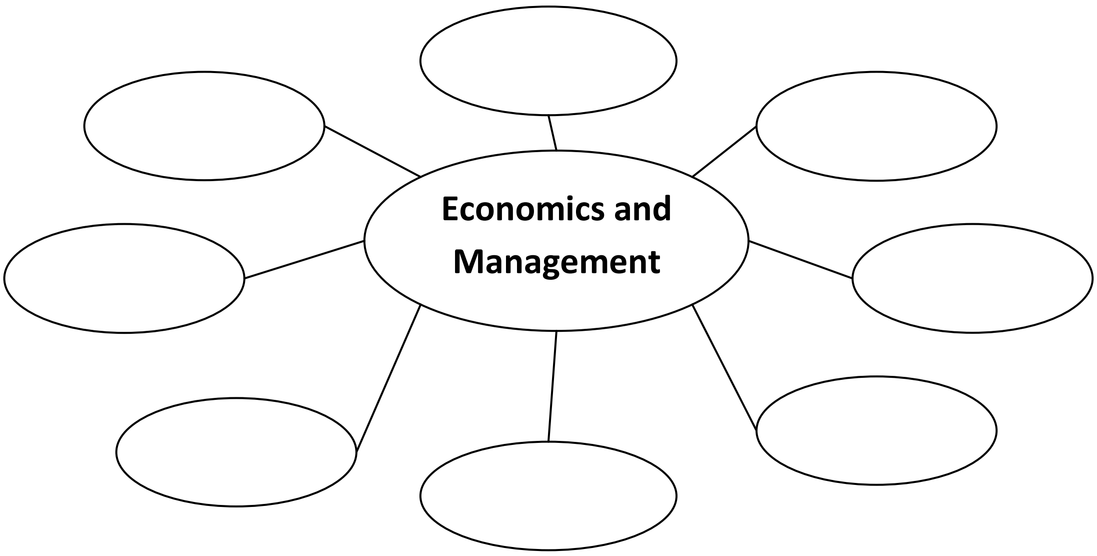
UNIT 1

INTRODUCTION TO ECONOMICS AND MANAGEMENT

Lead-in

Fill in the spidergram with the words associated with Economics and Management.



***Explain your associations*.**

Discuss the following questions.

1. Why did you decide to be an economist?
2. In your opinion, what does an economist do?
3. Do you know any world famous economists?
4. Do you agree that all human activity is connected with economy?

Terms and Vocabulary

social science	социальная наука
to attempt	стремиться, прилагать усилия
law	закон, правило
principle	принцип
range	круг, перечень
to deal exclusively with	иметь дело исключительно с
inflation	инфляция
roots	корни, источники
tie to	связь с
distributional justice	справедливость распределения
fair	справедливый
speculation	спекуляция
separate discipline	отдельные дисциплины
namely	а именно, то есть
to explore briefly	исследовать кратко
major division	основное деление
microeconomics	микроэкономика
macroeconomics	макроэкономика
functioning	функционирование
behaviour	поведение
decision making unit	отдел, принимающий решение
household	хозяйство, ферма
individual business	частнный предприниматель
consumer	потребитель
to charge	назначать цену
to address	обращать внимание
wealthy	состоятельный
to determine	определять
output	выпуск, объем производства
outside the scope	за пределами чего-либо
to pay	платить
poverty	бедность
to get paid for	получать плату
to consume	потреблять
scale	масштаб
in its turn	в свою очередь

Exercise 1. Read and learn the pronunciation.

[i:] discipline, principles, briefly, division, decision, deal
[a:] charge, market
[o:] explore
[ou] scope
[ə:] determine, turn, pursue
[ju:] consumer, produce
[ai] decide, micro-, divide
[æ] macro-
[aiə] tie
[k] knit, mechanism

Exercise 2. Pay attention to the stress in the following words.

′separate	′microecon′omics
exc′lusively	′macroecon′omics
′discipline	indiv′idual
distrib′utional	con′sumer

Exercise 3. Before reading the text tick what statement do you think is true.

1. Economics is only the study of money ☐
2. Economics is something government takes care of ☐
3. An economist basically decides how money is spent ☐

Exercise 4. Read the text, do the exercises.

WHAT DOES ECONOMICS STUDY?

Economics is a **social science** studying economy. Like the natural sciences and other social sciences, economics **attempts** to find **laws** and **principles** of economic functioning of society. Most students who take economics for the first time hardly can imagine the **range** of questions which this science studies. Some think that economics will teach them about the **stock market**, or what to do with their money. Others think that economics **deals exclusively with** problems like **inflation** and unemployment. In fact, it deals with all these subjects but they are parts of a much larger system.

Economics has deep **roots** in and close **ties to**, social philosophy. An **issue** of great importance to philosophers, for example, is **distributional justice**. Why are some people rich and others poor, and whatever the answer, is this **fair**? A number of nineteenth century social philosophers were trying to solve these questions and out of their **speculations** a **separate discipline** was born, **namely** economics. If you want to get quick idea of what economics studies, you should **explore briefly** the way economics is organized.

First of all, there are two **major divisions** of economics: **microeconomics** and **macroeconomics**. **Microeconomics** deals with the **functioning** of **individual industries** and the **behaviour** of **individual economic decision making units**: single business firms and **households**. **Macroeconomics** explores the decisions that individual businesses and **consumers** make. The choices of firms about what to produce and how much to **charge** and the choices of households about what to buy and how much of it to buy help to explain why the economy produces the things it does.

Another big question that microeconomics **addresses** is who gets the things that are produced. **Wealthy** households get more **output** then do poor households, and the forces that **determine** this distribution of output are **outside the scope** of microeconomics. Why do we have **poverty**? Who is poor? Why do some jobs **pay** more than others? Why do teachers or plumbers **get paid** for what they do? Think about all the things we **consume** in a day on the **scale** of a town, a whole country. Somebody decided to build the factories. Somebody decided to construct roads, build the housing, produce the cars, knit the shirts, and smoke the bacon. Why? What is going on in all those buildings? It is easy to see that understanding individual micro decisions is very important to any understanding of your society. Macroeconomics, **in its turn**, deals with the functioning of national economic complex and the behaviour of the main classes and social groups.

(McConnell C.R., Brae S.L. Economics)

Exercise 5. Answer the following questions.

1. To what branch of science does economics belong to?
2. Does economics have deep roots in social philosophy?
3. What problems does economics deal with?
4. Why, do you think, some people are poor and others are rich?
5. Which two main divisions of economics do you know?
6. What do micro- and macroeconomics deal with?

7. Which issue of economics is of great importance to philosophers and why?
8. What would you do to cope with inequality?

Exercise 6. Complete the sentences.

1. Economics studies a wide _________ questions.
2. Economics is closely tied with ________.
3. Many social philosophers were trying to solve a questions of _______.
4. Economics is subdivided into ________.
5. Microeconomics deals with ________ industries.
6. A household can be considered as an _______.
7. The firm must make a ________ what to produce.
8. Microeconomics doesn't ______ with the questions of output distribution.
9. The functioning of national economic complex is the sphere of ________.

Exercise 7. Give English equivalents to the following words and phrases from the text.

Изучать экономику, иметь глубокие корни в, национальная экономика, отдельная самостоятельная экономическая единица, изучать проблему, домашнее хозяйство, отдельная предпринимательская фирма, получить представление, функционирование отдельных отраслей промышленности, социальная философия.

Exercise 8. Match synonyms in columns A and B.

A.	B.
range	question
part	piece
to produce	several
to deal with	to consider
to explore	comprehension
unemployment	outside the sphere
discipline	scope
firm	well – to do
wealthy	connection
province	subject

understanding	to manufacture
a number	company
tie	lack of jobs
issue	to examine

Exercise 9. Translate the following chains of words. Determine the part of speech and the way of word – building.

economy – economics – economist
economic – economical – economically
economize – economizer
science – scientist – scientific
employ – employment – unemployment – employer – employee
organize – organizer – organization – organizational
produce – producer – production – productive – productivity

Exercise 10. Translate the following sentences into Russian using the dictionary.

1. Russia tries to base its relations with other countries on the peaceful principles.
2. There is an objective need for all states of the world to live in peace with each other and to cooperate on a basis of equality and mutual benefit.
3. An efficient economy is one that produces what people want and does so at the least possible cost.
4. Britain needs raw materials for its industries.
5. The country depends on foreign trade to supply raw materials for factories.
6. Imports exceed exports in many developing countries.
7. Invisible trade compensates the unfavorable balance of trade.

Exercise 11. Translate the following definitions into English.

Экономика – это наука, включающая две дисциплины: микроэкономику и макроэкономику.
Микроэкономика – это отрасль, которая изучает индивидуальных производителей, потребителей или рынки. Она также изучает, как деятельность правительства (регулирование и налоги) влияет на отдельные рынки. Микроэкономика пытается понять, какие факторы воздействуют на цены, заработную плату и прибыль.

Макроэкономика – это отрасль, которая изучает экономику в целом. В частности, она занимается общими цифрами производительности, безработицы и инфляции.

Exercise 12. Before you listen discuss the following questions with your partner.

- If you live in a modern economy, life is quite easy.
- Before the industrial revolution life was much harder.
- In what ways was life more difficult?

Listen to someone talking about industrial revolution and do the tasks.

– Which of these things are mentioned?

1. length of live
2. housing
3. illnesses
4. work
5. food
6. having children

– Match the description with the numbers.

1. life expectancy	A. about 250
2. number of children who died before they reached five years old	B. 1 in 10
3. number of women who died when they were giving birth	C. 25
4. years since the industrial revolution	D. 1 in 3

Exercise 13. Discuss the following points.

1. Do you sometimes listen to the economy news on TV or on the radio?
2. What do you think of the state of economy in Russia?
3. What do your parents (grandparents) think of economic reforms in Russia? Did they live better or worse before?
4. What type of economy does Russia build?
5. Do you think you have more opportunities to be well off than your grandparents?

Exercise 14. Read the text, do the exercises.

THE ECONOMY AND ECONOMIC SYSTEMS

The word “economy” is a word we hear or read almost every day. For example, we may be told that “the world economy is in the **doldrums**”, or “the European economy is making little progress”, or “the Russian economy is beginning to **recover**”. But what is meant by the economy? What is an economy? How does an economy work? The economy is a social mechanism which answers these three questions.

The economy **means** a system for the management, use and control of the money, **goods** and other **resources** of a country, **community** or household. In other words an economic system is the method society uses to **allocate** its resources (land, labour, capital and **entrepreneurship**) to satisfy its needs. The degree of economic development of the country is determined by the level and character of production forces and production relations. Due to public labour division the economy of a society is subdivided into separate **branches**, industrial complexes, economic regions and production infrastructure. What **distinguishes** one economic system from another is the control of the factor of production and the **interaction** of business, government and consumers.

In the modern world there are three main types of economic system: capitalism (or pure capitalism), mixed capitalism and communism (socialism). Capitalism (of pure capitalism, or a market economy), as it was originally described by Adam Smith in his eighteenth century book “Wealth of Nations“, is an economic system where the factors of production are in **private hands** and economic decision are made freely **according to** the market forces of **supply** and **demand**. In this system the economic questions of

– **What is to be produced?**

– **How much will be produced? Who will produce it?**

– **How much will it cost? Who will get it?**

are determined by the consumers in the **marketplace**. In pure capitalism industry and individuals use resources as they choose. The government takes a **hands-off approach** and does not **interfere** in the economic system.

Producers and consumers **pursue** their own self-interests. Producers make as much as they can sell and consumers buy as much as they can **afford**.

In this system each person behaves in the best interests of society, as if **guided by** an invisible hand. The marketplace is regulated by the interaction of the buyers and producers. If a company produces a defective product or **charges** too much for the product it is **rejected** by consumers. As a result, the producer has to improve the quality of the product or **reduce** the price to make any sales. The market place, **in essence** the invisible hand, regulates economic conduct. Government does not have to do any regulating.

(McConnell C.R., Brae S.L. Economics)

Wordlist

doldrums	спад в экономике
to recover	восстанавливаться
means	средства
goods	товары
resource	ресурс
community	общество
to allocate	распределять
entrepreneurship	предпринимательство
branch	отрасль, отделение
to distinguish	различать
interaction	взаимодействие
private hands	в частной собственности
according to	в соответствии с, согласно
supply	предложение
demand	спрос
marketplace	рынок
hands-off approach	пассивный подход, невмешательство
to interfere	вмешиваться
to pursue	преследовать
to afford	быть в состоянии, позволить себе
to be guided by	быть управляемым кем-либо
to reject	отклонять, отказываться
to reduce	сокращать, снижать
in essence	по существу

Exercise 15. Answer the following questions.

1. What is an economic system?
2. What distinguishes an economic system from another one?
3. What types of economic system do you know?
4. In whose hands are the factors of production in capitalism?
5. Who makes economic decisions under capitalism? Does the marketplace have influence on them?
6. Whose interests do producers and consumers pursue in the market?
7. If a company produces a defective product, will it be sold or rejected by consumers? What do you think of it?
8. Are you for or against the government's regulation of economic conduct in Russia?

Exercise 16. Give English equivalents to the following words and phrases from the text.

Экономическая система, труд, преследовать собственные интересы, снижать цены, распределять ресурсы, удовлетворять общественные потребности, чистый капитализм, факторы производства, взаимодействие производителей и покупателей, отвергнуть товар, регулировать предпринимательство.

Exercise 17. Translate into English.

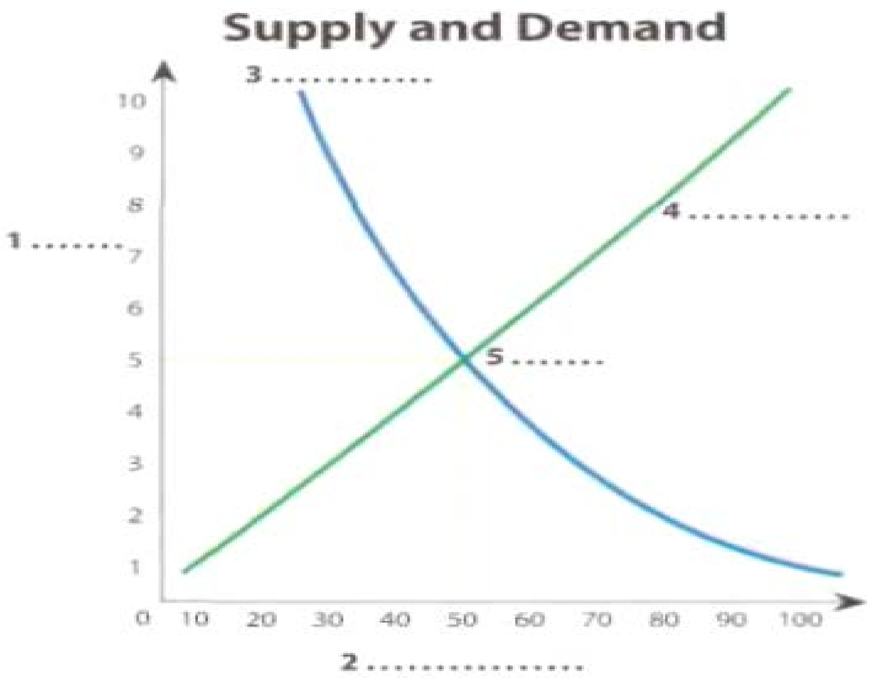
1. Рынок регулируется взаимодействием покупателей и производителей.
2. Экономическая система – метод, который используется обществом для распределения своих ресурсов.
3. Нам говорят каждый день, что экономика России выздоравливает.
4. Степень экономического развития страны определяется уровнем и характером производительных сил и производственных отношений.
5. При капитализме экономические решения принимаются в соответствии с рыночными законами спроса и предложения.
6. Экономическая обстановка регулируется рынком.
7. Товар отвергается покупателями, если он бракованный или стоит слишком дорого.
8. Ежегодно промышленными предприятиями производится большое количество новых товаров.

Exercise 18. Match synonyms in columns A and B.

A	B
doldrums	to get better
progress	to distribute
country	to require
to distinguish	advance
to allocate	to define
to demand	State
to recover	depression
to produce	to purchase
to buy	to manufacture
defective	to lower
to reduce	conduct
behaviour	faulty

Exercise 19.* 🖭 *Before listening, look at the chart of Supply and Demand and fill in the blank spaces with the words from the table. Then listen and check if you were right.

- Amount bought and sold
- Demand curve
- Equilibrium point



Exercise 20. Match the terms with the definitions.

Capitalism	deals with the functioning of individual industries and the behaviour of individual economic decision making units: single business firms and households.
Economy	explores the decisions that individual businesses and consumers make.
Microeconomics	is an economic system where the factors of production are in private hands and economic decision are made freely according to the market forces of supply and demand.
Macroeconomics	is a system for the management, use and control of the money, goods and other resources of a country, community or household.

Exercise 21. Translate the words in brackets into English.

1. The most important economic questions (*затронуты*) in the Financial Times and the Economist.
2. Adam Smith (*по праву считается*) the founder of political economics.
3. A lot of questions (*задают и отвечают*) at the lectures on economics.
4. The United Kingdom is considered one of the world's (*мировой лидер производства товаров*).
5. About two per cent of the population of the UK (*вовлечены/заняты*) in agriculture.
6. Today gold is mostly (*добывается*) by mining.
7. Every country is interested in (*экспорте*) its manufactured goods.
8. What questions (*обсуждаются*) during business talks?
9. The Leipzig Fair, which is (*проводится*) twice a year, is very popular with businessmen of different countries.
10. Foreign firms are interested in (*внедрение*) their goods to new markets.

Exercise 22. Discuss the following points.

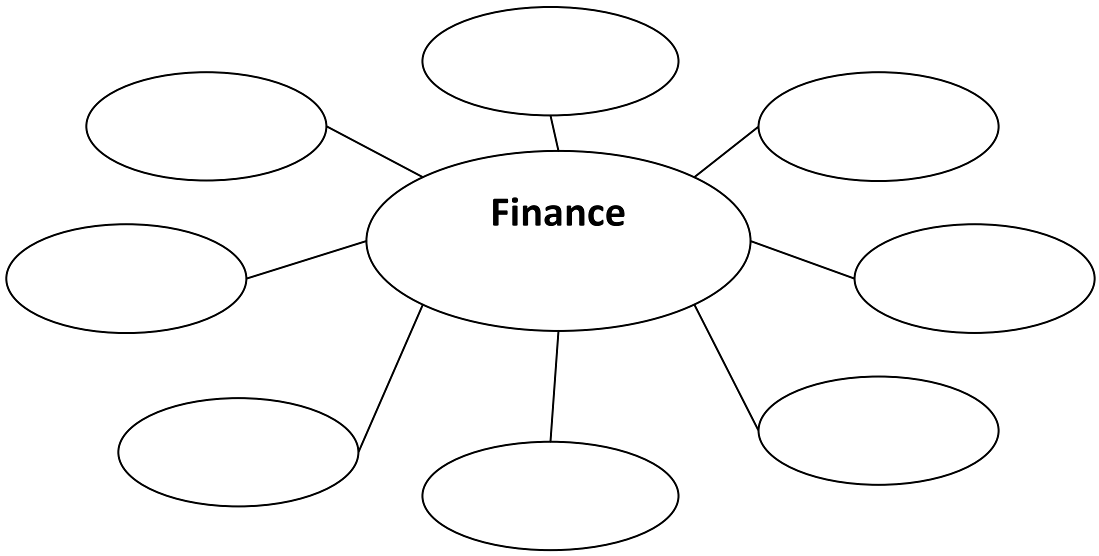
1. The significance of economics nowadays.
2. The reasons why some people are rich while some are poor.
3. The main types of economic systems.
4. Future of Russian economics.

UNIT 2

FINANCE

Lead-in

Fill in the spidergram with the words associated with Financing and Banking.



Discuss the following questions.

1. What do you know about banks?
2. What kinds do banks do you know?
3. Have you ever been a bank customer?
4. Do you agree that banks play a very important role nowadays? Why?

Terms and Vocabulary

a deal	дело, сделка, соглашение
to do a deal with	заключать сделку с
a dealer	дилер, агент
financial institutions	финансовые организации
to meet	встречать, встречаться; удовлетворять потребности
to save	спасать, сберегать
savings	сберегательный; сбережения

to loan	ссужать, давать взаймы
a loan	ссуда
mutual	совместный, общий
to invest	вкладывать деньги, капитал
investor	вкладчик
investment	вклад, капиталовложение
private	частный
profit	прибыль
to profit (by)	получать прибыль (с чего-либо)
to serve	служить
service	услуга
to offer	предлагать
to check	проверять
checking account	расчетный счет
broker	брокер
innovation	нововведение
to compete	состязаться, соревноваться
competition	состязание: конкуренция
in the face	перед лицом
deregulation	ослабление ограничений, дерегуляция
to install	устанавливать (техническое устройство)
teller	кассир
key	ключ
debit	дебет
retailer	розничный торговец
point	точка
to allow	позволять
merchant	купец, продавец
to accept	принимать, привлекать
network	сеть
to stimulate	стимулировать
to diversify	здесь: разнообразить услуги
diversification	здесь: разнообразие услуг
all over	по всей (территории)
to handle	проводить, вести, иметь дело (с)
transaction	дело, сделка

to result from	проистекать, происходить (из)
to urge	вынуждать, поощрять (к действию)
to assign	назначать, определять, ассигновать

Exercise 1. Read and learn the pronunciation.

[i:]	deal
[ə o:]	loan
[ə u]	innovation
[ə:]	service, merchant, urge
[ju:]	institutions, mutual
[ai]	financial, private, diversify
[æ]	handle
[au]	allow

Exercise 2. Pay attention to the stress in the following words.

fiʹnancial	ʹdebit
ʹmerchant	diversifiʹcation
acʹcept	ʹ mutual
comʹpete	tranʹsaction
dereguʹlation	aʹssign
stimuʹlate	ʹsavings

Exercise 3. Read the text, do the exercises.

FINANCIAL INSTITUTIONS

Businesses that distribute or deal in money are called **financial institutions.** New institutions that meet new **financial needs** are appearing almost every day. The most familiar institutions are **commercial banks, savings banks, savings and loan associations, mutual savings banks, credit unions, investment banks** and so on.

A commercial bank is a **privately owned profit-making** corporation. It serves both individuals and businesses by offering **checking and savings accounts, loans,** and **credit cards.** It also deals in some **brokerage, insurance,** and **financial advice.**

The commercial bank is the most important source of **short term** loans for businesses. Sometimes the borrowers **pledge collateral** to back up the loan. Such loan is a **secured loan.** Companies with a good **financial position** are given **the prime rate** of interest which is the lowest **commercial** interest rate.

The commercial bank offers its customers **accounts** of two types: **demand deposits** and **time deposits.** A demand deposit makes the money in it **available** to depositors immediately, while a time deposit **requires** depositors to leave their money with the bank for a **stated period** of time.

Most banks offer their **customers** various **savings certificates,** called certificates of **deposit.** Savers may put their money into thirty day, six month, or two and a half year certificates. The highest interest is paid to the customers who deposit their money for a longer period.

Banking services are **not free** and banks **charge fees** for them. Many banks **assess a service fee** if an **account balance** falls beneath a **particular minimum,** such as $200.

Technological **innovations** and increased **competition in the face** of **deregulation** are changing the face of banking nowadays. Banks and other financial institutions are using computer technology now. One of the innovations is the electronic funds transfer which transfers money from individuals to the bank, from bank to bank, and from city to city through an electronic system.

Large banks are installing automatic **teller** machines **outside** their buildings. A customer can get cash, make loan payments, or transfer money from one account to another at any time of the day or night. The **key** to the automatic teller machine is a **debit** card which helps to make transfers directly to and from a customer's checking account.

Some large **retailers** are installing **point-of-sale** terminals which **allow** a retail customer to transfer funds from his bank account to the **merchant's** account.
Electronic funds transfer is making it **easy** for commercial banks to **accept** deposits outside their home states. Groups of banks are setting up automatic teller machine **networks** for the customers to use their debit cards to withdraw cash, transfer funds and check balances in other states.

Nowadays the banking industry is becoming less regulated. This process is **stimulating** the **diversification** of banks, and service and **price** competition. Financial supermarkets are appearing **all over** the United States. These new financial institutions are handling all types of financial **transactions.** They are selling life insurance to their customers, buying and selling their homes and are lending them money in addition to the traditional services of stock and bond transactions.

The competition that **results** from deregulation is **urging** the banks to offer more and better services to their customers.

(V. Milovidov «English for Financial Management Experts»)

Exercise 4. Answer the following questions.

1. What are the businesses called that distribute or deal in money?
2. What are the most familiar financial institutions?
3. What services does a commercial bank offer to its customers?
4. What do the borrowers do sometimes to back up the loan?
5. What types of accounts do commercial banks offer to their customers?
6. What does the interest rate depend on?
7. What kind of technology are banks using now?
8. What are the electronic funds transfer doing with money?
9. What new services are the automatic teller machines providing for the customer?
10. What innovation makes it easy for the customer to handle all kinds of financial transactions outside his home state?
11. What process in modern banking is urging the banks to diversify?

Exercise 5. Fill in the blanks with adjectives <u>many</u> and <u>much</u>.

1. ___________insurance companies protect their customers against risk.
2. It takes one___________money to join a credit union.
3. Starting a business without financial support from the bank may cause you ___________ trouble.
4. Banks in the USA are subject to____________government regulations.
5. Savings and Loan Associations attract____________small savers who do not want to have any risk.

Exercise 6. Substitute the words in the statement with the given synonyms.

Statement: There are *many* commercial banks that offer their customers a wide range of financial services.
Example: There are a *lot of* commercial banks that offer their customers a wide range of financial services.

financial institution	clients	individuals and businesses
provide for	banking	render
different	were	a number of

Statement: *Banks* are now using computer technology to perform various financial transactions.

Example: *Financial institutions* are now using computer technology to perform various financial transactions.

business	electronic
numerous	employing
deals these at	methods
at present	handle

Exercise 7. Translate into English.

1. Существуют ли бесплатные банковские услуги? Нет, бесплатных банковских услуг не бывает. 2. Многие банки устанавливают плату за услуги. 3. Компании с хорошим финансовым положением получают некоторые привилегии. 4. Много ли денег на вашем расчетном счете? Да, много. 5. В моем справочнике один коммерческий банк и три страховые компании.

Exercise 8. Before listening discuss the following statements. How do you think whether they are true or false? Then listen and check if you were right.

1. The earliest kind of money was used about 3,000 years ago.
2. Shells were used a kind of fiat money.
3. The first metal coins appeared in Greece.
4. The first coins were round.
5. Paper money first appeared in China.
6. The idea of paper money traveled quickly to Europe.

***Exercise 9. Read and play the dialogue*.**

Dan and Sally, university tutors, are discussing their financial problems
D: Hello, Sally!
S: Hi, Dick! Happy to see you again. How are things with you?
D: Not bad. And how are you doing?
S: I've a problem, you know. I've just wrecked my new automobile. Had an accident. And I need money to have it repaired.
D: Oh, I think I can help you. Haven't you heard about the credit union that we formed?
S: Why, no! Could you tell me what it is?
D: It was a great idea! The members of our department pooled their money and now anyone can apply for a loan if necessary.
S: And may I join the union?
D: Of course you may. As a rule, a credit union consists of members of a specific group, such as university employees. And we belong to the same university.
S: Great! And how much do I have to pay?
D: Well, we require a minimum deposit – something about 100 dollars. And our credit union pays a higher interest rate than many other financial institutions pay on similar accounts.
S: That also sounds good. And who manages the pool?
D: I do.
S: Fine! Then I'll have my car repaired pretty soon!

Words and phrases to learn:

how are things with you?/how are you doing? – как дела?
pool – общий фонд
to pool – создавать общий фонд
to apply for – обращаться за чем-либо
to join – вступать
to require – требовать
that sounds good! – это (звучит) хорошо
to manage – управлять; успешно справляться с чем-либо
pretty soon – очень скоро

Exercise 10. Make up similar dialogues.

1. You are starting a new business and apply for funds to a commercial bank.
2. Your company has a good reputation and a commercial bank provides the prime rate for you.
3. You deposit some of your money into a bank which offers you accounts of two types. Choose one of them.

Exercise 11. Translate the following sentences.

1. Правительственные предписания ограничивают спектр услуг, который может предлагать банк.
2. Государственный банк запрещает выплачивать проценты по расчётному счёту.
3. Финансовые учреждения предлагают новые виды вкладов.
4. Некоторые банки экспериментируют со счетами.
5. Многие компании устанавливают в своих зданиях банкоматы.
6. Федеральное правительство использует электронную систему передачи средств.

Exercise 12. Put the verb in brackets into the right form.

1. Large commercial banks (install) automatic teller machines nowadays.
2. Customers usually (use) their debit cards to transfer money from their checking account to the merchant's account.
3. As a rule a customer (pay) a fee of forty cents for each transaction outside the state.
4. Financial supermarkets (appear) all over the USA these days.
5. The customers often (look) around for the highest return on their savings or the lowest rate they can get on a loan.
6. Small banks now (compete) with larger banks by finding a special need and meeting it.

Exercise 13. Make up sentences according to the following models.

Model: *to open a checking account*
I am thinking of opening a checking account.

1. to use the electronic funds transfer system.
2. to transfer money outside the state.
3. to provide new services to my customers.
4. to buy 100 shares of stock.
5. to sell some bonds.
6. to plan a number of financial transactions.
7. to assign my major customers a personal banker.

Model: *to balance my checkbook at last*
I am going to balance my checkbook at last.

1. to drop unprofitable services.
2. to ask for financial advice.
3. to wait on customers.
4. to install an automatic teller machine in my shopping center.
5. to attract more customers by providing less expensive services.
6. to pay a fee of a dollar for this banking transaction.
7. to use my debit card to a better purpose.

Exercise 14. Read the text, do the exercises.

FINANCIAL MANAGEMENT

In the past, financial management was not a **major concern** for a business. A company used to establish relations with a local bank. The bank handled the financing and the company took care of producing and selling.

Today only a few firms operate in this way. Usually businesses have their own financial managers who work with the banks. They **negotiate terms** of financial transactions, compare rates among competing financial institutions. Financial management begins with the **creation** of a financial plan. The plan includes **timing** and amount of funds and the **inflow** and **outflow** of money. The financial manager develops and controls the financial plan. He also forecasts the economic conditions, the company's **revenues,** expenses and profits.

The financial manager's job starts and ends with the company's **objectives.** He reviews them and determines the funding they require. The financial manager compares the expenses **involved** to the **expected** revenues. It helps him to **predict** cash flow. The **available** cash consists of beginning cash plus customer payments and funds from financing.

The financial manager plans a **strategy** to make the ending cash positive. If cash outflow **exceeds** cash inflow the company will **run out** of cash. The **solution** is to **reduce** outflows. The financial manager can **trim** expenses or ask the customers to pay faster.

The financial manager also chooses financing **techniques.** One of them is short-term financing. Another is long term financing.

Short-term financing. The seasonal financial needs of a company may be **covered** by short term sources of funds. The company must pay them off within one year. Businesses spend these funds on salaries and for emergencies. The most popular outside sources of short term funds are trade credit, loans, factors, sales finance companies, and government sources.

About 85 percent of all US business transactions involve some form of trade credit. When a business orders goods and services, it doesn't normally pay for them. The supplier provides them with an invoice requesting payment within a **settled** time period, say thirty days. During this time the buyer uses goods and services without paying for them.
A company can use the trade credit as a source of savings. A typical trade arrangement is 2/10, net 30. If a buyer pays within 10 days instead of 30, he gets a 2 percent discount. The savings a buyer obtains can be used as a source of short term funds.

Commercial banks lend money to their customers by direct loans or by setting up **lines of credit.** A line of credit is the amount a customer can borrow without making a new request, simply by **notifying** the bank. If the business doesn't pledge collateral when it borrows, the loan is an **unsecured loan.** Only customers with an excellent credit rating can get an unsecured loan. They usually repay it within a year's time. When a company wants to borrow a large amount of money it pledges collateral to back up the loan. Such a loan is a **secured** one.
Sometimes a company might sell its accounts **receivable** to a special financial broker: a factoring company, a factor. The factor immediately pays the firm cash, usually 50 to 80 percent of the value of the accounts receivable. When customers make the payments on their accounts, the money goes directly to the factor.
Some big firms obtain funds by selling **commercial paper.** Because commercial paper has no collateral behind it, only firms with a good financial reputation can sell it. In special cases, a business may obtain short term funds from the federal government.

Long-term financing. When a business needs funds to construct a new **assembly line** or to do **extensive** research and development which may **not** begin to bring in revenues for several years, short term financing wouldn't work. In this case, business will need long **term** sources of funds.

Firms may meet long term needs by increasing the company's **debt** either by getting loans or by selling bonds.
A long term loan is a loan that has a **maturity** of from one to ten years. Within this period of time the firm pays interest on the **debt.** Sometimes the lender **protects** its financial position by requiring that the company obtain the lender's **permission** before taking on any additional long term debt. If the loan is **particularly** risky, the lender may even require the firm to limit or **eliminate** dividends to stockholders.

If the firm wants to be free of lender's **restrictions,** it may **issue** bonds. These are long term debts with a maturity date of 20 to 30 years in the future. Governments issue government bonds. Corporations issue corporate bonds which may be secured or unsecured.

If a company wants to sell bonds it can offer some collateral. It is difficult, if not impossible, to find investors who are willing to buy bonds which are not backed up by collateral. Only huge corporations such as AT&T can successfully issue unsecured bonds, which are called **debentures.**

Most bonds carry a **face value** of $1000 and pay a **predetermined** interest rate (the **coupon** rate). The company pays this interest **regularly according to** the **indenture agreement** which **specifies** the terms of a bond issue. The company may **retire** bonds before they mature if the indenture agreement contains a **call provision.** In this case the firm pays the bondholders a **redemption** premium.

Another **flexible** feature in some agreements is the **conversion privilege.** It allows bondholders to convert their investment into a stated number of shares of **common stock.** If the price of the company's common stock is going up, the investors can profit from conversion. Convertibility makes the bond issue more attractive to **potential** investors.

(V. Milovidov «English for Financial Management Experts»)

Words and expressions

concern	забота, беспокойство
to negotiate	вести переговоры, обговаривать
timing	согласованность действий, операций
to flow	течь
inflow	приход, вход
outflow	выход
to forecast	прогнозировать, предсказывать, предвидеть
revenue	доход, доходные статьи
expenses	расходы
to compare	сравнивать
to involve	привлекать, вовлекать, втягивать
to expect	ожидать
to predict	предугадывать, предвидеть
available	имеющийся в наличии, доступный
to exceed	превосходить
to run out of	лишиться, истощить (запас)
solution	решение (проблемы)
to cover	покрывать
emergency	экстренная необходимость
trade	торговля
factor	фактор; агент, занимающийся скупкой неоплаченных долгов
invoice	квитанция
to settle	устанавливать, устраивать
to arrange	организовывать
arrangement	сделка
net	чистый (вес, стоимость и т. д.)
line of credit	открытый кредит, кредитная "линия"
to notify	извещать
unsecured loan	необеспеченный кредит
secured loan	обеспеченный кредит
receivables	неоплаченные счета
commercial paper	простой или переводной вексель
assembly line	конвейер
extensive	широкий; основательный

maturity	срок платежа, срок действия долгового обязательства
permission	разрешение
particular	особенный
to eliminate	отменять, исключать
restriction	ограничение
debenture	облигация без обеспечения
face value	номинальная стоимость
predetermined	заранее определенный
coupon	купон
regular	регулярный
according to	в соответствии с чем-либо
indenture agreement	контракт, оговаривающий обязательства эмитента и права держателя облигации
to specify	уточнять
to retire	отзывать
call provision	право эмитента выкупить по обусловленной цене облигации до истечения срока выкупа
to redeem	выкупать, возвращать
redemption	выкуп
flexible	гибкий

Exercise 15. Answer the questions.

1. Was financial management always a major problem for business?
2. What did a bank do in the past to help a company operate?
3. What does financial management start and end with?
4. What does the financial plan include?
5. What happens to the company if the outflow of funds exceeds the inflow?
6. What are the major financing techniques?
7. What are the most popular outside sources of short term funds?
8. What is a line of credit?
9. What firms are able to sell commercial papers?
10. When does a business need long term sources of funds?
11. What are the two ways of increasing the company's debt?
12. What does a company do if it wants to be free from the lender's restrictions?

13. Why is it difficult to sell debentures?
14. What makes it possible to retire bonds before they mature?
15. What does the conversion privilege allow the bondholders to do?
16. When do the investors profit from conversion?

Exercise 16. Study the figure below and describe the process of financial management.

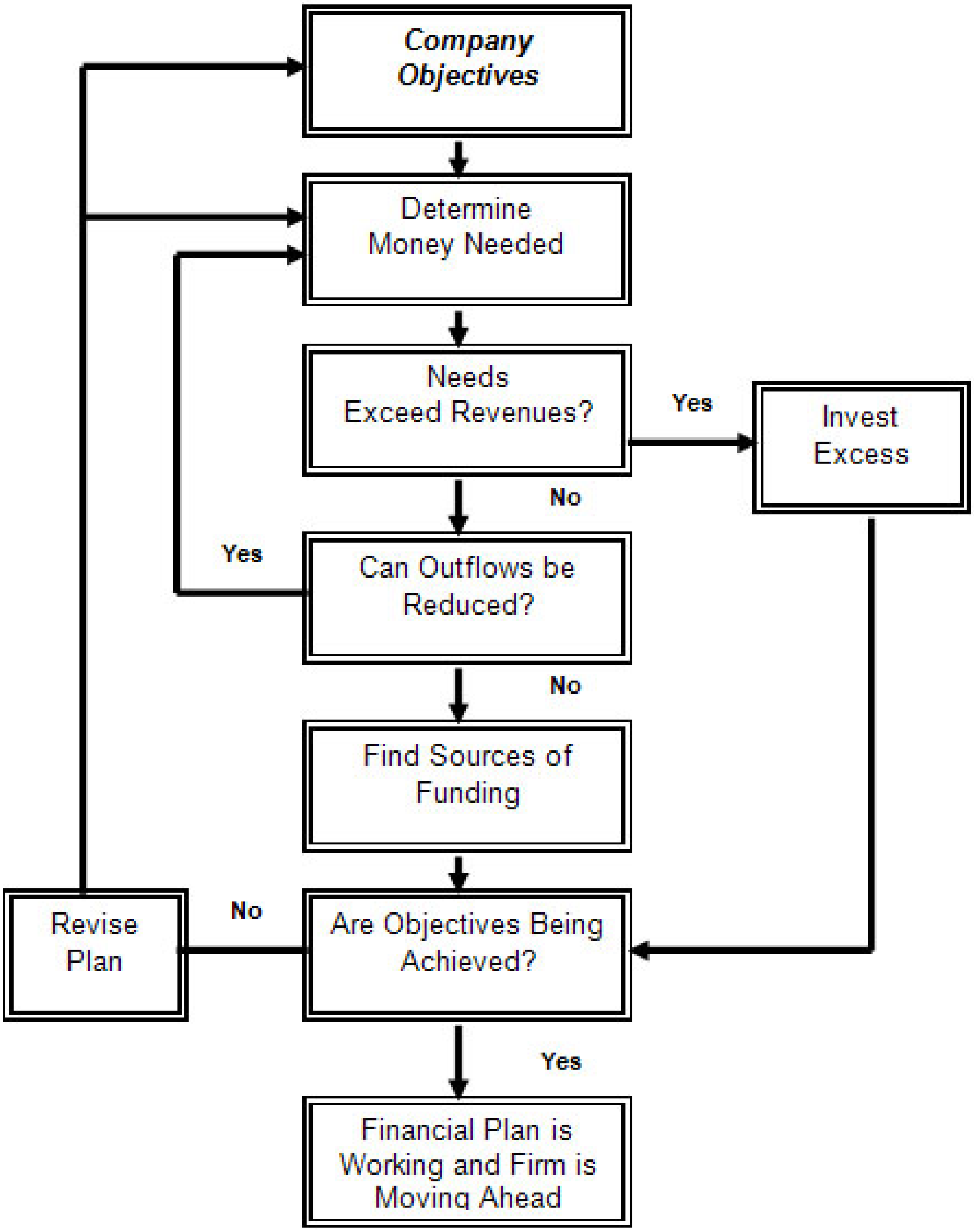


Fig. 1. Process of financial management

Exercise 17. Translate into English.

1. Некоторые непосредственные нужды компании покрывают краткосрочными источниками финансирования. 2. Компания должна выплатить долги в течение года. 3. Предприятие использует краткосрочное финансирование в случаях экстренной необходимости. 4. Компания может использовать торговый кредит, знаёмы, факторинг, правительственные источники. 5. Около 60 % всех деловых операций включают торговый кредит. 6. Обычно клиент, не платит за товары и услуги сразу. 7. Квитанция требует уплаты денег в течение установленного срока. 8. Покупатель использует товары и услуги, не платя за них. 9. Компания может использовать торговый кредит как источник сбережений. 10. Если клиент платит в течение 20 дней вместо 40, он получает 2%-ю скидку. 11. Коммерческие банки предлагают своим клиентам кредиты без обеспечения. 12. Только клиенты с отличной кредитной репутацией могут получить кредит без предоставления обеспечения. 13. Компания может установить обеспечение под заем. 14. Иногда компания продает невыплаченные долги своих клиентов фактору. 15. Когда клиенты расплачиваются по своим счетам, деньги идут непосредственно в факторинговую компанию. 16. Иногда компании продают векселя.

Exercise 18. Before listening read the summary which explains what open market operations are. Try to complete the gaps with your own words. Then listen and check if you were right.

The government can create (1)………… of money for commercial banks by (2)………… securities. Securities are a way to (3)………… money to the government at an agreed rate of interest. This is what is known as open market operations. When people buy securities the money supply (4)………… . This causes (5) ………… in the commercial banks' (6) ………… accounts, so they have to (7) ………… money from the central bank.

Exercise 19. Put the verb in brackets into the correct form.

1. Our company (establish) an effective system for recording financial transactions last year.
2. The financial manager (obtain) the needed funds for the next year yesterday.

3. The financial officer (find) sources of the funds for his company last week.
4. The corporation (determine) its overall needs for the next period of time this morning.
5. The Board of Directors (work out) a system of financial control to back up the company yesterday.
6. Last year most successful firms (use) new promising steps in planning and controlling their finances.
7. I though that you (to arrive) at some decision.
8. I believed that a long term loan (to be) absolutely necessary for that program.
9. They said they (to work) seven hours a day.
10. Did he say that there (to be) a lot of problems with this agreement?
11. Did he find out that a commercial loan (to be) for a smaller amount that his business (to want)?
12. I was sure that the bank (to arrange) a line of credit for our corporation.
13. She discovered that LTC corporation (to use) both loans and bonds for long term financing.
14. The manager said that we (to need) to reduce the amount of corporate income tax.
15. I hoped that the bond (to be) backed up by some collateral.

Exercise 20. Substitute the words in the statement with the given synonyms.

Statement: When *the company* wants to borrow a large amount of money or has an unsatisfactory credit rating, it pledges collateral to back up the loan.

Example: When *the firm* wants to borrow a large amount of money or has an unsatisfactory credit rating, it pledges collateral to back up the loan.

sum	cash	puts up
needs	credit	obtain
is known for	if	big
bad	financial	reputation
some of its	support	capital

Exercise 21. Study the following and do the exercise.

1. *Direct speech:* The customer said, "My business is running out of cash."
   Indirect speech: The customer said that his business was running out of cash.

2. *Direct speech:* The manager said, "We usually sell on credit. "*Indirect speech:* The manager said that they usually sold on credit.

3. *Direct speech:* The banker said, "We have just signed a contract."
   Indirect speech: The banker said that they had just signed a contract.

4. *Direct speech:* The buyer said, "I bought a large amount from you but it didn't work."
   Indirect speech: The buyer said that he had bought a large amount from me but it hadn't worked.

Change the direct speech into indirect speech.

1. The manager said, "We haven't made the necessary arrangements yet."
2. The retailer said, "You can buy machinery and tools on an open account."
3. The customer said, "I bought a new car at your shop and it needs repair."
4. The banker said, "I am opening a credit account for you."
5. The businessman said, "As a rule, we sell our goods abroad."
6. The manager said, "We haven't raised enough money to expand."
7. The wholesaler said, "I sold a large amount of tools to retailer' shops but they are not paying me in due time."

Exercise 22. Read and act out the dialogue.

A company is about to launch an expensive program while its revenues are too small to cover the expenses. The manager is consulting with his financial adviser.

Man: I'd just like to know the advantages and disadvantages of the debt financing.

Adv: Are you going to issue bonds or just to take out a loan?
Man: Well, it depends. If we manage to find an institution that will not demand any collateral, we'll try to obtain a loan.
Adv: But don't you know that you'll have to pledge collateral no matter what kind of a debt you're in for?
Man: Do you mean that even bonds issue needs collateral to back it up?
Adv: Why, yes. Unless you have a solid financial reputation, of course.
Man: We've just started, you know. Anyway, I'll have to report to the Board of Directors on Thursday. And meanwhile, how about talking about the advantages?
Adv: Well, compared to other types of securities, long term loans and bonds have at least two advantages. First, the holders are just creditors, not owners. This provides you with some flexibility in using the funds you have borrowed.
Man: You mean that the holders have no voting rights and can't participate in the operations of the corporation?
Adv: You've got it. And the second one is that the interest you pay to these creditors is tax deductible
Man: Oh, I see. We subtract this interest from the company's earning before taxes are calculated?
Adv: Right. And this eventually reduces the amount of corporate income tax.
Man: That sounds great!
Adv: Don't jump to conclusions! There are some disadvantages as well. First, these obligations must be repaid. You will have to plan a huge repayment at some fixed point in the future.
Man: I bet it will cause all of us many headaches!
Adv: And moreover, bond agreements often contain restrictive provisions that may limit your flexibility in handling the corporation's future finances.
Man: Yes, I see. We'll have to think twice before creating a debt in either way. Anyway, thanks a lot for your information!

Words and phrases to learn:

to launch – начинать
I'd like to – я бы хотел
it depends – это зависит от ...
don't you know – разве вы не знаете?
no matter what... – независимо от того ...
unless you have – если вы не имеете ...

meanwhile – тем временем, пока
compared to – в сравнении с
at least – по крайней мере, по меньшей мере
to vote – голосовать
voting rights – права голоса
you've got it – вы попали в точку
to deduct – скидывать, сбавлять; вычитать
deductible – вычитаемые (из сумм, облагаемых налогом)
to subtract – вычитать, сбавлять
to figure – считать, подсчитывать
to jump to conclusions – спешить с выводами
obligations – обязательства
I bet – бьюсь об заклад; здесь: я полагаю
headache – головная боль
to think twice – подумать дважды

Exercise 23. Make up dialogues of your own.

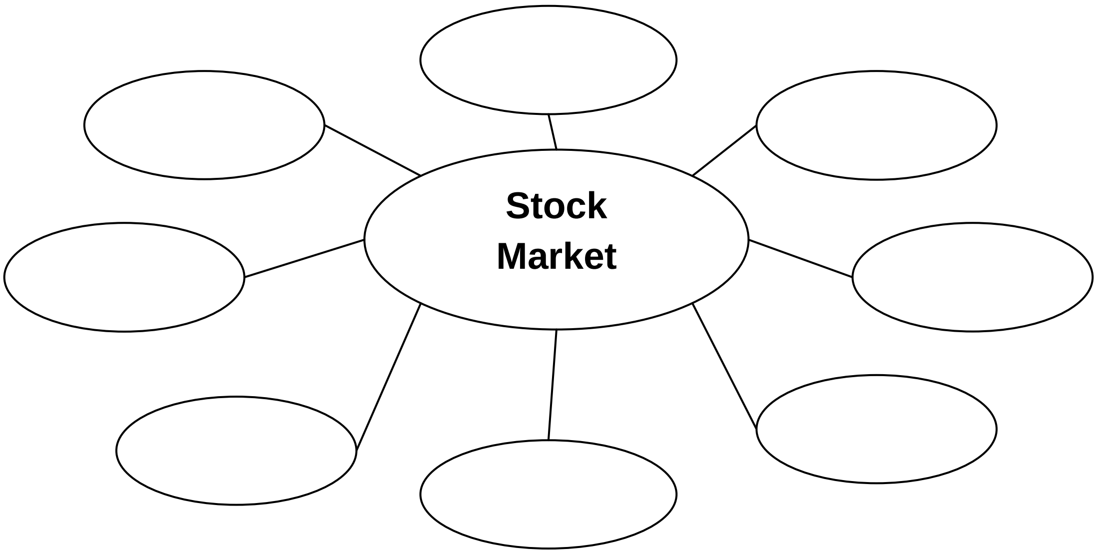
1. Your company is planning to construct a new building that would take up lots of money.
2. A bondholder is talking to the manager of the company about the advantages of bonds.

UNIT 3

STOCK

Lead-in

Fill in the spidergram with the words associated with Stock Market (use your active vocabulary from Unit 2).



Discuss the following questions.

1. What do you know about stock market?
2. What are the most famous stock markets?
3. Do you have any stock or bond, or security?
4. What can you say about the situation at the world's stock markets nowadays?
5. What are the most profitable stocks?

Terms and Vocabulary

primary	первичный
secondary	вторичный
previous	предварительный
to negotiate	вести переговоры
underwriter	поручитель
intermediary	посредник
membership	членство

“Big Board”	“Большое табло”
approximately	приблизительно
to list	здесь: регистрировать на бирже
pretax	до обложения налогом
tangible	реальный (осязаемый)
to qualify	квалифицировать(ся), законно претендовать
over-the-counter market	рынок без посредников
to be located	находиться, располагаться
screen	экран
up to date	в курсе
option	опцион

Exercise 1. Read and learn the pronunciation.

[i:] intermediary, predetermined
[a:] grant
[o:] floor
[əu] negotiate, located
[ə] approximately, predetermined
[ju:] execute
[ai] primary
[æ] pretax, tangible
[ai] underwriter

Exercise 2. Pay attention to the stress in the following words.

ʹprimary   underʹwriter   preʹtax
predeʹtermined
negotiʹate   ʹtangible   aʹccommodate   ʹimplement

Exercise 3. Read the text, do the exercises.

SECURITIES MARKETS

Securities are bought and sold at two types of securities markets: **primary** markets, which issue new securities, and **secondary** markets, where **previously** issued securities are bought and sold. If a company wants to sell a new issue of stock or bonds it usually **negotiates** with an investment bank, or

underwriter, who sells the securities for it. The underwriter buys the securities from the corporation and resells then to individual investors through the secondary market.

Organized security exchanges have developed to make the buying and selling of securities easier. The securities exchanges consist of the individual investors, brokers, and **intermediaries** who deal in the purchase and sale of securities. Security exchanges do not buy or sell securities; they simply provide the location and services for the brokers who buy and sell.

Stock transactions are handled by a stockbroker. A stockbroker buys and sells securities for clients. Stockbrokers act on the clients' orders. Stockbrokers receive a fee and are associated with a brokerage house. To trade on the exchange, a "seat" must be purchased. A seat is a **membership.** The members represent stockbrokers. When a stockbroker calls in an order to sell, the member representing that broker looks for a buyer at the price requested. When a broker calls in an order to buy, the exchange member looks for a buyer at the price offered.

The largest and best known exchange in the USA is the New York Stock Exchange (NYSE) also called the **"Big Board".** There are 1,300 seats on the NYSE and **approximately** 2,000 stocks and 3,400 bonds are traded daily. In order to be **listed** on the NYSE, a firm has to meet the following requirements:

1. **Pretax** earnings of at least $2.5 million in the previous year.
2. **Tangible** assets of at least $16 million.
3. At least 1 million shares of stock publicly held, and others.

The second largest stock exchange in the USA is the American Stock Exchange (AMEX). It is located in Manhattan and has about 500 full members and 400 associate members. AMEX operates in much the same way as NYSE, but smaller companies may **qualify** for listing. There are also regional stock exchanges that serve regional markets.

The over the **counter** market (OTC) sells and buys unlisted securities outside of the organized securities exchanges. About 5,000 brokers of OTC are scattered all over the country. They trade unlisted stocks and bonds by phone and keep in contact with each other.
The prices of the securities are established by **supply** and **demand.** Electronic **screens** in the offices of the brokerage firms display OTC

transactions, so brokers continually keep customers **up to date** on the latest prices.

Options are traded on the major stock exchanges, but also on a special market for options, the Chicago Bond Options Exchange (CBOE).

America's Financial Markets / The Economist, 2000. November 24.

Exercise 4. Answer the following questions.

1. Where are securities bought and sold?
2. What is the difference between primary markets and secondary markets?
3. Who does a company negotiate with if it wants to issue stock?
4. What does an underwriter usually do?
5. What is the main purpose of security exchanges?
6. Who are the participants of security exchanges?
7. Do the exchanges buy or sell securities?
8. Who are stock transactions handled by?
9. What do stockbrokers receive from clients?
10. What is the first thing you do to become a broker?
11. What does the member do when a stockbroker calls in an order to sell?
12. What is the largest stock exchange in the USA?
13. How many seats are there on the "Big Board"?
14. What requirements does a firm have to meet in order to be on the NYSE?
15. What are the major differences between the NYSE and AMEX?
16. What is OTC and how many brokers participate in it?
17. Where are options bought and sold in the USA?

Exercise 5. Substitute the words in the statement with the given synonyms.

Statement: Exchanges are simply *auctions* where investors get together to bid for stocks and bonds.

Example: Exchanges are simply *places* where investors get together to bid for stocks and bonds.

security markets	gather
trade	securities
just	businessmen

Exercise 6. Transform the sentences according to the model.

Model: *Security exchanges provide the location for the brokers.*
The location for the brokers is provided by security exchanges.

1. Securities markets buy and sell securities.
2. The company issues new stock through an underwriter.
3. The exchanges trade listed corporation securities only.
4. Several underwriters form an underwriting syndicate.
5. The underwriter buys securities from the corporations.
6. The individual used to sell stocks over the counter originally.
7. The National Association of Security Dealers developed the computerized communications system NASDAQ (National Association of Securities Dealers Automated Quotations) in the early 1970s.
8. NASDAQ ties the OTC market together in one vast electronic stock market.
9. The individuals trade the majority of stocks in a true bid auction.

Exercise 7. Read and act out the dialogue.

John Simpson is talking to his friend, Martin Walker, about his progress in business

J: Well, you know Martin, these new developments in computer systems are fantastic.
M: I bet they are. You seem to be glowing with delight.
J: Sure I am. It took me a lot of time to call the broker whenever I wanted to sell or to buy stock.
M: You have done away with the broker, haven't you?
J: Not really. I've got a computer now and. I can get the latest prices of all stocks in my portfolio from a database.
M: And how about the broker. Did you dismiss him?
J: Why should I? I just hooked my computer up to a telephone and send my instructions to the broker's computer.
M: How do you benefit from all of this?
J: Well, first of all, you save a minute or two on transactions. Moreover my broker has already offered a discount for computer orders.
M: The costs in processing these orders are comparatively low, aren't they?
J: Right! And even at lower costs it is good for the broker too.
M: But how much is it to use the computerized system?

J: Not really much. Just about $10 for the first hour each month and $20 per additional hour.

M: And is the system reliable? As far as I can remember the 1987 crash was caused to a great extent by the flaws in the use of computers.

J: I've read a lot about it. About 4 million shares were involved in transaction on the day of the crash and there was some problem with software which made a mess of most transactions. But I believe computer systems have improved since then.

M: I hope so, and wish you luck with it!

Words and expressions

to glow with delight – светиться от радости
to do away with – избавиться от чего–либо
database – банк данных
to dismiss – увольнять
to hook (v) – зацеплять; соединять
crash (n) – крах, катастрофа
to a great extent – в большой степени
flaw (n) – ошибка, промах; изъян
to make a mess (of something) – все испортить
to bet – биться об заклад

Exercise 8. Make up dialogues of your own.

1. You employ a broker to commit business transactions for you.
2. Your firm doesn't meet either NYSE or AMEX requirements so you come into contact with one of the OTC brokers to discuss the possibilities of cooperation.
3. Your computer is out of order. Contact your broker and discuss the situation.

Exercise 9. Transform the following sentences according to the model.

Model: – We can do it.
– It can be done.

1. They must introduce telecommunication on the OTC market.
2. We can't trade unlisted securities.
3. We should buy and sell unlisted stocks and bonds by phone.
4. I have to pay special attention to the major security markets of the

world.

5. They ought to close trading at the Tokyo exchange.
6. We must replace face to face buying and selling of securities by telecommunication.
7. We must watch the foreign exchange closely.
8. We should keep customers up to date on the latest prices.
9. We have to look through the NASDAQ national market quotations in the daily stock sections of national newspapers.
10. I should have my stock listed on regional and national exchanges.

Exercise 10. Translate into English.

1. Ценные бумаги продаются на первичных и вторичных рынках ценных бумаг. 2. Если компания хочет выпустить новые акции, она проводит переговоры с инвестиционным банком или поручителем. 3. Поручитель покупает ценные бумаги компании и перепродает их на вторичном рынке индивидуальным инвесторам. 4. Фондовые биржи делают процесс продажи и покупки ценных бумаг проще. 5. Фондовая биржа состоит из инвесторов, брокеров и посредников, которые занимаются покупкой и продажей ценных бумаг. 6. Операции с ценными бумагами проводятся биржевыми брокерами. 7. Биржевые брокеры получают вознаграждение. 8. Биржевые брокеры действуют по поручению клиентов. 9. Чтобы вести дела на бирже, брокер должен купить место. 10. Члены биржи представляют биржевых брокеров. 11. Крупнейшая и наиболее известная биржа в США – Нью-йоркская фондовая биржа ("Большое табло"). 12. Чтобы быть зарегистрированной на бирже, компания должна соответствовать ряду требований. 13. Американская фондовая биржа имеет около 500 полных членов и около 400 ассоциированных членов. 14. Рынок без посредников торгует незарегистрированными ценными бумагами. 15. Цены на ценные бумаги устанавливаются спросом и предложением. 16. Опционы продаются на главных фондовых биржах, а также на Бирже опционов в Чикаго.

Exercise 11. Read the text, do the tasks.

TRADING STOCKS

Trading stock begins with an investor **placing** an order that is informing the stockbroker as to what stock and how much he wants the broker to buy or sell. An order to buy or sell stock at the best possible price at the present time is called a market order. The broker **conveys** the order to an exchange member on the trading floor, who **attempts** to get a better price for the buyer by offering a little less. For example, the broker might offer 47 1/8 ($47.12.5) for the stock with a **current** price of 47 1/4 and see if someone will sell at this price. If the investor were selling, the broker would attempt to get a **slightly** higher price by offer say, 47 3/8.

The final sale will then be electronically **relayed** to the broker who placed the order. The investor might also place a limit order which specifies the highest or lowest price at which the broker may buy or sell. If the investor can't be **accommodated** immediately, the broker places the order in a sales book and then tries again in order of **priority.** If an investor wants to keep the order on the books he can issue an open order which instructs the broker to leave the order on the books until it is **executed** or **canceled.**

Sometimes the investor might give a **discretionary** order which allows the broker to exercise **judgment** in making money. The investor leaves it up to the broker to decide when and at what price to buy or sell.

An **odd** lot is any number of shares less than 100. One hundred shares comprises a **round** lot. Brokers usually trade shares in lots, **odd** lots being combined with a series of other small orders to form a round lot. A purchase of 10,000 shares is sometimes called a block sale. In addition to the price of the stock, the investor pays the broker a **commission** for buying or selling the securities.

Sometimes investors pay less than the full amount when they buy stock. This is called margin trading. The FRS determines the minimum margin required. In recent years the stock margin has been approximately 50 percent. **Fearing** that the investor might sell the stock and **abscond** with the funds, the broker keeps stock certificates of margin accounts at the brokerage as collateral. If the stocks were to **plummet,** the broker would call the investor and request that he put up more money or have the stock sold.

Active buyers of stock are called **bulls.** They believe that the prices of stocks are going to rise. During the mid 1980s, the US witnessed a very long bull market. At the 1987 crash even bulls became **bears.** A bear is an investor who makes a profit when the prices are going to fall. **Selling short** is a high risk strategy which bears use in order to do that. They sell borrowed stock in the hope of later buying it on the open market at a lower price.

Options are contracts that allow an investor to either buy or sell a security at a **predetermined** price within a certain time. Depending on the investor's expectations, he may buy a **put option** or a **call option.** A put option **grants** the owner the right to sell a security. Believing that the price of certain shares will **drop** over some period of time an investor might buy an option and benefit from selling the shares at the option price to the person who sold the options. A call option grants its owner the right to buy a certain amount of stock at a predetermined price within a fixed period of time.

(America's Financial Markets / The Economist, 2000. November 24)

Words and expressions

to place	размещать
to convey	передавать (сообщение, информацию)
floor	пол, площадка
to attempt	пытаться
current	текущая, существующая
slightly	немного, слегка
to relay	передавать, сообщать
to accommodate	здесь: оказывать услугу
to execute	выполнять
priority	приоритет, первенство
order of priority	в порядке очереди
to cancel	отозвать; отменить
discretionary	представленный на усмотрение, дискреционный
judgment	суждение, оценка, суд
odd	неполный, нечетный
round	круглый, полный
commission	комиссионный

to fear	опасаться, бояться
to abscond	сбежать с деньгами
to plummet	здесь: резко падать в цене
bull	бык
bear	медведь
short	короткий, кратковременный
to sell short	продать на срок без покрытия
predetermined	заранее установленный
put option	опцион продавца
call option	опцион покупателя
to grant	гарантировать
to drop	падать

Exercise 12. Answer the following questions.

1. How does the trading of stocks begin?
2. What is a market order?
3. Who does the broker convey the market order to?
4. What is a limit order?
5. What is an open order?
6. What is a discretionary order?
7. What is an odd lot and how does it differ from a round lot?
8. What is a block sale?
9. What is margin trading and how is the margin trading regulated?
10. What does a broker do to protect his interests in case the stock falls down in price?
11. What is a bull market?
12. What is a bear market?
13. What is the selling short procedure?
14. What is a put option?
15. What is a call option?

Exercise 13. Change the following sentences according to the example.

Example: *If an investor wants to keep the order on the books, she can issue an open order.*

If an investor wanted to keep the order on the books, she could issue an open order.

1. If the investor wants to sell or buy at the current price, he can issue a market order.
2. If someone sells at the offered price, the broker will settle the transaction.
3. If the investor specifies the highest price at which the broker may buy, the broker will commit to the deal.
4. If the investor pays the ten percent commission, the broker will work harder.
5. If the investor absconds with the funds, the broker will go bankrupt.

Exercise 14. Translate into English.

1. Торговые операции с фондами начинаются с передачи приказа брокеру продавать или покупать ценные бумаги. 2. Брокер передает приказ о покупке (продаже) члену биржи, который пытается найти лучшую цену для покупателя. 3. Сведения об окончательной продаже передаются брокеру, передавшему приказ. 4. Инвестор передает брокеру приказ, ограниченный условиями высшей цены, по которой брокер может купить акции. 5. Иногда инвестор дает брокеру дискреционный приказ, который позволяет брокеру показать свое умение делать деньги на бирже. 6. Федеральная резервная система определяет минимальную маржу. 7. Опасаясь бегства инвестора с деньгами, брокер хранит акционерные сертификаты. 8. Активные покупатели акций называются "быками", активные продавцы – "медведями". 9. Опцион продавца гарантирует право продать ценные бумаги по заранее установленной стоимости в течение определенного срока.

Exercise 15. Listen to the text and complete the notes.

Other names: (1)………… (2)…………
Main trading centres: (3)………… (4)………… (5)…………
Most traded currencies: (6)………... (7)………… (8)…………
Amount traded daily: (9)…………
Trading hours: (10)…………
Main traders: (11)………… (12)………… (13)…………
(14)………...

Exercise 16. Study Fig.1 and make a report about Stock Market and Over-the-Counter Quotations.

Fig.1

Number of shares (in hundreds) traded this day

Highest and lowest prices at which the stock traded this day

Closing price of the stock

Net change in the price of this stock over that of the previous business day's close

Highest and lowest prices during the past 52 weeks

Name of the company, Texas Instruments

Reading a Stock Market Quotation

52 weeks High	Low	Stosk	Div.	Yld. %	P-E Ratio	Sales 100s	High	Low	Close	Net Chg
57 1/2	48 7/8	TxET pf.	5.35e	10.9	...	6	49 1/2	49	49	+1/8
35	25 5/8	TexInd	.80b	3.1	11	14	26 1/4	26	26	- 1/4
148 1/4	87 1/2	TexInst	2.00	1.8	...	876	111 1/2	109 1/2	109 5/8	- 1/8
33	23 3/4	TxPac	.40	1.5	18	16	27 1/4	27	27 1/4	...
35 1/4	25 7/8	TexUtil	2.68	8.1	8	4683	33 5/8	33 1/8	33 1/4	...
5 5/8	2 5/6	Texfi In			68	26	3 1/2	3 3/8	3 3/8	- 1/4
65 1/3	44 1/8	Textron	1.80	3.5	9	912	52	51 3/4	52	...

Current annual dividend paid per share, in this case, $2.68

Yield, which is the dividend divided by the selling price

P – E (price - earnings) ratio, which is the market price divided by earnings per share

Name of the company

High and low prices

High and low prices during the business day

Reading an Over-the-Counter Quotation

365 Days High	Low			Sales (hds)	High	Low	Last	Net Chg
20 3/4	9 1/4	Apollo	Comptr	2047	11	10 3/4	10 1/8	...
33 1/8	11 1/8	Apple	Bank	172	27 3/4	26 7/8	27	+ 1/8
39 1/8	14 1/4	Apple	Comptr	6700	31 1/4	31 1/8	31 3/8	+ 1/8
55	18	Appld	Biosyst	1040	42 1/4	41		3/8
16 5/8	8 1/2	Applied	Matl s	1566	9 1/4	8 1/2	41 5/8	+ 1/4
14 1/4	8	Arabian	Solar	7	12 3/4	12 1/4	9	...
4 3/4	2 1/4	Arbor	Ship	100	2 3/8	2 1/4	12 1/4	+ 1/4

Number of shares (in hundreds) traded this business day

Closing price of the stock

Net change over the closing price on the previous Business day

The stock of TexInst Co. (3) had a high price of 148 1/4 (1) and a low price of 87 1/2 (2) during the previous 52 weeks. It paid a dividend of $2.00 (4) which is a yield of 1.8 percent (5) dividend by the stock price. On this particular day 87,600 were traded (7) at a high rate of $111 1/2 (8) and a low of $109 1/2 (9). The closing price was $109 5/8 (10) which a net change in the stock price at $1/8 (11).

It is much easier to read over the counter stocks.

Exercise 17. Read the text, do the exercises.

HOW TO MAKE MONEY IN THE STOCK MARKET

Investors buy stock for one simple reason: to make money. The surest way to earn money from investing is to create as diverse a portfolio as possible and **hang on** to it for a long time. To **succeed** at making money investors need good sources of information.

Much information is supplied by stockbrokers. They study market reports and get information on the forecasted financial performance of companies. Brokers usually recommend **opportunities** or provide special services such as newsletters. For this brokers charge additional fees.

Sometimes investors prefer to avoid high brokerage fees. They **implement** their own investment strategy. Serious investors **subscribe** to investment newsletters and carefully study the stock market. Best investors become an expert in a particular industry.

A simpler investment strategy is to choose some reliable blue chip stocks and **stick** to them. This strategy is safe and can earn money **over the long run.** Investors should avoid making common mistakes which are: 1) failure to diversify, 2) paying too much for a stock which would not go up, 3) not knowing when to sell a stock going down, 4) paying too much attention to **rumors** and **tips.**

There are also several techniques of **predicting** the stock prices. Most investors begin with fundamental analysis, which is the process of comparing a company's current financial position and future prospects with those of other firms in the same or different industries. Some investors usually called "chartists" try to identify a specific stock's **behavior charting** it over time and then predicting its future price movement. Other investors believe that prices are **random.** The random walk theory is based on the assumption that future stock prices are independent of past stock prices. They choose stocks **at random.** A group of investors has adopted an unusual approach, **contrarianism,** which holds that the market will move in the direction opposite to that predicted by the general public. In other words, these investors do the opposite of what the general public does.

(V. Milovidov «English for Financial Management Experts»)

Words and expressions

to hang on to something	держаться (за что-либо)
to succeed	иметь успех
opportunity	шанс, возможность
to implement	приводить в исполнение
to subscribe to	подписываться на...
to stick to something	придерживаться чего-либо
over the long run	здесь: на протяжении долгого времени
rumor	слух, сплетня
tip	совет
to predict	предсказывать
to chart	изображать в виде графика
behavior	поведение
random	случайный, беспорядочный
at random	наугад
contrarianism	от contrary - противоположный

Exercise 18. Answer the following questions.

1. What reason do investors buy stock for?
2. What is the surest way to make money in the stock market?
3. What do investors need in order to succeed at making money?
4. Who supplies information about the market?
5. Where do the stockbrokers obtain information from?
6. What do stockbrokers charge for information?
7. What do investors do if they want to avoid brokerage fees?
8. What is the serious investors' approach to studying the market?
9. What is the simplest investment strategy?
10. What are common mistakes usually made by investors?
11. What is the fundamental market analysis?
12. How do the "chartists" predict stock's behavior?
13. What is a "random walk theory"?
14. What is contrarianism based upon theoretically?

Exercise 19. Read the dialogue.

Lorna McCourt, a stockbroker, is consulting with Brian Lowman, an investor in IBM

B: Suppose, the stocks go down by 5 points. How much will I lose?
L: As far as I know, you have about $75,000 invested in IBM and that would be about a $20,000 loss. But that won't happen over the long run, I hope. IBM is going up steadily.
B: But anyway, what would you recommend to make a safer portfolio?
L: Diversify and study the market. Here I have some of the latest reports. You take them and study most thoroughly. You will easily see the direction most companies head to if you do it rather regularly.
B: And could you possibly do it for me?
L: I am a so called discount broker, you know, and I do not usually do that kind of a job. But if...
B: Well, I see, that means some additional payment?
L: Right. Brokers usually get an additional 20 percent for information about the market.
B: That'll suit me. That'll help me to avoid mistakes.
L: That'll be of some help, sure. But you've got to be aware that even the best brokers sometimes perform below average and do not pick a winner every time.
B: You have to run risks if you want to stay in the business, haven't you?

Exercise 20. Make up dialogues of your own.

You consult a broker about possible mistakes in the investment policy in order to avoid them. Choose between major techniques of predicting stock market activity.

Exercise 21. Translate into English.

1. Наиболее надежный способ зарабатывать деньги на фондовом рынке – создать диверсификационный портфель акций. 2. Чтобы преуспеть в бизнесе, инвесторы должны иметь хорошие источники информации. 3. Биржевые брокеры изучают биржевые отчеты и предоставляют инвесторам бюллетени о состоянии капиталов компаний. 4. Брокеры устанавливают дополнительный гонорар за информационное обслуживание. 5. Если инвесторы хотят избежать уплаты высоких

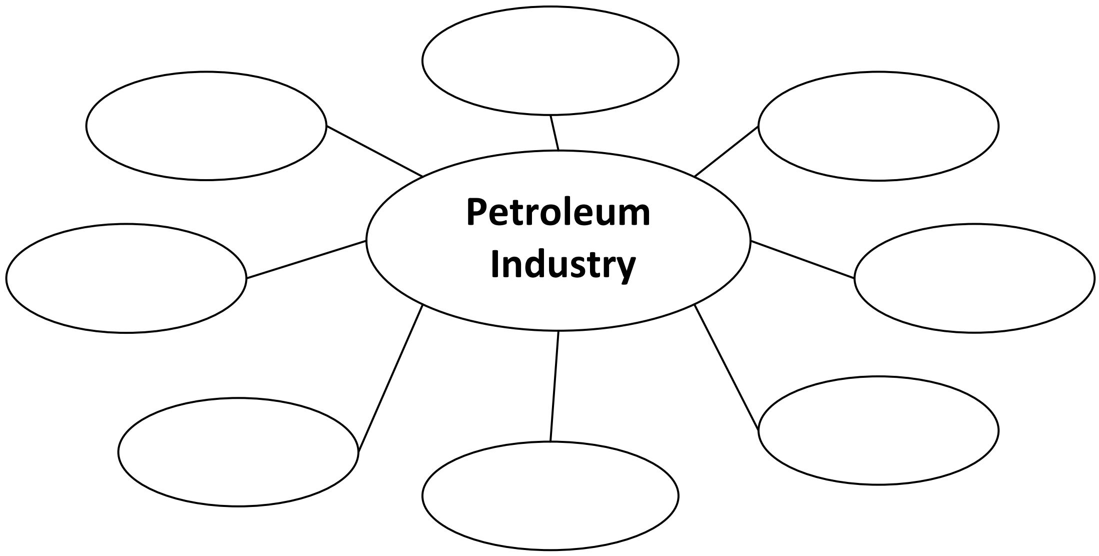
брокерских гонораров, они полагаются на собственную финансовую политику. 6. Многие инвесторы становятся экспертами в конкретных отраслях. 7. Простейшая инвестиционная стратегия состоит в выборе надежных "голубых фишек". 8. Главные ошибки инвесторов состоят в неспособности к диверсификации, придании слишком большого значения советам и слухам, в незнании, когда следует продать акции, теряющие в цене. 9. Серьезные инвесторы полагаются на фундаментальный анализ рынка. 10. Они сравнивают текущее финансовое состояние разных компаний в разных отраслях промышленности. 11. "Чартисты" пытаются установить поведение акций. 12. Другие инвесторы выбирают акции наугад.

UNIT 4

THE ECONOMY OF PETROLEUM INDUSTRY

Lead-in

Fill in the spidergram with the words associated with Petroleum Industry.



Key words: hydrocarbon raw materials, gas-bearing territory, exploration, production of oil and gas, resources, marine shelf, license, geological research, investment capacity.

Discuss the following questions.

1. Do you agree that Russia is one of the leading oil-extracting countries of the world?
2. Where are the largest oil and gas deposits situated in our country?
3. What other oil-producing countries do you know? Where are they located?
4. Do you think that oil and gas industry is very important for Russian economy?
5. In what way does oil and gas industry contribute to the development of Russian economy?

Terms and Vocabulary

oil-extracting	нефтедобывающий
reserve	запас
hydrocarbon raw materials	сырое углеводородосодержащее сырье
to explore	разведывать
exploitation	разработка, эксплуатация
to possess	владеть
gas-bearing	газоносный
internal	внутренний
external	внешний
persistent	стабильный, настойчивый
field	месторождение
in accordance with	в соответствии с, согласно
long-term	долгосрочный
perspective shelf	перспективный пласт
capacity	мощность
in terms of	в каком-либо выражении
to estimate	оценивать
deposit	залежь, месторождение
resources	запасы
autonomous	автономный, самостоятельный
unit	область
to be under production	производиться
to be worked out	разрабатываться
depths usage	использование недр
to stipulate	ставить условием, обуславливать
procedure	процедура, порядок
issuing license	имеющиеся лицензии
to render	представлять
despite	несмотря на
prolonged	продолжительный
unevenly	неравномерно
to a great extent	в большей степени
gas condensate	газоконденсат
infrastructure	инфраструктура
objective	объективный
profitable	прибыльный, рентабельный
consumption	потребление
share	акция, доля

Exercise 1. Read and learn the pronunciation.

[i:] material, leading, division
[o:] explore, accordance, autonomous, resource, prolong, raw, core
[ə:] reserve, internal, external, persistent, curve, nurse, averse
[ju:] stipulate, unit, usage, mature
[ai] licence, despite, hydro-, cycle
[æ] capacity, activity
[ɛə] share

Exercise 2. Pay attention to the stress in the following words.

po′ssess	′hydro′carbon
per′sistent	au′tonomous
a′ccordance	des′pite
distri′butional	un′evenly
′infrast′ructure	ob′jective
p′rofitable	con′sumption
app′roximately	e′fficiently

Exercise 3. Read the text, do the exercises.

OIL AND GAS IN RUSSIA. DEVELOPMENT AND FINANCING OF LARGE PROJECTS

Russia is one of the leading **oil-extracting** countries that has a large **reserve** of **hydrocarbon raw materials**, less than half of which are **explored** and under industrial **exploitation**. Russia **possesses** a vast area of oil and **gas-bearing** territories exceeding 10M km2 with 3.5M km2 of **internal** and **external** marine shelf.

For one and a half centuries Russia has been carrying out a **persistent** policy of search and exploration of oil and gas **fields in accordance with the long-term** interests of the national economy. Already 15 bln MT of liquid hydrocarbons and 12 trln m3 of gas have been extracted from the depths but a large part of the land and the main part of the **perspective shelf** remain unexplored and can become objects of large international projects. Investment **capacity** of the Russian Federation **in terms of** hydrocarbon raw materials is **estimated** at USD 60 bln.

At the moment about 3000 oil and gas **deposits** are to be found in Russia, about half of them under **exploitation**. Western Siberia and the Urals-Volga region are the main centres of oil and gas industry, providing 95 per cent of Russian oil and gas production. Oil **resources** were explored in 40 federative units of the Russian Federation, more then half of them are in the Khanty-Mansiisk **autonomous** region. Large oil reserves are in deposits of the Yamalo-Nenetskii and Nenetskii autonomous regions, Tatarstan, Baskortostan, Udmurtia and some other regions. From 80 to 90 percent of explored oil reserves are under industrial production in the main oil regions. Gas resources have been found in 33 **units** of the Russian Federation. The total amount of discovered gas available for industrial production is 46.6 trln m^3. The Yamalo-Nenetskii autonomous region contains 34.6 trin m^3 or 74 percent of the gas. Large gas deposits were also found in the Astrakhan and Orenburg regions, Saha (Yakutia) republic, at the shelf of the Barents, Kara and Okhotsk seas etc.

The gas-production industry of the Russian Federation has more **resources** than that of oil-production. At the beginning of 2001 47 per cent of discovered resources **were under production** and 18 per cent of them were **worked out**. They are concentrated in three regions – the Astrakhan and Orenburg regions and Yamalo- Nenetskii autonomous region. The rules of **depths usage** were **stipulated** by federal laws "On depths", "On production division agreements", "On continental shelf of the Russian Federation", Regulation on the **procedure** of **issuing licenses** for depths use and several other federal, territorial and ministerial regulations.

The right to use the depths can be **rendered** on the base of a license for geological research of the depths for 5 years, for production of minerals for 20 years and for geological research of the depths and production of minerals for 25 years. It can be generally stated that **despite prolonged** activity of the oil and gas production industries and economical difficulties in the last years there are large reserves of hydrocarbon raw materials. The raw materials are of different qualities and **unevenly** distributed, unevenly worked out and still there are considerable geological and technological possibilities to improve production of oil and gas. These possibilities, **to a great extent**, are connected with technical and technological modernization of oil, gas and **gas condensate** deposits, development of **infrastructure** and beginning of production in new regions, use of heavy oils, coal gas and other factors.

Objective evaluation of presence in the depths of Russia of large **profitable** oil and gas resources as well as economical, technical, social, political and ecological factors form the bases of a long-term strategy of development of the Russian oil and gas complex.

In the end I would like to stress once more that Russia has a large potential of unexplored oil, gas and condensate resources. Its economic importance is extremely high and will increase considerably in the future along with increases of energy **consumption** in Russia and in the world. This opens the way for different forms of large international projects in the sphere of geological exploration of oil and gas fields in Russia. The projects may be of different term and investment **share** of foreign companies. Russia is interested to make this co-operation stable and long-term.

(B.A. Yaskevich,
Minister of natural resources of the Russian Federation)

Exercise 4. Answer the following questions.

1. How does Russia carry out a policy of search and exploration of oil and gas fields?
2. How much liquid hydrocarbons and gas have been extracted so far?
3. How many oil and gas deposits are found in Russia?
4. What are the main centres of oil and gas industry?
5. How is oil and gas extraction regulated?
6. How long can the license for geological research be valid?
7. In what way can economical difficulties be solved in oil and gas industry?
8. What are the main components of a long-term strategy of oil and gas complex development?
9. What makes Russia attractive for foreign investments?
10. Is Russia open for international cooperation? Prove it using information from the text and your general knowledge.

Exercise 5. Agree or disagree with the following statements.

1. Russian oil and gas resources are almost exhausted.
2. Large international projects can be realized in Russia.
3. There is only one federal law regulating the rules of depths usage.
4. The raw materials are very similar all over the country.
5. Russia is interested in getting foreign investments.

Exercise 6. Complete the sentences.

1. The gas-production industry … than that of oil-production.
2. The amount of investments can be as great as … .
3. Most oil resources are to be found in … .
4. 74 % of gas is located in … .
5. Exploration and production of hydrocarbons are carried out on the basis of … .
6. With technical and technological modernization of oil and gas deposits it is possible to … .
7. A long-term strategy of oil and gas complex development is based on … .
8. Worldwide increase of energy consumption opens the ways of … .

Exercise 7. Discuss in pairs .

a) Think and say. Do you find the speech of the Minister optimistic? Pick out some facts and prove that the future of oil and gas industry is favourable.
   If you don't share the optimism of B.A. Yaskevich, explain why. What are the negative effects of oil and gas production?
b) Pair work.
   You are a foreign journalist of "The Economist" Mr.Yaskevich is giving a press conference. Ask him questions about oil and gas development prospects in Russia.

Exercise 8. Discuss the following questions before reading the text.

1. Are the USA rich in oil and gas? Where are oil and gas extracted? (name some regions) What American oil and gas companies have you heard of?
2. What kinds of oil and gas companies do you know? (according to their main activities)

Special terms:
flooding – заводнение (пласта)
mature – зрелый
mature production – поздняя стадия разработки месторождений
overhead – накладные (общие) расходы производства
to exploit – эксплуатировать, разрабатывать месторождения

to deplete – истощать, исчерпывать (запасы), хищнически эксплуатировать

Now try to guess the meaning of the terms “*the exploitationist*” and “*the depletionist*” in reference to oil companies.

OPPORTUNITIES AWAIT U.S. INDEPENDENTS WILLING TO CHANGE

Major **trends** are changing the ways independent oil and gas producers do business. Companies that recognize these major trends and take advantage of them will **prosper**. The ones that don’t change will **wither on the vine**. The trends **reflect** the advanced stage that the U.S. has reached in the production **cycle** of its petroleum resource. **Mature** production means that:

• Major oil companies have sold off many of their **low-return properties** and **shifted** their financial resources and human resources to **core properties**.

• Major oil companies are shifting assets from the U.S. to other producing countries at earlier stages of production.

• The operating **divisions** of major oil companies in the U.S. are becoming more like independents.

• Independents are filling the **void** left by major oil companies.

• These independents are either exploitationists or depletionists.

These trends are changing not just business practices but the positions independent producers take on **long-running** political issues.

Three ages

In 1956 M.King Hubbert, an American scientist, made the prediction of oil production in the USA. His predictions were based upon the production life of oil fields and they are still true. Using the Hubbert **curve**, we have divided the life of the oil industry in the U.S. into three ages. Each age lasts **approximately** 35 years. The first age, when the oil industry was “young”, lasted from 1918 to 1953. The industry’s “middle age” lasted from 1953 to 1988. The “mature” stage will last from 1988 to 2023.

From ages to stages
The production life of the field can be divided into three stages corresponding to the industry's ages. The first, exploration, **coincides** with the industry's youth. This stage **favors** the major oil companies, with their vast financial and human resources. The main players are geologists and geophysicists. During this stage, large risks are taken. The stage coinciding with the middle age is exploitation, when the large fields discovered during the exploration stage are **waterflooded**. Again, it favors the major oil companies because they own the large fields and have the financial and human resources to **install** and operate large waterfloods. The principal players in this stage are engineers. Large risks are taken during this stage, but not as large as risks of the exploration stage.

The **depletion** stage occurs during the mature age. At this stage, current fields are worked on by **plugging** back or deepening wells to new producing zones, and by infill drilling. Fields smaller than the discoveries of the exploration stage are found, and waterfloods begin in fields smaller than those waterflooded in the exploitation stage. Depletion is a stage of innovation, where many ways are found to do things cheaper and more **efficiently**. During this stage we see the **widespread** application of new technology such as 3D seismic, horizontal drilling, and CO_2 flooding. This is the first stage that does not favor the major oil companies. Their large financial and human resources are better **adapted** to exploring for and exploiting large fields. Depletion favors independents, with their much lower **overhead**. And it favors two types of independents: the exploitationist and the depletionist.

Independent types
The exploitationist has a full staff of engineers, geologists, **landmen**, and accountants. He is familiar with and has participated in most of the new technology: 3D seismic, horizontal drilling, CO_2 flooding, and so forth. In addition, he is capable of drilling wells very cheaply and has very low overhead. I like to think that my company, Henry Petroleum Corp., is an exploitationist. The exploitationist is willing to take some risks but does very little pure exploration.

The second type of company, the depletionist, is much different from the exploitationist. A depletionist has **virtually** no technical staff. With his low overhead he is able to operate wells much cheaper than either the major oil companies or the exploitationist. He will **nurse** wells along and pay close attention to them but does not have the technical staff to operate waterfloods and CO_2 floods or to conduct 3D seismic. The depletionist is **risk-averse**. Independent operators must decide whether they will be exploitationists or depletionists. There is little room for compromise between the types. You can be either an exploitationist with a large technical staff or a depletionist with very little, if any, technical staff; you can't be both.

(O&G Journal, November 2007)

Words and expressions

trend	направление, тенденция
to prosper	преуспевать, процветать
to wither on the vine	остаться нереализованным
to reflect	отражаться
cycle	цикл
mature	высокоразвитый
low-return properties	низкоприбыльная собственность
to shift	менять, перемещать
core properties	основная собственность
division	отдел, подразделение
void	пустота
long-running	долго играющий
curve	кривая
approximately	приблизительно
to coincide	совпадать
to favor	помогать, содействовать
to waterflood	заводнять
to install	устанавливать
depletion	уменьшение, истощение (ресурсов)
plugging	тампонирование, закупоривание
efficiently	эффективно, рационально
widespread	широко распостраённый
to be adapted to	быть адаптированным к чему-либо
overhead	отбираемый с верха (колонны) ; надземный (о трубопроводе)
landman	рабочий
virtually	фактически, в сущности
nurse	экономно вести хозяйство; беречь
risk-averse	не расположенный к риску

Exercise 9. Answer the questions.

– Did you find the explanation of the terms “the exploitationist”, “the depletionist” in the text? What were you right/wrong in?
– Can you state the difference between these companies now? Give a detailed answer.

Exercise 10. Answer the following questions.

1. What stage in the production life of its petroleum resource has the U.S. reached?
2. Why have major oil companies sold off their properties?
3. How do independent companies appear?
4. What kind of independents are they?
5. What are the three ages in the life of U.S. oil industry?
6. What kind of companies prefer to work during the first exploration stage? Why?
7. What specialists do the companies mainly need during the second exploitation stage? Why?
8. Why does the author call the third depletion stage a stage of innovation?
9. What companies operate during depletion stage?
10. In your opinion, what companies get the greatest profit?

Exercise 11. Translate into English.

1. Производственный цикл месторождения имеет три стадии.
2. Крупные нефтяные компании обладают обширными средствами.
3. Крупные нефтяные компании сильно рискуют на стадии разведки месторождения.
4. Экономический риск на стадии эксплуатации не такой большой, как на стадии разведки.
5. Независимые компании ищут более дешевые и эффективные способы эксплуатации месторождений.
6. Независимые компании имеют более низкие общие расходы производства, чем крупные нефтяные компании.

Exercise 12. Give English equivalents to the following words and phrases from the text.

Пользоваться преимуществом чего-то, переводить активы, нефтедобывающие страны, деловая практика, производственный цикл, широкое применение новых технологий, трехмерные сейсмические исследования, горизонтальное бурение, технический персонал.

Exercise 13. Think of the nouns from the text which can be used with these verbs. Make up some sentences.

ex: *to change – to change trends.*
Major trends of business in oil and gas industry are changing.

To take advantage of, to reach, to sell, to shift, to divide, to favor, to take, to waterflood, to find, to apply, to participate in, to conduct, to pay attention to.

Exercise 14. Read the text quickly to find answers for the questions below. You may need some terms to grasp the main ideas of the text.

E&P spending (spending on exploration and production) – затраты на поиск и добычу
to overspend – потратить больше, чем было запланировано
a survey – опрос, обследование, обзор
growth rate – темп роста

LEHMAN BROS: E&P SPENDING TO SEE SLOWER GROWTH

After “extremely strong growths” of 20% in 2005 and 30% in 2006, **global exploration** and **production spending** is expected to rise slower: rate of 9% to $300 billion in 2007, with more **emphasis** on international rather than US projects, said analysts at Lehman Bros. Inc., New York. That’s based on the company’s latest E&P Spending Survey of some 300 public, private, and government-owned oil and gas companies, “the largest ever” such study since-Lehman-Bros began the **semiannual** surveys in 1982, said James Crandell, oil service analyst at the firm.

International spending

The **surveyed** companies said they plan to increase their international E&P spending by 13 % to $200 billion in 2007, after a 28 % growth in 2006 US spending will grow by 5.1 % to $ 75 billion in 2007, following a 40 % **boost** in 2006.

Canadian spending will be down 8% next year however, compared with a 19% increase in 2006. "**Deteriorating** economics are more **pronounced** in Canada", Grandell said. He also noted "the **impact** of Anadarko [Petroleum Corp.] leaving the region" and "**relatively** large **declines**" in the operations of other large companies such as Apache Corp. Canadian Natural Resources Ltd. recently agreed to buy Anadarko Canada Corp. for $4.24 billion, but Anadarko **maintains interests** in the Mackenzie Delta and other Canadian arctic **frontier**, properties (OGJ Online, Sept., 14, 2006). In 2005 Apache and ExxonMobil Corp. completed a series of agreements for **transfers** and **joint ventures** across a broad range of properties in Western Canada, the Permian basin, Louisiana, and the Gulf of Mexico Outer Continental Shelf.

Companies significantly overspent their budgets in 2006; particularly on international projects, where 60 % of the surveyed companies said they spent more than 10 % over their original E&P budgets. National oil companies will lead the 2007 increase in international spending with the largest spending growth among the Russian companies, Crandell said. The five largest Russian companies are expected to **hike** their international spending by an average of 42 % to $24.3 billion, he said.

Other companies estimated to have **double-digit gains** in international E&P spending include: Chevron Corp., up 34 %; Apache, up 20 %, India's, state-owned Oil & Natural Gas Corp. and Petroleos Mexicanos, up 11 % each; Petroleo Brasileiro SA (Petrobras), up 18 %; Repsol YPF SA, up 19 %; Woodside Petroleum Ltd., up 62 %, PetroChina Co. Ltd., Statoil ASA, and Royal Dutch Shell PLC each up 10 %. However, several other companies are **moderating** those international gains with "either small declines or small increases", Crandell said Among those are: Anadarko, flat, BHP Billiton Ltd., up 4 %; BP PLC, down 2 %; ConocoPhillips, up 5 %; ExxonMobil, up 7 %; Eni SPA, up 8 %; Petroleos de Venezuela SA, up 1 %; and Total SA, up 7 %.

US spending

The surveyed companies plan a **substantial slowdown** in the growth rate of their US E&P expenditures in 2007 due to concerns about **cash flow** and **perception** of lower gas prices. Companies **responding** to the survey said their plans are based on an average gas price of $ 6.72/Mcf in 2007, "and that's going to increase concern regarding project economics", Crandell said.

RepsolYPF, Eni, Murphy Oil Corp., and Quicksilver Resources Inc. will be making some of the larger cuts in US E&P spending, he said. Other companies indicating “above-average declines” in US spending include Anadarko, Cabot Oil&Gas Marathon Oil Corp., Newfield Exploration Co., and Plains Exploration & Production Co. Drilling economics are seen as attractive in the industry but the percentage is down from last year, said Lehman Bros, analysts. “For the long term, E&P companies were very positive on the outlook for oil and natural gas. Over half view the longterm real price, of oil at $ 50–70/bbl, with half expecting the price to be $ 50–70/bbl for the long term and half expecting **crude** to be $ 60–70/bbl. Companies also are **overwhelmingly bullish** on natural gas with **roughly** 85 % of respondents saying longterm outlook for natural gas drilling is good or excellent” Sedita said.

Questions:

1. What is the main tendency of global exploration and production spending?
2. Will growth rate be quicker or slower in 2007 as compared to that one in 2005 and 2006?
3. Who made E&P Spending Survey?
4. Does Canada keep to this growth tendency?
5. What companies will have the largest spending growth?
6. What companies showed insignificant change in E&P spending?
7. Why will US E&P expenditures slow down in 2007?
8. What is the expected oil price range?

Words and expressions

global exploration	мировое исследование, разработка
production spending	затраты на прориизводство
emphasis	внимание, ударение
semiannual	полугодовой
surveyed	проанализированный
boost in	повышение в, подъем
deteriorating	ухудшение
to be pronounced	быть резко выраженным
impact	влияние
relatively	относительно

decline	спад
to maintain interest	сохранить интерес
frontier	граница
transfer	передача в собственность
joint venture	совместное предприятие
to hike	внезапно подниматься
double-digit gain	двойная выручка
to moderate	сдерживать, уменьшать
substantial slowdown	существенное замедление
cash flow	движение денежной наличности
perception	восприятие
to respond	отвечать
crude	сырой, неочищенный
overwhelmingly	очень, чрезвычайно
bullish	играть на повышении
roughly	приблизительно, ориентировочно

Exercise 15. Imagine that you are an oil and gas analyst. Prepare a short report on the problems and perspectives in oil and gas industry development.

Exercise 16. Discuss the following with your partner before listening.

An embargo happens when a country stops trading with another. In 1973, there was an embargo on oil. What effects do you think this had on the world's economies?

Listen and complete the notes.

1. After …………, industrial nations enjoyed economic growth.
2. They used huge amounts of ……….
3. A lot of oil came from countries in the ………….
4. The embargo began on the …………, 1973.
5. Prices of oil rose to …………times higher than before.
6. The New York Stock Exchange lost …………dollars in a few weeks.
7. The embargo ended in ………….

Exercise 17. Discuss the following points.

1. What well-know foreign oil and gas companies have you heard of? Can you give any names? What countries were they set up? What countries do they operate in?
2. What Russian oil and gas companies do you know? What regions of the country do they operate in? What are their main activities? Do you know any facts from their history?

Key words: global energy provider, listed company, shareholder, petroleum refining, drill bit, down hole tool, joint venture, lubricant, cost-cutting program, licence, stake, proven reserves.

Exercise 18. Read the text.

TOTAL

Total at a Glance (2005 figures)
A global multi-energy provider

• World's fourth-largest **integrated listed** oil and gas company
• Largest **market capitalization** on the Paris Bourse and the eurozone: ˆ130.5
billion at December 31, 2005
• 95, 000 employees (1)
• Operations in more than 130 countries
• Exploration and production operations in 41 countries
• Producer in 29 countries
• More than 500,000 **shareholders**
• 2005 sales: ˆ143.2 billion

Total's operations **span** the entire oil and gas chain, from exploration, development and production to **midstream** gas, refining and marketing, and crude oil and petroleum product **trading and shipping**. Total is also a world-class chemicals producer, as well as having interests in coal mines, cogeneration and power generation. In addition, Total is helping to secure the future of energy through its **commitment** to developing **renewable** energies, such as wind, solar and **photovoltaic power**.

A leader in each of the core businesses: 2005 **key indicators**

• Exploration & Production: – Production: 2.49 million barrels of oil equivalent per day – Reserves: 11.1 billion barrels of oil equivalent as of December 31, 2005
• Refining & Marketing: No. 1 European Refiner-Marketer and No. 1 in Africa- Refining capacity: **approximately** 2.7 million barrels per day- Retail network: nearly 17,000 service stations – Sales: approximately 3.9 million barrels per day – Brands: TOTAL, Elf, Elan, AS 24
• Chemicals: Total is one of the world's largest integrated producers and a European or global leader in each of our markets – Petrochemicals and **Fertilizers**, Specialties.

Shareholder base

- **Predominantly** European (75 %), held in particular by investors from France (33 %), the United Kingdom, Germany, Switzerland and Belgium. Strong shareholder base in North America.
- Institutional shareholders (87 %), employees (4 %) and other individual shareholders (9 %).
- Total S.A. is a French société anonyme (**limited company**) created in March 1924.
- Total is listed on the CAC 40, Dow Jones Stoxx 50, Dow Jones Euro Stoxx 50 and Dow Jones Global Titans 50 indices and the FTSE4Good, DJSI World, DJ STOXX SI, FTSE ISS CGI and ASPI Sustainable Development and Governance indices.

Words and expressions

integrated	объединенный, единый
listed	перечисленный
market capitalization	рыночная капитализация
shareholder	акционер
to span	охватывать
midstream gas	газ в середине потока
trading	торговля
shipping	транспортировка
commitment	обязательство
renewable	возобновляемый, заменяемый
photovoltaic power	фотоэлектрическая энергия
key indicator	основной критерий оценки
approximately	приблизительно
fertilizer	удобрение
predominantly	особенно, преимущественно
limited company	общество с ограниченной ответственностью

HALLIBURTON

For almost a century, Halliburton has made an **indelible** impression on the world. From developing **breakthrough** technologies and constructing monumental infrastructure projects to managing logistics for **military** operations, Halliburton and our **predecessor** companies have been leaders in the energy services and engineering and construction (E&C) industries. Halliburton has **expanded** through internal growth and **acquisition** since it was established in 1919. Major **purchases** include Brown & Root, an engineering and construction company, in 1962 and Dresser Industries, a major provider of integrated services and project management for the oil industry, in 1998. Dresser had acquired M.W. Kellogg, a leader in petroleum **refining** and petrochemical **processing**, technology, engineering and construction, in 1988.

About Halliburton

Halliburton adds value through the entire lifecycle of oil and gas reservoirs, starting with exploration and development, moving through production, operations, **maintenance**, **conversion** and refining, to infrastructure and **abandonment**. We operate in over 120 countries working in four major operating groups.

Halliburton consists of three business segments:

• Drilling, Evaluation and Digital Solutions

• Fluid Systems

• Production Optimization

These segments offer a broad **array** of products and services to **upstream** oil and gas customers worldwide, ranging from the manufacturing of **drill bits** and other **downhole and completion tools** to **pressure pumping services**. KBR, Halliburton's engineering **subsidiary**, is a global leader in construction and project management, with a strong historical position in LNG and oil and gas projects. The company is a leading **government services contractor** as well.

Halliburton Vision Statement

Leading the world in integrated energy services, energy equipment, engineering, construction, and maintenance. Supported by four key goals:

• Technological Leadership

• Operational Excellence

• Innovative Business Relationships

• Dynamic Workforce

Words and expressions

indelible	незабываемый, неизгладимый
breakthrough	прорыв
military	военный
predecessor	предшественник
to expand	расширяться, развиваться
acquisition	приобретение
purchase	покупка
refining	очистка; переработка (нефти)
processing	обработка (химическая или термическая)
maintenance	техническое обслуживание и ремонт
conversion	переработка, химическое превращение
abandonment	ликвидация скважины
fluid System	жидкостная система
array	ряд
upstream	апстрим
drill bit	буровая коронка, буровое долото
downhole and completion tool	оборудование для забоя и заканчивания скважины
pressure pumping service	работы по снижению давления
subsidiary	дочерний
government service contractor	сервисная фирма, выполняющая государственный подряд

BP – BRITISH PETROLEUM

The BP group operates across six continents, and our products and services are available in more than 100 countries.

Africa

Our **exploration and production activity** in Africa is focused on Algeria, Angola and Egypt. We have working relationships with many national oil companies in this region. These are typically joint ventures, with BP providing management **support**, technical expertise and training. **Elsewhere** in Africa, our main activities are in refining and marketing, with a significant

retail presence in Southern Africa and marketing operations for **lubricants**, oil and gas products, **and solar panels** across the continent.

Asia

In Asia, our exploration and production activities are centered in China, Indonesia, Vietnam and Pakistan, while we do significant chemicals manufacturing in China, the Philippines, South Korea and Malaysia. BP also holds a leadership position in Liquefied Natural Gas (LNG) in China, where we are involved in a number of joint ventures. In fact, our working relationships with many national oil companies in Asia – for example Kuwait and United Arab Emirates – are typically joint venture activities. BP Solar has a manufacturing plant in India. We market lubricants and oil products throughout the region, with major retail operations in India and China.

Australasia

Our exploration and production activities in Australia and New Zealand are centred in Australia, where BP Solar also has a manufacturing plant. Sales and marketing of lubricants and oil products takes place throughout the region, with major retail operations in both Australia and New Zealand.

Europe

London is where BP's **corporate headquarters** are located, and the UK is therefore a centre for trading, legal, finance and other **mainstream** business functions. The UK is also home to three of BP's major global research and technology groups. Our exploration and production business in Europe covers the North Sea – both the UK and Norway – and also The Netherlands. In Russia we have an important joint venture through our 50 per cent ownership of TNK-BP, a major oil company with the majority of its assets in Russia. We are involved in a number of exploration and production projects in Azerbaijan, and are leading the Baku-Tbilisi-Ceyhan (BTC) pipeline project. Refining and marketing activities are spread throughout Europe, with BP owning or having a **stake** in nine refineries across the region. BP retail sites are a common sight in several European countries. In Germany we market under the Aral brand. We also sell lubricants and other oil products in Europe to both consumers and business customers. One of BP Solar's manufacturing sites is based in Spain and we also have a number of chemical plants in the region.

North America

The BP group is the largest oil and gas producer and one of the largest gasoline **retailers** in the United States. We are the largest non-US company on the New York Stock Exchange. Our BP Alternative Energy business has an operations centre in Houston, and we also have solar manufacturing facilities in the USA. In Canada, our activities focus on the production of natural gas and **derivatives** and we are currently considering a North American natural gas pipeline project in a joint venture. Exploration and production work is a core aspect of BP's presence in Trinidad and Tobago – where we are a major local producer.

South America

Exploration and production work is a **core aspect** of BP's presence in Colombia and Venezuela. In Brazil we have a chemicals joint venture and significant solar projects. Elsewhere in South America, our activities centre on the sale of oil, lubricants and oil products.

Words and expressions

exploration activity	поиск полезных ископаемых
production activity	производственная деятельность
to support	поддержать
elsewhere	где-то в другом месте
retail	розничный
lubricant	смазочный материал
solar panel	солнечная батарея
corporate headquarters	штаб-квартира корпорации
mainstream	основной, представляющий большинство
stake	доля, участие (в капитале предприятия)
retailer	розничный продавец
derivative	производное соединение
core aspect	ключевой аспект, основная причина

ROSNEFT

Rosneft was one of the last vertically integrated oil companies to **emerge** from the reorganization and large-scale privatization of Russia's oil industry in the years following the **dissolution** of the Soviet Union. Initially, Rosneft was established in 1993 as a state enterprise on the basis of **assets** previously held by Rosneftegaz, the successor to the USSR Ministry of Oil and Gas.

In 1995, a Russian government decree transformed Rosneft into an open joint stock company (OJSC). From 1995 until 1998, Rosneft **endured** a series of **rapid** management changes that undermined the practical control which successive Moscow-based executives were able to exert over the Company's assets. This undermined the coordination between Rosneft's various businesses and, thus, did significant harm to the Company's overall operational performance with production declining and the limited utilization of **refining capacity** throughout the period.

Recovery

In order to secure Rosneft's position as an important player in Russia's energy industry, the government **appointed** a new management team in October 1998, headed by the Company's current president, Sergey Bogdanchikov. The new team immediately began **implementing** what would become a **full-scale turnaround** of the Company. By 2000, Rosneft was again realizing profits. That year also marked the start of a new period of growth, with average oil production increases in **excess** of 11% annually.

Continued growth and expansion

Improved management, asset **acquisition** and consolidation, financial discipline and technological integration all resulted in significantly improved performance from existing assets and allowed Rosneft to **embark** on a program of growth and **expansion**.

From 2000-2004, Rosneft boosted its annual oil production, from 268 kb/d in 2000 to 433 kb/d in 2004. Gas production increased from 5.6 bcm in 2000 to 9.4 bcm in 2004. In 2001, Rosneft became the official state representative in Production Sharing Agreements (PSAs). In 2002, Rosneft expanded its international operations by entering into projects in Algeria. In 2003, the Company began producing oil at the Aday block in the Caspian Sea region of Western Kazakhstan, and in 2005, it entered a PSA at the Kurmangazy structure on the Caspian Sea shelf in Kazakhstan.

Rosneft has **pursued** its **upstream asset acquisition strategy** in Russia with a focus on geological quality and transport efficiency. Among the key assets acquired between 2000 and 2004 were Selkupneftegaz (2000), Severnaya Neft (2003), the Veninsky block at Sakhalin-3 (2003) and the Anglo-Siberian Oil Company (2003), owner of the license to the Vankor oilfield in Eastern Siberia. In December 2004, the Company purchased a controlling stake in one of Russia's largest oil and gas companies, Yuganskneftegaz.

This acquisition, together with significant organic growth, has **propelled** Rosneft into its current position as Russia's second largest oil producer, with average daily production of approximately 1.5 million barrels in 2005. In early 2005, Rosneft won the auction to the Vorgamusur field in the Timano-Pechora province, an acquisition that will ensure further growth of Severnaya Neft, whose operations are located only 80 kilometers away.

At the end of 2005, Rosneft announced the acquisition of a 25.94 % stake in Verkhnechonskneftegaz, which was later **complemented** by the acquisition of an exploration license to the East Sugdinsky block. These acquisitions are consistent with the Company's goal of establishing a major presence in Eastern Siberia which it believes is **poised** to become one of Russia's most significant new oil and gas production bases.

In July 2006, Rosneft conducted its first ever public share offering, which raised USD 10.6 billion, making it the world's fifth-largest IPO. Finally, in October 2006, Rosneft completed the consolidation of 12 of the Company's upstream and downstream subsidiaries. This consolidation program will allow for further improvements in **transparency** and management efficiency as Rosneft grows as a public company.

1993 – Rosneft established as a state enterprise on the basis of Rosneftegaz, the shortlived **successor** to the USSR Ministry of Oil and Gas.

1995 – Rosneft transformed into an OJSC.

1998 – New management **appointed** at Rosneft to begin **rehabilitation** work. First crude oil produced on the Sakhalin shelf.

1999 – Cost-cutting program **launched**. Major reconstruction of the Komsomolsk Refinery begins. Well efficiency enhancement program implemented.

2000 – Financial performance improves in all areas. Introduction of modern satellite communications network.

2001 – Rosneft appointed as the state representative in PSA (Production Sharing Agreement) projects.

2002 – Rosneft appointed as official representative of the Russian Federation in developing the Caspian Sea's Kurmangazy field. Sakhalin-5 **gets underway**. Rosneft awarded license to develop the Kaygansko-Vasyukansky sector. Rosneft awarded licenses to develop the Kynsko-Chaselskaya and Udmutsko-Chatylkinskaya groups of fields.

2003 – Rosneft purchases Severnaya Neft. Rosneft receives license to develop the Vankor and Northern Vankor fields in Eastern Siberia. Oil production begins at the Aday block in Kazakhstan. Development begins on the Sea of Azov shelf. Oil production begins at the Kynsky deposit. Rosneft receives exploration license to the Veninsky sector at Sakhalin-3.

2004 – First **prospective drilling** at Vankor. First prospective drilling at Sakhalin-5. Launch of transport system involving the Belokamenka floating **oil storage facility** and Privodino station. Rosneft purchases Baikalfinansgroup LLC, owner of Yuganskneftegaz.

2005 – Oil production begins at Sakhalin-1. Operational and logistical integration of Yuganskneftegaz. Geological prospecting continues at the Vankor and Northern Vankor fields; a well with a flow of 1,000 cubic meters a day is drilled. Completion of Udachnaya-1 exploration well drilling at Sakhalin-5, with highly promising reserves discovered. Purchase of strategic stake in Verkhnechonsk oil and gas condensate field. Purchase of East Sugdinsky development license. All-time oil production high of 74.6 million tons is achieved.

2006 – Exploratory drilling begins at the Kurmangazy structure. Rosneft acquires 51 % stake in Udmurtneft. Rosneft conducts USD 10.6 billion IPO. Consolidation of 12 subsidiaries completed.

Words and expressions

to emerge	возникать
dissolution	распад
assets	активы
to endure	терпеть, вынести

rapid	быстрый
refining capacity	перерабатывающие мощности
to appoint	назначить
implementing	осуществление
full-scale	полномасштабный
turnaround	полное изменение
excess	превышение
acquisition	получение, приобретение
to embark	начинать, вступать в дело
expansion	развитие, рост
to pursue	преследовать, добиваться
upstream	апстрим
asset acquisition strategy	стратегия приобретения активов
to propel	двигаться вперед, продвинуться
complemented	дополненый
to be poised	быть готовым
transparency	прозрачность
successor	преемник, наследник
to be appointed	быть назначенным
rehabilitation	восстановление
launched	предпринимать, начинать
to get underway	начать осуществлять
prospective drilling	перспективное бурение
oil storage facility	нефтехранилище

LUKOIL

The company was founded by three West-Siberian oil and gas plants: “Langepasneftegas”, “Urayneftegas” and “Kogalimneftegas”. This initial letters of these names formed the first part of the new presence in the Russian oil and gas industry – LUKOIL.

LUKOIL is one of the world’s leading vertically integrated oil & gas companies. Main activities of the Company are exploration and production of oil & gas, production of petroleum products and petrochemicals, and marketing of these outputs. Most of the Company’s exploration and production activity is located in Russia, and its main resource base is in Western Siberia. Most of the Company’s production is sold on the international market. LUKOIL petroleum products are sold in Russia, Eastern Europe, CIS countries and the USA. LUKOIL is the second largest private oil

Company worldwide by proven hydrocarbon reserves. The Company has around 1.3 % of global oil reserves and 2.1 % of global oil production. LUKOIL dominates the Russian energy sector, with 18 % of total Russian oil production and 18 % of total Russian oil refining. LUKOIL **proven reserves** at the beginning of 2005 were 15,972 mln barrels of crude oil and 24,598 bcf of natural gas, totaling 20,072 mln.

LUKOIL has an outstanding portfolio of production assets. The main production region for LUKOIL Group is Western Siberia. The Company is developing a new production base in Timan-Pechora where its crude oil output has increased by more than 1.6 times in 5 years. LUKOIL is carrying out international exploration and production projects in Kazakhstan, Egypt, Azerbaijan, Uzbekistan, Saudi Arabia, Iran, Columbia, Venezuela and Iraq. With putting into operation the Nakhodkinskoye gas field the Company started its gas program which **targets** at a rapid growth of gas production in the mid-term.

The key regions for development of LUKOIL gas production are the Bolshekhetskaya Depression and the Northern Caspian as well as the Kandym – Khauzak – Shady project in Uzbekistan and the Shakh Deniz project in Azerbaijan. LUKOIL owns significant oil refining capacity both in Russia and abroad. In Russia the company owns four large refineries at Perm, Volgograd, Ukhta and Nizhny Novgorod. Total capacity of LUKOIL facilities in Russia is 41.8 mln tons of oil per year. LUKOIL also has refineries in Ukraine, Bulgaria, and Romania, with total capacity of 16.7 mln tons per year. In 2004 LUKOIL refined 44.0 mln tons of oil at its own refineries, including 35.5 mln tons at its Russian refineries.

By the end of 2004 LUKOIL's sales network covered 17 countries of the world, including Russia, the CIS (Azerbaijan, Belarus, Georgia, Moldova, Ukraine), Europe (Bulgaria, Hungary, Cyprus, Latvia, Lithuania, Poland, Serbia, Romania, Czech Republic, Estonia) and the USA, and consisted of 199 tank farms and 5,405 filling stations. LUKOIL sales network consisted of 10 marketing **entities** operating in 59 regions of Russia.

Words and expressions

proven reserves	достоверные запасы
target	делать мишенью, целиться
entity	экономический объект

Exercise 19. Answer the following questions.

1. What spheres does Total operate in?
2. Does Total operate only in France?
3. When was Total created?
4. What does the abbreviation S.A. (Total S.A.) stand for?
5. When was Halliburton established?
6. In what way did Halliburton expand?
7. How many countries does Halliburton operate in?
8. What are the key goals of the company?
9. Can we say that British Petroleum operates worldwide?
10. Does BP form joint ventures in many countries? (Give some examples).
11. Where are BP's corporate headquarters located?
12. What is TNK-BP? What does the abbreviation TNK stand for?
13. What are the major activities of BP?
14. How was Rosneft established?
15. Was Rosneft a successful company from the start?
16. Do you consider Rosneft's growth and expansion very impressive?
17. How many subsidiaries does Rosneft have?
18. What are the main activities of LUKOIL?
19. What were the companies that founded LUKOIL?
20. Does LUKOIL carry out international projects?
21. What is the total capacity of LUKOIL facilities in Russia and abroad?

Exercise 20. Complete the sentences.

1. Rosneft emerged as a result of … .
2. Bad management coordination did … .
3. New acquisitions and international operations made Rosneft … producer.
4. Easten Siberia is viewed as … .
5. LUKOIL main resource base is in … .
6. LUKOIL sells its products in … .
7. LUKOIL has refineries both in … and … .
8. BP products and services … in more than 100 countries.

9. London is the center for BP's … .
10. BP forms a lot of … in the countries where they operate.
11. The major part of Total's investors are from … .
12. Halliburton provides services in … industries.

Exercise 21. Match each abbreviation with its full version and translate.

1. OJSC	a) Dow Jones
2. PSA	b) Initial Public Offering
3. LLC	c) billion cubic feet
4. IPO	d) Liquefied Natural Gas
5. bcf	e) Limited Liability Company
6. LNG	g) Open Joint Stock Company
7. DJ	h) Production Sharing Agreement

Exercise 22. Discuss the following with your partner before listening.

Russia is the second largest oil producer in the world. It also produces huge amounts of natural gas. How many other oil producing nations can you name?

Listen to the text and complete the notes with the correct numbers.

Russia's gas reserves: (1)………… cubic meters.
Russia's gas output: (2)……… cubic meters per day.
Russia's oil reserves: (3) ………barrels.
Russia's oil output: (4)…………barrels per day.
Proportion of European oil and gas bought from Russia: (5)…………
Proposed pipeline to connect Russia with China and South Korea:
Length of pipeline: (6)………… km.
Cost of proposed pipeline: (7)…………$.

Exercise 23. Make up dialogues.

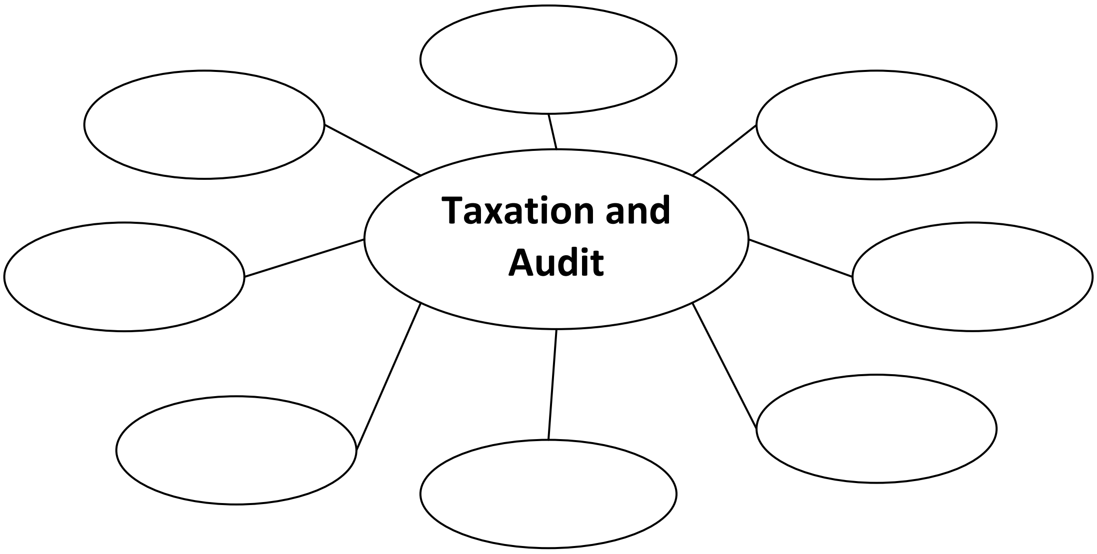
a) Imagine that you are a PR representative of one of the oil companies. You are asked to make a press release about main activities and historical background of your company.
b) Pair work. You were invited for a job interview. You are an applicant and talk to an interviewer of an oil company. Find out as much information as possible.

UNIT 5

TAXATION AND AUDIT

Lead-in

Fill in the spidergram with the words associated with Taxation and Audit.



Discuss.

1. What does the word “tax” mean? What kind of taxes do you know? Where do taxes taken by governments go to?
2. Do you think all people should pay equal taxes? How much is income tax in Russia now? In your opinion, is it fair when oil and gas companies pay taxes on the usage of natural resources? Why? Why not?

Terms and Vocabulary

distinction	различие
taxes	налоги
direct taxes	прямые налоги
revenue authorities	департамент налогов и сборов, финансовое управление
incidence	снижение налогового бремени
income tax	подоходный налог
vehicle excise duty	акцизный сбор с транспортного средства
indirect taxes	косвенные налоги
burden	налоговое бремя, расходы
elasticity of demand	эластичность спроса
demand curve	кривая спроса
to recoup	возместить
to assert	утверждать
individual tax	налог физических лиц
collection cost	затраты на взыскание
capital gains tax	налог на прирост капитала
controversial	противоречивый
progressive	пропорционально увеличивающийся
regressive	регрессивный
proportionate	соразмерный, пропорциональный
flat rate	единая ставка, цена без начисления процентов
to distort	искажать, изменять
deliberate	спланированный, взвешенный
demerit goods	недостаточные товары
pricing policy	ценовая политика
foreign trade	внешняя торговля
to levy	облагать налогом, взимать
profligate	неэкономный, расточительный
principle of non-distortion	принцип невмешательства
willingness	желание
value	ценность
marginal rate	предельная налоговая ставка
alteration	изменение, перемена
expenditure	затрата, трата, расход(ы)
RPI (Retail Prices Index)	индекс розничных цен

Exercise 1. Read the text and do the exercises.

TAXATION

The traditional **distinction** between, or classification of, **taxes** is to call them direct or indirect. **Direct taxes** are ones where the individual who pays the tax to the **revenue authorities** also bears the loss or **incidence** of the tax. **Income tax** is the clearest example but there are problems with the classification and it is not very useful. **Vehicle excise duty** is, for example, a direct tax on a private car owner who pays for the car out of his or her own **pocket** but if the tax is paid by a business it can be **recovered** wholly or in part via the prices charged to customers and is indirect.

Indirect taxes are ones where the individual or firm that pays the tax to the revenue authorities can pass on some or all of the **burden**, loss or incidence of the tax to other people. The manufacturer pays the tax but recovers some of it from the distributors, wholesalers and retailers, who in turn **raise** their **prices** so that the final customer bears some of the incidence. The public often believes that the whole of the tax burden is passed on but if there is any **elasticity of demand** at all, that is the **demand curve** is not vertical, the manufacturer and distributors suffer a loss of sales and profit when they try to raise their prices **to recoup** the tax. Thus the incidence, or loss, of an indirect tax is normally shared by three groups, manufacturer, retailers and wholesalers and final purchaser.

Principles behind the tax system.

It is usually **asserted**, following Adam Smith, that an **individual tax** should be certain, that is the payer should be clear as to what is liable to be taxed, how much the tax bill is and when and how to pay it. Another principle is that the cost of collecting a tax should be minimal. Modern taxes are usually very productive in the sense that their **collection cost** is only a very small percentage of the total raised. There are some exceptions to this and some taxes such as **capital gains tax** are maintained nowadays as a gesture to the old concept of equality of tax burdens, that is the idea that the rich should bear the greater share of tax.

The principles mentioned above are important but a much more fundamental, and **controversial**, one is that of equity. It is controversial because it is interpreted in different ways. The consensus used to be that an individual tax or the whole system was equitable if it contained a strong element of progression, that is the higher income groups paid a larger percentage of their income in tax than the lower income groups.

Technically, a tax is **progressive** if the proportion of income in tax rises with income. A tax is **regressive** if the proportion of income taken in tax falls as income rises and this includes most indirect taxes on expenditures. It is possible for a tax to be **proportionate** if the percentage of income taken in tax remains the same as income rises, for example a **flat rate** 10 % income tax without any allowances.

Another principle that is important is that taxes should not **distort** the economy to any serious extent unless that is the **deliberate** intention as **demerit goods** are taxed. Taxes also affect **pricing policies**, especially in alcohol, tobacco and petrol markets or in **foreign trade** if tariffs are **levied**. A badly designed tax system can seriously affect the **allocation** of resources within a country and one nation's tax regime can have an adverse impact on the world economy. An example of the latter effect is the USA whose low tax policy for fuel oil and gasoline leads to the **profligate** use of scarce world resources.

One important application of the **principle of non-distortion** is that taxation should not adversely affect the **willingness** of people to work, to save or to take risks in their enterprise. It is generally "acknowledged that the individual will often have a backward bending" supply curve for their labour because they come to a point where they **value** extra leisure above the additional income from working longer hours. The level at which they reach this point will be affected by their **marginal rate** of tax.

Other considerations which can be elevated to the status of principles are:
- minimum impact on the rate inflation. **Alteration** in most taxes on **expenditure** affect the **RPI (Retail Prices Index)** and the rate of inflation. Fuel tax increases are particularly inflationary;
- **ease** of alteration. The tax mechanism must lend itself to easy and administratively cheap change;
- contribution to economic stabilization. Some taxes **aggravate** a recession while others fail to help restrain a boom. Indexation of some taxes helps to prevent this tendency but not all taxes can be **indexed**;
- **encouragement** to **saving**. This may be achieved by the differential taxation of savings and expenditure or, in the company sector, by taxing distributed profits more highly than retained profits.

Exercise 2. Think over and answer the questions.

1. Did you find any answers to the questions, you discussed before reading, in the text? Can you give more detailed answers now?
2. Did you come across the definition of “a tax”? Read the following definition taken from the dictionary of economic terms and translate it into English:

“Налоги – платежи, взимаемые государством с предприятий и организаций, населения. Являются одной из форм финансовых отношений, обеспечивающих распределение и перераспределение национального дохода в соответствии с задачами экономического и социального развития”.

Exercise 3. Determine whether the statements are true or false.

1. The distinction between direct and indirect taxes is very clear.
2. It is the final customer who bears tax burden.
3. A tax can be called productive if its collection cost is very low.
4. The principle of equity means that all people pay the same percentage in taxes.
5. The introduction of new taxes does only good to the country and its citizens.
6. A progressive tax can prevent people from having extra jobs.

Exercise 4. A)*. *Pick up the main ideas and sum up the text.
B). Find information and make a short report about taxes in Russia.

Exercise 5. Read the article, do the exercises.

Kazakhstan’s New Oil Tax Regime
Two types of contracts

Mineral exploration and **extraction** activities are permitted only to those who have an **appropriate contract** with the Republic of Kazakhstan, termed a subsurface user contract. The **Tax Code** offers alternative tax regimes for **taxpayers** involved in mineral exploration and extraction activities, which the **legislation terms** “subsurface users”.

Model 1 offers a regime under which the subsurface user is subject to all the taxes which affect ordinary taxpayers (**corporate income tax**, social tax, vehicle tax, **property tax**, **land tax**, etc) and, in addition, certain specific taxes applicable to mineral extraction activities:

• **Bonuses** (both on signature of the contract and following a commercial discovery)
• **Royalties**
• **Excess Profits Tax**
• **Rent Tax** on Export of Crude Oil

Of these taxes, the first three existed prior to the 2004 tax changes, but the reform package includes major changes to the way they operate which are described later in this article. The fourth, Rent Tax, is a completely new tax. This is also described in more detail below.

Royalties and Rent Tax apply to **gross income** and are **deductible** in calculating both corporate income tax ("CIT") and Excess Profits Tax. CΓT is deductible in computing Excess Profits Tax.

Model 2 offers a production sharing regime of the type familiar from other hydrocarbon provinces around the world. Though not **explicitly** confined to hydrocarbon extraction activities, the mechanism for allocating production between the State and the subsurface user is written with hydrocarbon liquid extraction activities in mind and may not be easily adapted to other kinds of minerals, including gas. Subsurface users which **sign up** to Production Sharing Agreements ("PSAs") are obliged to share production with the Republic in accordance with formulae **set out** in the PSA itself, and to the other taxes prescribed in tax legislation, excluding, however:

• Rent Tax on Export of Crude Oil
• Excise Tax on Crude Oil (including gas condensate)
• Excess Profits Tax
• Land Tax
• Property Tax

The gross income of the contractor for CIT purposes includes both **cost recovery oil** and the contractor's share of profit oil. The base for calculating the contractor's royalty obligation is the gross amount of crude oil produced before production sharing.

In 2003, the possibility of a third model was extensively discussed. This was to be based around a rent tax similar in concept to that discussed below, but the idea was **abandoned**, apparently following discussions with state oil company Kazmunaigaz.

Bonuses
The Tax Code continues to provide for 2 types of bonuses:
• **Signature Bonus**
• Commercial Discovery Bonus
The major change in respect of Signature Bonuses is an explicit statement that the amount will be set by competitive tender. The framework of the competitive tender is to be prescribed by a proposed new PSA law.

The calculation of the amount of Discovery Bonus continues to be based on the officially approved estimate of **recoverable reserves**. The rate is now **fixed at** 0.1 percent of the value of recoverable reserves, rather than this figure being specified as the minimum amount as previously.

Royalty
The most important change to the royalty regime is the introduction of a fixed
scale of royalty rates for oil production based on tons produced. In the past, royalty rates (except for those applicable to "commonly occurring useful minerals" which were specified in the Tax Code) have been subject to negotiation within **broad** parameters and in at least two cases have not been applied to a project on economic grounds.

Associated gas is to be converted to equivalent using a formula of 1,000 cu. m. equals 0.857 t.

The new rules provide that the Government may publish separately, rates for solid minerals, but is completely silent on how the base for dry gas will be calculated. Presumably, one should apply the conversion factor specified for associated gas and then apply the **sliding scale** for oil, but this is not clearly stated anywhere. There is also considerable uncertainty about how the sliding scale should actually be applied.

For example, what rate would be applied if the amount extracted was exactly 2 **min t**? Once the production passes 5 min t in the year does the scale operate to subject all production, since the beginning of the year, to the 6-percent rate?

Rent Tax on the Export of Crude Oil
The most fundamental change introduced by the recent **amendments** is the creation of a completely new tax which **applies to** exports of crude oil. The tax will apply to taxpayers who export crude oil, **apart from** those who are

parties to PSAs. It is not clear whether the tax will apply to an oil trader who purchases crude from the producer in Kazakhstan and then exports it.

Reflecting government concerns about transfer pricing, the tax base is not the actual sale price of the exported crude, but a formula which applies an average price for a basket of widely-traded **benchmark** oil prices, to the volume of oil sold. There is provision to adjust this **deemed price** for quality differentials as a result of mixing the oil in pipelines, though it is not completely clear how this is to operate. The components of the basket will be fixed by the Government. **Transportation costs** should be deducted to arrive at the base for calculating the tax. Which transportation costs is not explained, nor is it indicated whether these are only the costs incurred by the producer or whether one can take into account the costs of shipping crude to a location comparable with one where the benchmark crudes are traded.

In the rather likely event that the deemed price is not a round number of dollars per barrel, the legislation is silent on how the **resulting fraction** will impact the rate, e.g., if the deemed price is $25.57 per barrel, then should the rate be 16 percent or 17 percent or somewhere between the two?
The tax period is to be a calendar month, and the taxpayer will be required to pay tax for a particular month by the 10th day of the month following. A tax declaration will be due by the 15th of the following month. Like all **turnover taxes**, the rate of rent tax has no relationship to **profitability**, and will, therefore, tend to depress the economic viability of projects in the hostile conditions of the North Caspian.

Words and expressions

extraction	добыча; извлечение нефти, газа
appropriate contract	подходящие контракты
tax code	налоговый кодекс
taxpayer	налогоплательщик
legislation term	законодательный срок
corporate income tax	налог на доход корпорации
property tax	налог на собственность
land tax	земельный налог
royalty	плата за право разработки недр
excess profits tax	налог на сверхприбыль
rent tax	налог на аренду
gross income	валовой доход
deductible	нестрахуемый минимум

explicitly	детально, подробно
to sign up	подписать
to set out	установить
recovery oil	переработаная нефть
cost	затраты, издержки
abandoned	оставленный
recoverable reserves	извлекаемые запасы
to be fixed at	быть зафиксированным на
associated gas	нефтяной газ, попутный газ
broad	широкий, многочисленный
t/min	тонн в минуту
amendment	поправка
to apply to	заявить, подать заявку на
apart from	отдельно от
benchmark	база (сравнения)
deemed price	разумные цены
transportation costs	транспортные расходы
resulting fraction	результирующая фракция
turnover taxes	налог с оборота
profitability	прибыльность, рентабельность

Exercise 6. Answer the questions.

1. Who is likely to be interested in this information?
2. Are alterations in tax regime favourable for foreign oil and gas companies?
3. Is everything clear and well thought over in the new oil tax regime?
4. Write out the names of taxes which should be paid by “subsurface users” according to Model I. Are the same taxes paid according to Model II? What is different?
5. Find those parts of the text where the author says about some uncertainties in the new tax application. Comment on them.
6. Find the conclusion the author made on the economic viability of projects in Kazakhstan. Do you agree with it?

Exercise 7. Look through the text and be ready to answer some questions.

1. Does the first sentence of the text have the same meaning as the title?
2. What problem is discussed?
3. Is it a local or a global issue?
4. What kinds of fiscal systems are mentioned in the text?

Different fiscal systems complicate reserve values

The value of hydrocarbon reserves in-the-ground varies **dramatically** worldwide because of the existence of numerous reserve categories and diverse **fiscal systems**.

For a company's survival in the petroleum industry, value replacement is more important than reserve replacement. But unfortunately, when it comes to international reserve values, nobody seems to speak the same language. Discoveries are often measured in terms of **gross recoverable reserves**. But, reserve and financial transaction reporting differ widely.

Term uncertainty

In the U.S. during 1994, $4.50/bbl was the average price paid for proved developed producing reserves. In other words, reserves in-the-ground were worth about $4.50/bbl. Unfortunately, some of the confusion begins right here. Quoted U.S. reserve transaction values are based usually, but not always, on **net-revenue-interest** barrels. In fact, it is often impossible to determine from published sources whether **working-interest** barrels or net-revenue-interest barrels are quoted.

Some published U.S. reserve/production transaction data include working interest barrels while others record net-revenue-interest barrels. Unless the terms are defined, uncertainty will exist.

The U.S. Security and Exchange Commission (SEC) 10-K reporting requires net-revenue-interest barrels. But unfortunately outside the U.S., this consistent treatment disappears. In fact, the net-revenue-interest concept is almost nonexistent in countries with contractual systems.

Fiscal systems

Fig. 1 groups the world's petroleum fiscal systems.

• Under royalty/tax systems, oil companies **take title to** produced hydrocarbons at the **wellhead** and then pay the appropriate royalties and taxes. The royalties are **paid** either **in cash** or **in kind**.

• In contractual systems, oil companies receive a **fee** for exploration, development, and production operation services.

• With a production sharing contract (PSC), the fee is a share of production so that ultimately the oil company takes title to a share of hydrocarbons—usually at the point of export.

• Service or risk service agreements are similar to PSCs except the fee is in cash.

The company does not take title to any hydrocarbons. This fact creates the confusion: How can a company book reserves it does not own?

Exercise 8. Study and discuss Figures 1, 2.

1. The difference between definitions of reserves "booked" (Fig. 1)
2. Classification of petroleum fiscal systems (Fig. 2)

Definitions of reserves "Booked"

Royalty/tax	**Production sharing**
Gross recoverable reserves	Gross recoverable reserves
x Working interest (%)	x Working interest (%)
= Working-interest reserves	= Working-interest reserves
- Royalty	- Royalty
= Net-revenue-interest bbl	- Government profit oil
	= Contractor entitlement*

*The contractor share of profit oil is usually taxed.

Fig. 1

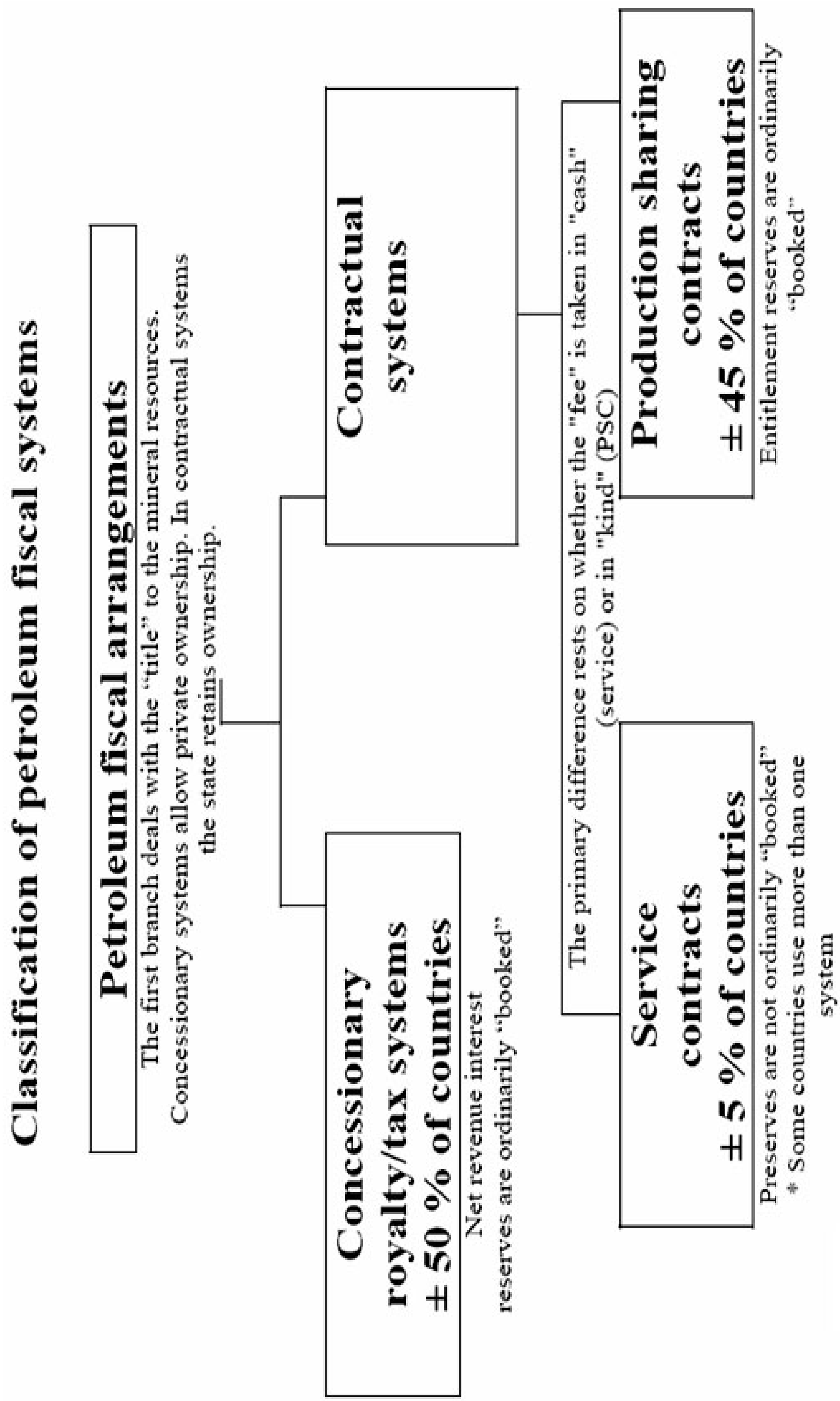

Classification of petroleum fiscal systems
Petroleum fiscal arrangements
The first branch deals with the "title" to the mineral resources.
Concessionary systems allow private ownership. In contractual systems the state retains ownership.
Concessionary royalty/tax systems ± 50 % of countries
Net revenue interest reserves are ordinarily "booked"
Contractual systems
The primary difference rests on whether the "fee" is taken in "cash" (service) or in "kind" (PSC)
Service contracts ± 5 % of countries
Preserves are not ordinarily "booked"
* Some countries use more than one system
Production sharing contracts ± 45 % of countries
Entitlement reserves are ordinarily "booked"

Fig.2

Words and expressions

dramatically	эффектно, поразительно
fiscal systems	налоговая система
recoverable reserves	извлекаемые запасы
net-revenue-interest	доля чистого дохода компании от общего дохода по проекту
working-interest	процент участия
take title to	брать право собственности на товар
wellhead	устье скважины
to pay in cash	платить наличными
to pay in kind	платить товаром
fee	плата

Exercise 9. Discuss the following points.

1. Have you ever heard or read that a particular company has problems with revenue authorities? What company was it? What was the problem?
2. Do all businesses in Russia pay taxes in full? Why do you think some of them try to avoid taxes? What should the authorities do with such companies? Do you know what the auditors deal with?

Auditors and their reports

Auditors are usually independent certified **accountants** who review the financial records of a company. These reviews are called ***audits.*** They are usually performed at fixed intervals – **quarterly**, **semiannually** or annually. Auditors are employed either regularly or on a part-time basis. Some large companies maintain a continuous internal audit by their own **accounting departments**. These auditors are called ***internal auditors.***

Not so many years ago the presence of an auditor suggested that a company was having finacial difficulties or that **irregularities** had been discovered in the records.

Currently, however, outside audits are a normal and regular part of business practice. Auditor's see that **current transactions** are recordered promptly and

completely. Their duty is to reduce the possibility of **misappropriation**, to identify mistakes or detect **fraudulent** transactions. Then they are usually requested to propose solutions for these problems.
Thus auditors review financial records and report to the management on the current state of the company's fiscal affairs in the form of ***Auditor's Report*** or ***Auditor's Opinion.***

Words and expressions

auditors	аудитор
accountant	бухгалтер
quarterly	по квартально
semiannually	раз в полгода
internal auditor	внутренний аудитор
irregularity	нарушение
current transaction	текущие операции
misappropriation	незаконное присвоение, растрата
fraudulent	обманный, мошеннический

Exercise 10. Answer the following questions.

1. What do auditors do?
2. Audits are planned actions, aren't they?
3. What did the presence of an auditor in a company suggest in the past?
4. What is auditors' duty?
5. In what form do the auditors make their report?
6. What is the difference between internal and independent auditors?

Exercise 11. Decide whether the statements are true or false.

1. Auditors are usually chiefs of accounting departments.
2. It is quite usual when an auditor comes to a company anytime he/she likes.
3. Internal auditors are employees of the same company where they make audit.
4. If auditors review the financial records of a company, it doesn't mean that this company has some problems.
5. Auditors are supposed to know how to solve financial problems.

Exercise 12. Read the text and find information on the following points.

1. The names of the auditing and audited companies;
2. The reason of Transneft's changing its auditor;
3. The names of the documents to be complied with while conducting audit;
4. Characteristics of an emerging market.

Independent Auditor's Report

We have audited the accompanying **consolidated balance sheet** of OAO AK Transneft and its subsidiaries (the "Group") as of 31 December 2003, and the related consolidated statements of income, **cash flows** and changes in shareholders' equity for the year then ended. These consolidated financial statements, as set out on the pages 6 to 25 are the responsibility of the Group's management. Our responsibility is to express an opinion on these consolidated financial statements based on our audit.

The consolidated financial statements of the Group for the year ended 31 December 2002 were audited by another auditor, whose report dated 26 May 2003 expressed an unqualified opinion on those statements.

We **conducted** our audit **in accordance with** International Standards on Auditing as issued by the International Federation of Accountants. Those standards require that we plan and perform the audit to obtain reasonable **assurance** about whether the financial statements are free of material misstatement. An audit includes examining, on a test basis, evidence supporting the amounts and disclosures in the financial statements. An audit also includes assessing the accounting principles used and significant estimates made by management, as well as evaluating the overall financial statement presentation. We believe that our audit provides a reasonable basis for our opinion.

In our opinion, the consolidated financial statements present fairly, in all material respects, the financial position of the Group of 31 December 2003 and the results of its operations, cash flows and changes in equity for the year then ended in accordance with International Financial Reporting Standards **promulgated** by the International Accounting Standards Board.

Without qualifying our opinion, we **draw your attention to** the fact that, whilst there have been improvements in the economic situation in the

Russian Federation in recent years, the country continues to display some of the characteristics of an emerging market. These characteristics include, but are not limited to, the existence of a currency that is not freely **convertible** in most countries outside of the Russian Federation, restrictive currency controls, and relatively high inflation. The prospects for future economic stability in the Russian federation are largely dependent upon the effectiveness of economic measures undertaken by the government, together with legal, regulatory, and political developments.

(KPMG Limited
Moscow, Russian Federation
28 June 2004)

Words and expressions

consolidated balance sheet	консолидированный баланс
cash flow	движение денежной наличности
to conduct	проводить
in accordance with	в соответствии с
assurance	гарантия, заверение
to promulgate	пропагандировать, распространять
to draw your attention to	привлекать внимание
convertible	конвертируемый

Exercise 13. Look through the table which represents "Consolidated Balance Sheet" of Transneft Company.

1. Translate the terms into Russian.
2. Discuss the numbers in the table, compare and comment on them.

Consolidated Balance sheet derived from the consolidated financial statements – year ended 31 December 2003
(in millions of Russian roubles, unless otherwise stated)

Assets	**31 December 2003**	**31 December 2002**
Non-current assets		
Intangible assets	535	510
Property, plant and equipment, net	261.185	225.74
Available-for sale investments	1.198	1.380
Total non-current assets	262.918	227.064

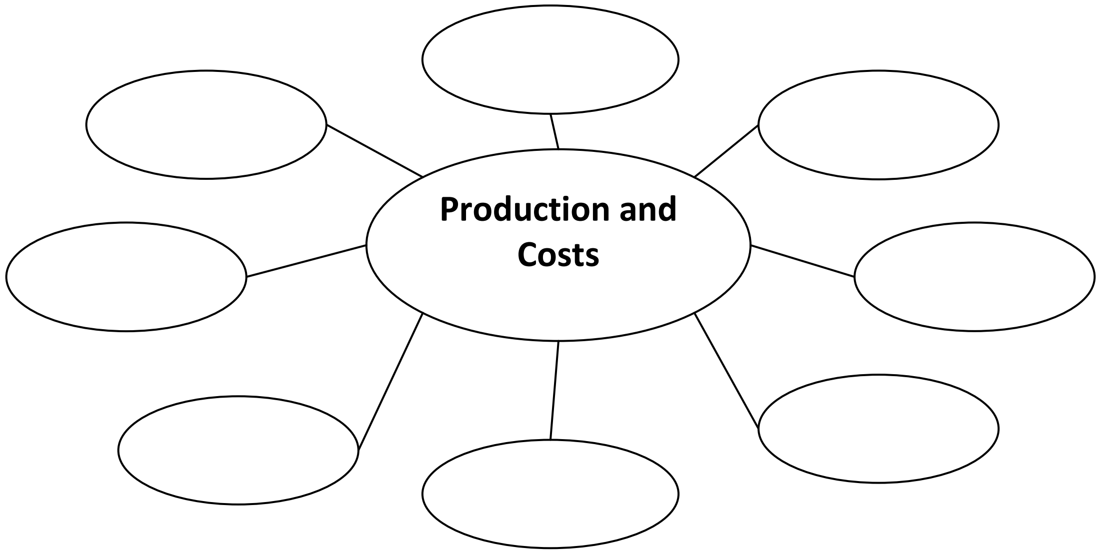
Current assets		
Inventories, net	7.515	6.051
Receivables and prepayments, net	6.842	2.394
VAT assets	19.501	15.686
Prepaid profit tax	3.234	700
Available-for-sale short-term investments	890	–
Cash and cash equivalents	17.219	13.472
Total current assets	55.201	38.303
Total assets	318.119	265.367
Shareholders' Equity, Minority interests and liabilities		
Shareholders' equity		
Share capital	307	307
Retained earnings	228.719	200.803
Total shareholders' equity	229.026	201.110
Minority interests	10.014	8.573
Non-current liabilities		
Borrowings	15.952	3.485
Deferred taxes	28.694	28.019
Provisions for liabilities and charges	5.195	2.907
Total non-current liabilities	49.841	34.411
Current liabilities		
Trade and other payables	26.236	11.968
Profit tax liabilities	570	321
Borrowings	2.432	8.984
Total current liabilities	29.238	21.273
Total liabilities	79.079	55.684
Total shareholders' equity, minority Interests and liabilities	318.119	265.367

UNIT 6

PRODUCTION AND COSTS

Lead-in

Fill in the spidergram with the words associated with Taxation and Audit.



Discuss the following questions.

1. What types of costs do you know?
2. Who manages production costs at enterprises?
3. How production costs affect the final cost of the goods?
4. How to reduce production costs?
5. Which production costs prevail in petroleum industry?

Terms and Vocabulary

entrepreneur	предприниматель
to deal with	иметь дело с
output of goods	выпуск товаров
input	затраты
to adjust	исправлять, налаживать
productive resources	производственные ресурсы
to vary	различаться
to gauge	измерять
marginal product	предельный продукт

to diminish	уменьшать
machinery	машинное оборудование
returns	возврат, возмещение
total output	валовой объем производства
rate	ставка
total production	общий объем произведенной продукции
to simplify	упростить
fixed cost	постоянные затраты
overhead	накладные расходы
idle	неработающий, бесполезный
leased properties	собственность, взятая в аренду
deprecation	возражение, протест
variable cost	переменные издержки
total cost	совокупные издержки
marginal cost	предельные затраты
cost of the lot	стоимость лота
total revenue	общая выручка
marginal revenue	предельная выручка
cost-benefit	рентабельность
break-even analysis	анализ безубыточности
incremental	увеличивающийся постепенно

Exercise 1. Read the text and do the exercises.

Production and Costs

Whether they are film producers of multimillion-dollar epics or small firms that market a single product, suppliers face a difficult task. Producing an economic good or service requires a combination of land, labour, capital, and **entrepreneurs**. The theory of production **deals with** the relationship between the factors of production and the **output of goods** and services. The theory of production is generally based on the short run, a period of production that allows producers to change only the amount of the variable **input** called labour. This contrasts with the long run, a period of production long enough for producers **to adjust** the quantities of all their resources, including capital.

The Law of Variable Proportions state that, in the short run, output will change as one input is varied while the others are held constant. The Law of Variable Proportions deals with the relationship between the input of **productive resources** and the output of productive resources and the output of final products. The law helps answer the question: How is the output of the final product affected as more units of one variable input or resource are added to fixed amount of other resources? Of course, it is possible to **vary** all the inputs at the same time. Economists do not like to do this, however, because when more than one factor of production is varied, it becomes harder to **gauge** the impact of a single variable on total output. When it comes to determining the optimal number of variable units to be used in production, changes in **marginal product** are of special interest.

There are three stages of production — increasing returns, **diminishing** returns, and negative returns — that are based on the way marginal product changes as the variable input of labour is changed. In stage one, the first workers hired cannot work efficiently because there are too many resources per worker. As the number of workers increases, they make better use of their **machinery** and resources. This results in increasing **returns** (or increasing marginal products) for the first five workers hired. As long as each new worker hired contributes more to **total output** than the worker before, total output rises at an increasingly faster **rate**. This stage is known as the stage of increasing returns. In stage two, the **total production** keeps growing, by smaller and smaller amount. This stage illustrates the principle of diminishing returns, the stage where output increases at a diminishing rate as more units of variable input are added. The third stage of production begins when the eleventh worker is added. By this time, the firm has hired too many workers, and they are starting to get in each other's way. Marginal product becomes negative and total plant output decreases.

Measures of Costs

Because the cost of inputs influences efficient production decision, a business must analyze costs before making its decision. To **simplify** decision making, cost is divided into several different categories.

The first category is **fixed cost** — the cost that a business incurs even if the plant is **idle** and output is zero. Total fixed cost, or **overhead**, remains the same whether a business produces nothing, very little, or a large amount. Fixed costs include salaries paid to executives, interest charges on bonds, rent payments- on **leased properties**, and local and state property taxes. Fixed costs also include **deprecation**, the gradual wear and tear on capital goods over time and through use.

Another kind of cost is **variable cost**, a cost that changes when the business rate of operation or output changes. Variable costs generally are associated with labour and raw materials. The **total cost** of production is the sum of the fixed and variable costs.

Another category of cost is **marginal cost** – the extra cost incurred when a business producers one additional unit of a product. Because fixed costs do not change from one level of production to another, marginal cost is the per-unit increase in variable costs that stems from using additional factors of production. The cost and combination, or mix, of inputs affects the way businesses produce. The following examples illustrate the importance of costs to business firms. Consider the case of a self-serve gas station with many pumps and a single attendant who works in an enclosed booth. This operation is likely to have large fixed costs, such as the **cost of the lot**, the pumps and tanks, and the taxes and licensing fees paid to state and local governments. The variable costs, on the other hand, are relatively small. As a result, the owner may operate the station 24 hours a day, seven days a week for a relatively low cost. As a result, the extra wages, the electricity, and other costs are minor and may be covered by the profits of the extra sales.

Measures of Revenue

Businesses use two key measures of revenue to find the amount of output that will produce the greatest profits. The first is **total revenue**, and the second is **marginal revenue**. The total revenue is the number of units sold multiplied by the average price per unit. The marginal revenue is determined by dividing the change in total revenue by the marginal product. Keep in mind that whenever an additional worker is added, the marginal revenue computation remains the same. If a business employs, for example, five workers, it produces 90 units of output and generates $ 1,350 of total revenue. If a sixth worker is added, output increases by 20 units, and total revenues increase to $ 1,600. To have increased total revenue by $ 300, each of the 20 additional units of output must have added $ 15. If each unit of output sells for $ 15, the marginal or extra revenue earned by the sale of one more unit is $ 15 for every level of output. Marginal revenue can remain constant but businesses often find that marginal revenues start high and then decrease as more units are produced and sold.

Marginal Analysis

Economists use marginal analysis, a type of **cost-benefit** decision making that compares the extra benefits to the extra costs of an action. Marginal analysis is helpful in a number of situations, including **break-even analysis** and profit maximization. In each case the costs and benefits of decisions that are made in small, **incremental** steps. The break-even point is the total output or total product the business needs to sell in order to cover its total costs. A business wants to do more than break even, however. It wants to make as much profits as it can. But, how many workers and what level of output are needed to generate the maximum profits? The owner of the business can decide by comparing marginal costs and marginal revenues. In general, as long as the marginal cost is less than the marginal revenue, the business will keep hiring workers. When marginal cost is less than marginal revenue, more variable inputs should be hired to expand output. The profit-maximizing quantity of output is reached when marginal cost and marginal revenue are equal.

(Garry Clayton)

Exercise 2. Decide whether these statements are True (T) or False (F).

1. The theory of production deals with a period of production that allows producers to change the amount of labour used.
2. The law helps answer the question: How is the output of final product affected as more units of one variable input or resource are added to fixed amount of other resources?
3. In stage one of production the more workers are hired the less are the returns.
4. When an additional worker is added, the marginal revenue computation changes according to the stage of production.
5. When marginal cost is less than marginal revenue, more variable inputs should be hired to expand output.

Exercise 3. Study the explanation of special terms.

output *(n)* – the amount of goods or services produced by a person, machine, factory, company, etc.
input *(n)* – ideas, advice, effort, *o* money that you put into something to help it succeed
factor of production – something that is needed to produce a particular product
diminishing return – the idea that a point can be reached where the advantage or profit you are getting, stops increasing in relation to the effort you are making

marginal *(adj)* – relating to a change in a cost, value, etc. when one more thing Is produced, one more dollar is earned, etc.
costs *(n)* – money that a business or an individual must regularly spend
fixed costs – costs to a business that do not change when the amount of goods or services produced does
incur *(v)* – if you incur a cost, a debt, or a fine, you do something that means that you lose money or have to pay money
overhead costs – costs not directly related to a particular product or service, but related to general costs for buildings, equipment, etc.
interest *(n)* – an amount paid by a borrower to a lender, for example to a bank by someone borrowing money for a loan or by a bank to depositor
charges *(n)* – an amount of money paid for services or goods
rent payment – money paid for the use of a house, office, etc.
lease *(v)* – to give somebody the right to use something for a particular period of time in return for payment
depreciation *(n)* – decreasing in value over a period of time
variable costs – costs that change when the amount of something produced changes
rate of operation – capacity of work done by a company or machine
marginal cost – the extra cost of producing one more of something
self-service *(n)* – a self-service shop, restaurant, etc. is one in which customers get the goods themselves and then go and pay for them
lot *(n)* – an area of land on which nothing has been built and which may be available to rent, or build on
revenue *(n)* – money that a business or organization receives over a period of time, especially from selling goods or services
break-even *(adj)* – when a company is neither making a profit or a loss

Exercise 4. Give English equivalents to the following words and expressions.

фиксированные затраты; самообслуживание; безубыточный; норма загрузки производственных мощностей; доход, выручка; переменные издержки; накладные расходы; износ; сокращающийся доход; фактор производства.

Exercise 5. Choose the appropriate word or expression from the box to complete the following sentences.

returns	**costs**	**fixed cost**	**incurred**
rents	**leased**	**depreciation**	**interest**

1. Commercial ______ have decreased significantly since their peak in 1997.
2. The East Moline foundry has been operating at less than 50 % capacity and has _______ significant operating losses.
3. The _____ is the added output resulting from employing one more worker.
4. Their retail branches are a _______, so the more business they put through them the better.
5. Delay in construction could increase _______ significantly.
6. Chrysler might run out of money to pay _______ on its bonds.
7. The proposed site of the factory may lead to _______ of property value in the immediate vicinity.
8. The local authority _______ him the property.

Exercise 6. Discuss the following with your partner before listening.

Price in not only the cost of something. Every purchase has a hidden cost. What do you think this is?

Listen and choose the best answer for each question.

1. What is opportunity cost?
   a) Something you have to give up in order to have something else.
   b) Something a company can charge people for goods or services.
   d) Something that companies pay when they first start business.

2. What could be the opportunity cost of watching television?
   a) Getting sore eyes.
   b) The cost of buying a television.
   c) Not sunbathing in the garden.

3. What is the opportunity cost of Alice's decision?
   a) ₤ 3,000
   b) ₤ 39,000
   c) ₤ 13,000

Exercise 7. Discuss the following points.

1. Comment on the statement: Profit is maximized when the marginal costs of production equal the marginal revenue from sales.
2. Explain the use of marginal analysis for break-even and profit maximizing decisions.
3. Many oil-processing plants shift workers to maintain operations. How do you think a plant's fixed and variable costs affect its decision to operate around the clock?

Exercise 8. Prepare presentation on the following topics.

1. Costs in the petroleum engineering
2. Costs in the oil and gas exploration
3. Costs in the oil and gas transportation
4. Costs in the pipeline constructions.

Exercise 9. Read the article and do the exercises.

The Benefits of Being Small: Balancing Economies of Scale Against the Advantages of Intimacy Is a Delicate Task

In the 1970s the British economist E.F. Schumacher coined the phrase "small is beautiful." The expression focused on a design question. As companies become larger and more complex, can they restructure to retain the human benefits of smaller companies? Schumacher believed that they could not. They would have to reduce in size and change their command structure. His argument was simple. As a company adds more people in more locations the **sheer** task of holding this lot together becomes an end in itself. The economic advantages of scale will be **eroded** by the disadvantages of a loss of intimacy.

Schumacher was largely ignored outside Europe. At the time a **prevailing** view was that large companies could be very profitable if structures were crystal clear and rational. Through these means human error or **deviance** could be minimized. One company was always quoted as the supreme example of the triumph of structure over deviance: International Business Machines, arguably the greatest exponent of machine-like precision through command and control structures. However, in 1993 IBM lost $5bn (£ 5.6bn). Forthoseon the inside, the **collapse** of the world's most successful computing company was stunning. At the time I taught on IBM's senior management programme at La Hulpe in Belgium and I could **track** the growing unease. Yet the IBM **staff** still believed that creative, structural solutions would save the day.

Managers largely ignored the evidence of **paralysis** at the top. They were part of the paralysis. The rest is history. Lou Gerstner, with no background in computing, was brought in to rebuild IBM. Seemingly, overnight half of the far-flung 450,000 devoted, loyal, programmed IBM-ers were banished. The rational model had been shown to be **flawed**. Since the 1990s various studies have reinforced the idea that 1,000 employees in one location is about the maximum size for any company if it is to retain the advantages of the economies of scale and minimize the human diseconomies arising from adding more people. IBM did clean out 50 per cent of its workforce – but controlling size was not the main way the company reinvented itself. Its most important decision was to **offload** its entire hardware and components manufacturing.

Outsourcing was its most spectacular strategy. In the latest McKinsey Quarterly, the logic and effect of outsourcing as a strategy and how it affected IBM are examined. The research question posed by the authors is: has outsourcing gone too far? The logic of outsourcing is that by shedding assets companies can concentrate on the interesting work. Employees are remotivated to develop product or services, discover solutions and be innovators or supply chain integrators. Liberation leads to an increased rate of return on invested capital The Journal provides sensible, practical insights into the sort of questions companies should ask before embarking on outsourcing. If internal suppliers can meet industry standards within a set time and present a competitive advantage, an internal solution may be preferable. If, as well, the internals are not readily substituted outside and are vital to the corporate culture and reputation, the company should resist outsourcing.

Conversely, if there are dramatic **cost savings** available from cheaper labour sources or the skills are hard to acquire or suppliers have greater productive capacity and higher levels of expertise and knowledge, the case for outsourcing is strong. Rarely is outsourcing an either/or decision. So the authors discuss a mixture of tactics in which the company gets the best from both sources, internal and external. They rightly question the general assumption that outsourcing is always best. One issue that the authors do not discuss is **dependence**. This is often critical.

How dependent does a company become once it has transferred all its information technology processing to a supplier? Transferring staff is fine if the explicit and tacit knowledge is readily available elsewhere. It may be dangerous if it is not. By the mid-1990s IBM had redefined its core business as **e-business** services and solutions, research and design and semiconductor architecture and manufacturing and spun off its hardware and components manufacturing business. By 2000 it reported revenues of $ 8.09 bn. What does all this tell us? First, by outsourcing manufacturing IBM made possible a massive strategic shift.

Lesson: outsourcing is not just a tactic for transferring costs, or people problems. Second, IBM's leaders could not have known in 1994 how the company's future would evolve. This was not change based on a clear vision and a rational plan. Lesson: To outperform the competitors, companies must take risks, follow a shared hunch and tolerate ambiguity about the outcomes. Third, this transformation was achieved by relentless segmentation into smaller units.

Lesson: Schumacher's argument on the human diseconomies of size was valid. For innovation and creativity, free forming self-governing teams are essential. Small in this sense is beautiful.

(John W. Hunt, "Financial Times")

Words and expressions

to erode	разрушать
sheer	полный, явный
prevailing	преобладающий, превалирующий
deviance	отклонение
to collapse	разрушать
to track	следить, отслеживать
staff	персонал
paralysis	бессилие
to flaw	повредить
offload	быть бессильным
outsourcing	аутсорсинг (передача стороннему подрядчику бизнес-функций)
cost savings	снижение себестоимости
dependence	зависимость
e-business	интернет-компания, дот-ком (фирма, ведущая бизнес в интернете)

Exercise 10. Answer the following questions.

1. What human benefits did Schumacher have in view when he coined the phrase "small is beautiful"?
2. Did other economists and industrialists share his opinion?
3. How did industrialists intend to minimize possible human error or deviance in a large company?
4. What other strategy besides controlling size did IBM use to reinvest itself in 1990s?
5. Was outsourcing strategy an efficient measure? What is the logic of this strategy?

Exercise 11. Put the sentences in the logical order.

A Yet the IBM staff still believed that creative, structural solutions would save the day.

B First, by outsourcing manufacturing IBM made possible a massive strategic shift.

C In the 1970s the British economist E. F. Schumacher coined the phrase "small is beautiful.

D Outsourcing was its most spectacular strategy.

E They rightly question the general assumption that outsourcing is always best.
F Small in this sense is beautiful.
G Schumacher was largely ignored outside Europe.

Exercise 12. Match up the words with their definitions.

1) economies of scale;	a) something that is different from what is socially acceptable;
2) to erode;	b) a person who expresses support, performs, or is an example of a stated thing;
3) deviance;	c) the advantages that a big factory, shop, etc. has over a smaller one because it can spread its fixed costs over a larger number of units and therefore produce or sell things more cheaply;
4) exponent;	d) to perform better than anyone else;
5) outsourcing;	e) to wear or to be worn away gradually, esp. by slow action of water, wind, etc.;
6) to outperform;	f) if a company, organization, etc. employs another company to do a part of its contract;
7) far-flung;	g) a situation, when there is more than one possible meaning or interpretation; unclear;
8) ambiguity.	h) spread over a great distance.

Exercise 13. Translate into English.

Сущность и структура издержек производства

Производство любого товара сопряжено с определенными затратами (издержками). Затраты материальных ресурсов и денежных средств, которые несет производитель на производство продукции, называются издержками производства.

Поскольку в рыночной экономике конечной целью производителя является получение прибыли, то издержки производства как один из ее ограничителей всегда находятся под его пристальным вниманием.

Следует различать издержки производства:

а) прямые и косвенные;
б) внешние и внутренние;
в) постоянные и переменные;
г) краткосрочные и долгосрочные.

К прямым издержкам производства относятся те затраты по производству продукции, которые несет непосредственно производитель.

В экономической теории они получили название **себестоимости.**

На предприятиях, где существует найм рабочей силы, они включают следующие элементы:

- сырье, основные и вспомогательные материалы;
- топливо и энергию;
- амортизацию;
- зарплату и отчисления на социальное страхование;
- прочие затраты.

Косвенные расходы по производству продукции несет государство. Это расходы на образование, медицину, спорт (финансируемые за счет государства) и др. Как правило, эти расходы обеспечивают производство рабочей силы на качественно новой основе и создают условия для нормального функционирования производства. Основным источником погашения этих затрат является прибавочный продукт, изымаемый государством в виде налогов и обязательных платежей. Поэтому в основе цен на товары и услуги лежит не себестоимость, а стоимость, т. е. общественные затраты на производство продукции.

UNIT 7

BUSINESS PLAN

Exercise 1. Read the text and comment on the principles of a Business Plan.

What does the model structure of business plan look like?

The model structure of business plan contains the following sections:

1. **Title page of business plan** – contains the company name, its legal and actual addresses, telephones, e-mail and address of site, name and complete properties of owners of the company, the name and very briefly (by one suggestion) – essence of project, information about the performers of project and date of his drafting.

2. **Resume of investment project** – is the basic positions, essence, "pressing" out from a project, its basic conclusions. The purpose of resume - to interest an investor and compel him more detailed to familiarize with maintenance of business plan. Volume of resume is about 2–3 pages of text which must be made in simple terms without the use of terminology. It must perform the advantage and perspective of investments in the presented investment project to the investor.

3. **Description of company** – contains the information about a company, which offers this investment project, the information about a company, which developed this business plan, its complete properties, information about founders and their properties, the purposes of company, information about guidance, the background of company, achievement, organizational structure, basic products, and place of company at the market.

4. **Description of product or favour** – includes information about a product or favour, his basic descriptions, basic users, consumer properties of commodity, differences from existent analogues, information about patents and licences.

5. **Marketing analysis** – contains information about commodities, products of competitors, comparison of descriptions and consumer qualities of commodities of competitors and offered product, information about the name

of competitors and their properties, costs of competitors and their strategy of advancement of commodities are presented at the market.

The marketing analysis is the first stage in writing of business plan. Determination of volumes of market of sale of products is a major section in the marketing analysis, to the market share of competitors, determination of motivation of buyers to acceptance of decision about the purchase.

It is the basic task of the given section to give an answer for questions – how many and what commodity is required by a market, at what price and why users are exactly ready to buy it. In this section the analysis of the state and tendencies of development of industry, median income and production volumes of enterprises of industry, degree of development of competition and barriers of including, in her must be resulted also.

6. **Strategy of advancement of commodity** – here determination of market niche is basic, I.e. what exactly and what categories of users a commodity is intended for, quantitative and high-quality analysis of users, where they are located by what exactly methods and channels of sale it is suggested to realize a commodity or favour. Information about strategy of advertising of product or favour is led, expenditures on marketing, price and credit policy during work with buyers. This section of business plan often is the its weakest point.

7. **Production** – in case if it is a production enterprise, the given section includes the information about the chosen technology of production, motivation of its choice, description of basic technological processes of enterprise, chart of his work placing of equipment. If reconstruction or building is assumed, description of build decisions and computations of expenditures on the reconstruction or building is led.

In a section the computations of necessity in materials and raw material on production of goods are led, expenditures on their purchase, analysis of suppliers, expenditures on service and planned repairs of equipment. In case if the specific of production of that requires information about the necessity of acquisition of licences and other permissions is led, requirements on accident prevention of labour.

In this section the computations of necessity in materials and raw material for production of goods are led, expenditures on their purchase, analysis of suppliers, expenditures on service and planned repairs of equipment. In case if the specific of production of that requires information about the necessity of acquisition of licences and other permissions is led, requirements on accident prevention of labour.

In case if it is a build or service enterprise is reflected also information about contractors, their description and properties is given.

8. **Plan on a personnel** – in this section the information about a necessity in a personnel, his quantity and qualification is led, market analysis of labour on every position of workers, computations of expenditures on payment of labour of personnel, his public welfare are led methods of stimulation and teaching.

9. **Organizational structure and management of investment project** – contains the organizational chart of management by an enterprise, information about quantitative and high-quality composition of subdivisions of enterprise, requirements to his qualification, computation of expenditures on payment of labour public welfare and stimulation of labour of handling personnel.

In the case of reorganization or re-created enterprise information about a form is given to own of enterprise, his basic or supposed shareholders, their properties, stakes in the capital of enterprise, process of acceptance of decisions and principles of management.

10. **A financial plan of investment project** – is the most interesting part of business plan from the practical point of view, it shows what financial resources will be required for realization of investment project and in what periods of time and also return from a project at the set basic data and loyalty of conclusions of marketing research.

In a financial plan accounts all money streams of enterprise - expenditures, profit yield from realization, taxes and income are led or settled.

11. **Analysis of risks of investment project** – in this section the description of possible risks of project and their description is given, and also strategy on their minimization is led.
12. **The appendixes** – are documents which a business plan was made on the base of: data of marketing researches, specifications and detailed descriptions of products, unfolded descriptions of competitors and their products, copies of selling aids, price-lists, catalogues, letters from buyers and customers,

contracts, resumes of leaders of project and subdivisions of enterprise, conclusions of experts and other documents.

(www. Wikipedia.ed)

Exercise 2. Study the example of the Engineering Consulting Business Plan.

StructureAll Ltd. - Consulting Engineers

Executive Summary

1.0 Executive Summary

StructureAll Ltd. will be formed as a consulting firm specializing in structural engineering services. A home office in Yellowknife, NT will be established the first year of operations to reduce start up costs. The founder of the firm is a professional engineer with eighteen years of progressive and responsible experience.

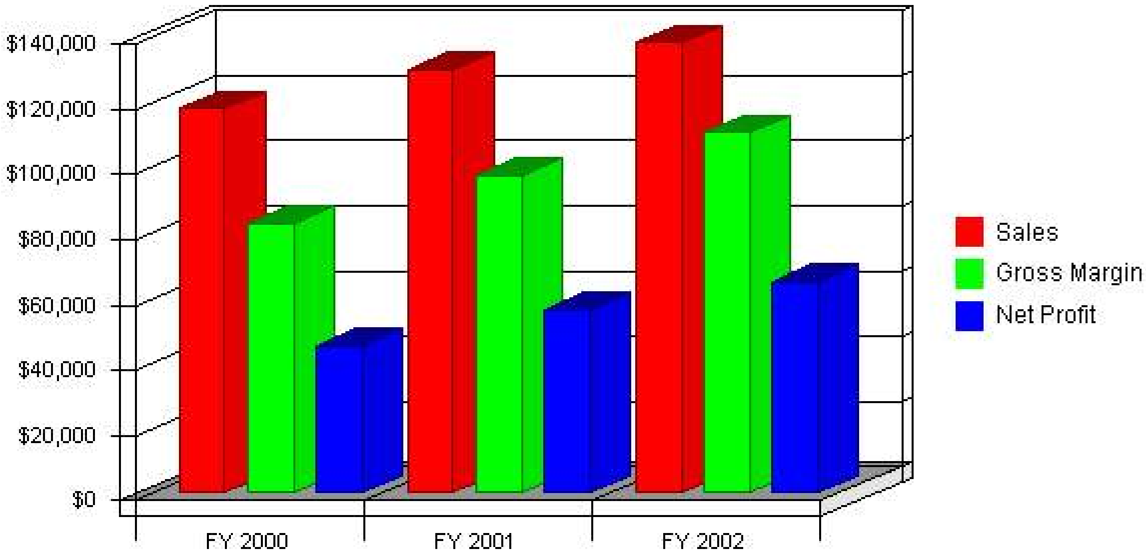
Initial start up costs amount to $20,000. Of this total, $13,000 is required for start up expenses while the balance is to be placed in the company accounts as working capital. The founder, Philip Nolan, provided an initial investment of $20,000 towards start-up costs.

Projected sales and profits for the first three years of operation are summarized below:

Year	Sales($)	Profits($)	Sales/Profit(%)
1	118,000	9,150	7.8
2	130,000	12,650	9.8
3	138,000	15,100	11.0

The firm will specialize in providing three dimensional modeling and visualization to our clients. State-of-the-art analysis and design tools will be an integral part of the business plan. Implementation of a quality control and assurance program will provide a focus for production work.

Highlights



1.1 Objectives

Revenues of $118,000 the first year, approaching $138,000 at the end of three years.
Achieve 20 % of market value at the end of the third year of operation.
Increase gross margin to 80% by the third year of operations.

1.2 Mission

Our mission is to provide clients across Canada's North with structural engineering services for all types of buildings, from concept planning through to completion, with a highly skilled professional team working together, using common sense and practical experience.

1.3 Keys to Success

Provide professional quality services on time and on budget.
Develop a follow-up strategy to gauge performance with all clients.
Implement and maintain a quality control and assurance policy.

Company Summary

2.0 Company Summary

StructureAll Ltd. is a new company which provides professional engineering design services for clients which manage, maintain, and plan for residential, commercial, and industrial type buildings. Our focus will be the public sector market in remote communities across Canada's North.

2.1 Company Ownership

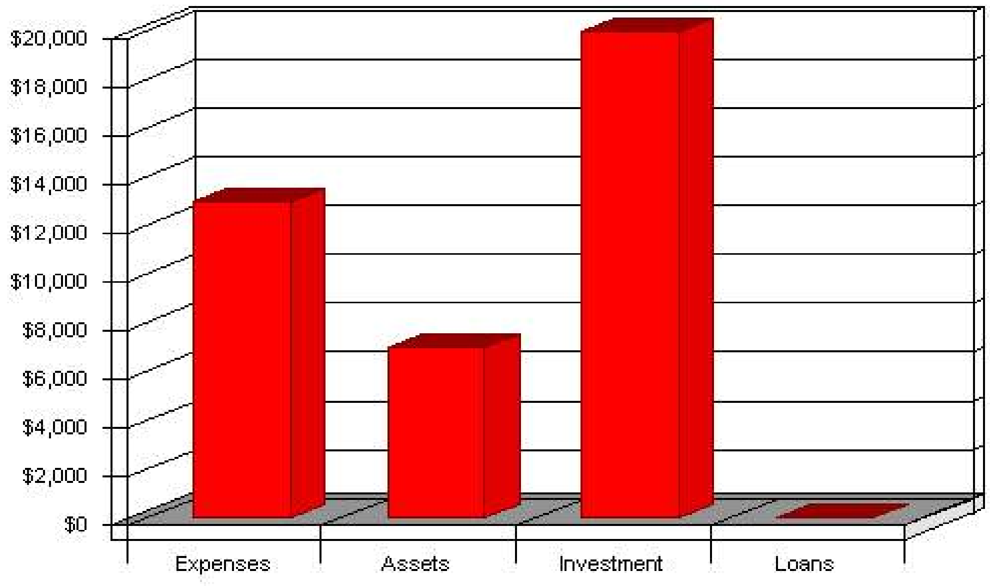
StructureAll Ltd. will be created as a limited liability company. The company will be privately owned by Philip D. Nolan. Leslie C. Goit will also be listed as a Director.

2.2 Start-up Summary

Our start-up expenses amount to $13,000, which allows for initial legal expenses, licenses, permits, stationary, specialty software, office equipment, and furniture. In addition to these start-up costs, an initial balance of $7,000 will be placed in the company accounts. The software purchases include an allowance of $5,000 for AutoCADD® 2000, $1,800 for National Master Specifications, and $200 for Quickbooks® (accounting package).

Philip Nolan will contribute $20,000 towards the overall start-up costs.

Start-up



Requirements

Start-up Expenses

Professional Liability Insurance	$1,200
Web Site Development	$600
Legal Services	$500
Business Licenses	$1,000
Permit Holder (NAPEGG)	$500
Software Purchases	$7,000
Stationery	$600
Office Furniture	$600
Office Equipment	$500
Other	$500
Total Start-up Expenses	$13,000

Start-up Assets Needed

Cash Balance on Starting Date	$7,000
Other Current Assets	$0
Total Current Assets	$7,000
Long-term Assets	$0
Total Assets	$7,000
Total Requirements	$20,000

Funding
Investment

Philip D. Nolan	$20,000
Investor 2	$0
Total Investment	$20,000

Current Liabilities

Accounts Payable	$0
Current Borrowing	$0
Other Current Liabilities	$0
Current Liabilities	$0
Long-term Liabilities	$0
Total Liabilities	$0
Loss at Start-up	($13,000)
Total Capital	$7,000
Total Capital and Liabilities	$7,000

2.3 Company Locations and Facilities

We will establish a home office in Yellowknife, NT in order to reduce start-up costs. The office space is estimated to be 150 square feet. We will be installing a dedicated fax line as well as a high-speed Internet connection. An interactive website will also be developed which will serve as a marketing tool. The domain name of "structureall.com" has already been reserved.

Services

3.0 Services

StructureAll Ltd. offers complete structural engineering services. We will focus on buildings with the following 'Use and Occupancies':
Residential.
Commercial.
Industrial.

The company is 'project' oriented where each project involves:
Renovations.
Rehabilitation.
Additions.
New construction.

We offer innovative and economical design services, maintaining state-of-the-art design technology. We meet client needs on projects of all sizes and smaller, special design projects.

3.1 Service Description

Project Consulting: Proposed and billed on a per-project and per-milestone basis, project consulting offers a client company a way to harness our specific qualities and use our expertise to develop and/or implement plans, from conceptual planning to turnover. Proposal costs will be associated with each project.

Forensic Investigations: Proposed and billed on a per-project and per-milestone basis, our investigations will serve the public and private sector markets. We will focus on troubleshooting buildings where damage and or failure has occurred. Our reports will outline the description of the problem, the nature of the mechanism which has caused damage or failure, and a list of options for remedial action including estimated budget costs for implementation.

Project Management: Our project management services include defining client needs, preparing bid documents, tendering, bid analysis, construction review, payment certification, contract administration, and warranty inspections. Projects include new facilities, renovations, repairs, and remodeling.

Dispute Resolution: We draw upon our broad range of construction and contract administration experience to provide dispute resolution services, including arbitration, mediation and expert reports for litigation. This work is supported by forensic engineering services to identify the cause of failures.

Restoration Engineering: We provide condition survey, design, and construction review services for the repair of building structures.

Home Inspections: We will provide prospective homeowners with an assessment of the various systems in a residential home, including foundations, framing, building envelope and efficiency, mechanical systems, electrical systems, and general safety issues. We provide a photographic record along with a thorough written report.

3.2 Competitive Comparison

StructureAll Ltd. offers their clients superior service accompanied with state-of-the-art analysis and design capabilities. We will offer three-dimensional visualization services to reduce the possibility of spatial conflicts with architectural elements and other engineering disciplines. In comparison, our competitors rely mostly on two-dimensional models.

We will implement a quality assurance and control program for all projects undertaken. This document will serve to focus on the standards which will be achieved and a means of measuring performance.

A systematic manner of sorting and retrieving a library of structural elements and assemblies will be implemented. Slide libraries will be available from a tool bar within AutoCADD for quick access. We will adopt the layering standards of the American Institute of Architects (AIA). In comparison, our competitors do not have an integrated database.

StructureAll Ltd. will adopt the filing systems developed by the AIA. All project information will be tracked using an integrated database management system. All of our business tools will be year 2000 compliant.

3.3 Sales Literature

A brochure system, which covers a broad spectrum of the target market segment will be developed during the initial year of operations. This system will be modular in nature and include many 'boiler plate' sections which may be edited to suit specific needs. Brochure inserts will be maintained as individual sheets to facilitate their assembly in any custom situation.

Our website will be developed the first year of operations and include a description of our services, the areas which we plan to serve, contact information, a list of representative projects, and a brief biography of Philip D. Nolan. An Internet domain name has already been reserved for this purpose ... http://www.structureall.com

A series of templates will be developed for project proposals. The format for all proposals will include:

Cover letter.
Scope of services for each project.
Fee (if requested).
Firm's qualifications to provide services (overview).
Project Team (describes each person's tasks and qualifications).
Philosophy of design approach.
Relevant experience.
Schedule to provide services.

3.4 Fulfillment

We will turn to qualified professionals to supplement computer aided design and drafting (CADD) services, specialty connection designs, and analysis support services which are areas that we can afford to contract out without risking the core values provided to the clients.

We have fostered several alliances with suppliers of structural elements, including glued laminated lumber, pre-engineered dimension lumber trusses, engineered lumber, and steel to facilitate this strategy.

In the second year of operations, we intend to secure a storefront presence in Yellowknife. At this stage, we will seek qualified northern engineering students to provide them with work experience in a structural engineering office environment.

3.5 Technology

StructureAll Ltd. will maintain complete and comprehensive Windows® based analysis tools for structural design. An integrated computer aided design and drafting tool permits several evaluations to be made on a structure at minimal cost.

StructureAll Ltd. will maintain an Internet website complete with file transfer protocol (ftp) capabilities.

3.6 Future Services

Quality Control and Assurance: Serving the needs of the welding industry, we will ensure that certified firms and their employee welders are qualified to perform specific welds in accordance with the requirements of the Canadian Welding Bureau (CWB) as a certified Welding Inspector. We are currently in the process of completing a comprehensive home study program offered through the CWB for this purpose.

There are four firms presently in the NWT which require these services in order to maintain their certification with the CWB. On-site inspections are required four times per year.

Fabrication and Detailing Drawings: Serving the special needs of steel and concrete construction, StructureAll Ltd. will be working toward offering these services to contractors in the future.

Toll-Free Communications: We will provide our clients a toll-free number to access 24 hours a day in the second year of operations.

Market Analysis Summary

4.0 Market Analysis Summary

StructureAll Ltd. will focus on traditional Architect/Engineering (A/E) contracts. The owner will usually contract the A/E to perform planning and design services. These design services include preparation of plans, specifications, and estimates.

Construction services may be limited to occasional field visits and certain contract administration requirements. Typically, these types of projects distribute total design fees amongst the professionals involved in accordance with the following guideline:
Architecture Design (65 %).
Structural Design (10 %).
Mechanical Design (15 %).
Electrical Design (10 %).
Our most important clients will be established architectural/engineering firms who require structural engineering services.

4.1 Market Segmentation

The market for engineering services may be summarized with the following groups:

Established Architectural and Engineering firms: Typically, the structural portions of any building project involve a Prime Consultant who pre-selects their team members and promotes their strengths in a proposal call to prospective clients. Our strategy is to offer these established firms a viable resource from which to draw upon. We can undertake the entire structural engineering process or provide assistance to their own in-house staff.

Territorial and Federal Governmental Departments: The Government of the Northwest Territories (GNWT) and the newly created Nunavut Territory retain consultants for a variety of purposes. We intend to position ourselves as a local firm offering expertise in consulting, project management, forensic, and restoration engineering. The Federal Government also retains consultants for similar purposes.

Law Firms: We will market our services to the legal community to provide dispute resolution services, including arbitration, mediation and expert

reports for litigation. This work is supported by forensic engineering services to identify the cause of failures.
Contractors: We will offer design/build services to contractors for the multitude of potential projects which the Territorial Government and Nunavut Territory have recently undertaken. Contractors occasionally require structural engineers to submit sealed alternatives for equivalents to construction details.

Municipal Governments: Remote Municipal Governments in the Territories can expect to have more autonomy with respect to infrastructure growth and development in the years to come. This initiative is part of the GNWT mandate. We will promote our services to the local municipal governments for this purpose. To attract this market potential, we will offer to train those students in each community who are interested in engineering as a career choice. On the local front, the City of Yellowknife often provides recommendations to builders and homeowners for structural engineering services related to renovations, additions, and new construction.

Private Individuals: We will focus attention on homeowners in Yellowknife who are renovating or contemplating an addition to their residence. We will also promote home inspections to those parties contemplating the purchase of a home.

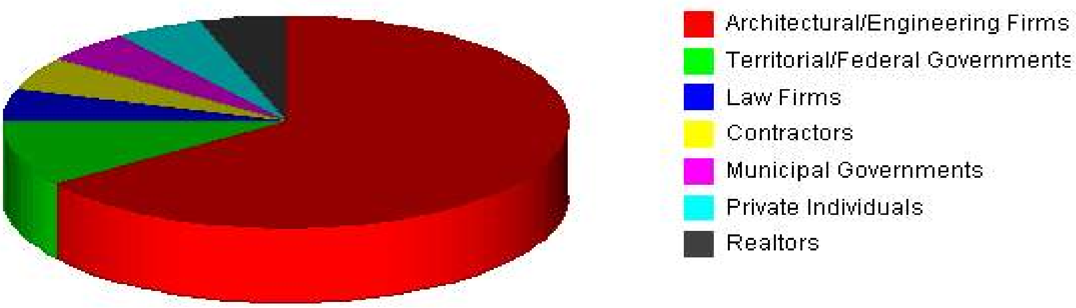
Realtors: In conjunction with home inspections, we will make all the Realtors aware of this service.

The Potential Market Chart and the Market Analysis Table are based on percentages which each of these groups could contribute to the services offered. This manner of describing the potential market is more appropriate for this type of business. As can be seen, the Established Architectural/Engineering firms account for 65 % of the potential market with the other participants claiming the balance in smaller proportions.

Market Analysis

Potential Customers Growth	1999	2000	2001	2002	2003	CAGR	
Architectural/Engineering Firms	0 %	65	65	65	65	65	0.00 %
Territorial/Federal Governments	0 %	10	10	10	10	10	0.00 %
Law Firms	0 %	5	5	5	5	5	0.00 %
Contractors	0 %	5	5	5	5	5	0.00 %
Municipal Governments	0 %	5	5	5	5	5	0.00 %
Private Individuals	0 %	5	5	5	5	5	0.00 %
Realtors	0 %	5	5	5	5	5	0.00 %
Total	0.00 %	100	100	100	100	100	0.00 %

Market Analysis (Pie)



4.2 Service Business Analysis

The following sections describe in more detail these aspects of the service business environment:
Business Participants.
Competition and Buying Patterns.
Main Competitors.

4.2.1 Business Participants

The majority of consulting services cater to the needs of the Territorial Governments. The Territorial Governments operate on a budget of approximately $1,170 million per year, based on the 1998/1999 Main Estimates. Of this total, approximately $1,028 million is spent on Operating and Maintenance Expenditures while $142 million is allocated to Capital Expenditures.

Within the Capital Expenditures, Buildings and Works is a sub-category. This is the area of the annual operating budget from which all building design consultants must draw upon. Our analysis of the 1998/1999 Main Estimates indicates a total expenditure of $59,339,000. A typical A/E contract derives fee estimates from total budgets. For this analysis, we will apply 9% as a guideline for design fees. This yields a figure of about $5,340,000 in design fees available for distribution to the consulting industry.

The major clients within the Territorial Governments include:
Department of Education.
Department of Transportation.
Department of Municipal and Community Affairs.

Our competition matrix indicates a total of 102 persons within the consulting field in the Territories. This total has been subdivided into the types of positions these people hold. Based on reasonable estimates of salary expectations including 30 % burdens for administration yields a value of about $7,800,000. This figure represents an estimate of the revenues required to sustain engineering consultants in the Territories.

From this evaluation, the Territorial Governments account for close to 70% of design fees while other participants in the building marketplace account for the balance. The Territorial Governments retain consultants for the following types of buildings:
Schools.
Health Centres.
Community Halls.
Arenas.
Warehouses.
Firehalls.

These types of buildings are constructed on a rotating basis across several communities in the NT. In addition to new construction, rehabilitation, renovations, and additions are also in demand.

Typically, the Territorial Governments issue a proposal call to consultants to service these needs. StructureAll will position itself as a Structural Sub-Consultant or resource to the Prime Consultant.

StructureAll Ltd. will also promote its services as structural specialists and project managers to the Territorial Governments.

4.2.2 Competition and Buying Patterns

Pricing of projects and billing rates are surprisingly variable. In consulting at this level, it is easier to be priced too low than too high. Clients and potential clients expect to pay substantial fees for the best quality professional advice. The nature of the billing, however, is sensitive. Clients are much more likely to be offended when a job starts at $20 K and ends up at $30K because of overruns, than if the same job started at $30 K or even $35 K.

Clients rarely compare consultants directly, looking for two, or more, possible providers of a proposed project or job. Usually they follow word-of-mouth recommendations and either go for the job or not, rather than selecting from a menu of possible providers.

The most important element of general competition, by far, is what it takes to keep clients for repeat business. It is worth making huge concessions in any single project to maintain a client relationship that brings the client back for future projects.

4.2.3 Main Competitors

Ferguson Simek Clark (FSC Group): This well established architectural and multi-discipline engineering firm would be our main competitor. This firm has branch offices in Iqaluit, NT and Whitehorse, YT besides a head office located in Yellowknife, NT. Their principal strength is undertaking a project from inception through to completion under one roof. Their weakness stems from an understaffed structural engineering group. At present, there is only one structural engineer who services the needs of all their in-house architects and outside clients. The drafting aspects of any project rely upon recollection and modification of past projects typically. There is no systematic manner in which standard block libraries are maintained or updated. They underutilize the programs at their disposal for structural analysis and design.
A.D. Williams Engineering Ltd. (ADWEL): This multi-discipline engineering firm is well established in Yellowknife. Their head office is located in Edmonton, Alberta. They can draw on additional resources from the core group as required to meet the demands of project schedules. At present, there is no resident structural engineer on staff in Yellowknife.

Girvan and Associates: This is a small one person architectural and engineering firm which specializes in providing services for residential construction projects. Ian Girvan services the private sector mostly. It is our hope that we can form a strategic alliance to carry out consulting work jointly as needs and occasions arise.

Strategy and Implementation Summary

5.0 Strategy and Implementation Summary

StructureAll Ltd. will focus on the Western Arctic area initially. We believe the creation of Nunavut will still provide opportunities for structural engineering services; however a separate Association of Professional Engineers for Nunavut is anticipated.
We are also licensed to practice in the Yukon Territories, although we have not planned for any aggressive marketing in this area.
The target client is usually an Architect Manager.

5.1 Competitive Edge

StructureAll Ltd. offers the following competitive edge:
State-of-the-art modeling, design, analysis, and drafting capabilities.
Quality control and assurance program.
An Internet website (http:\\www.structureall.com, and e-mail, info@structureall.com).

5.2 Marketing Strategy

The sections which follow describe in more detail our positioning statement, pricing, and promotion strategy.

5.2.1 Positioning Statement

For established engineering and architectural firms in Yellowknife who require structural engineering sub-consultant services, StructureAll Ltd. offers a competitive and economical option. Projects may be delegated to StructureAll Ltd. directly or arrangements can be made to supplement and assist their own in-house staff.

5.2.2 Pricing Strategy

Most consulting work is billed on an hourly basis to pre-determined levels dictated by project schedule milestones. We have assigned a rate of $80/hour for basic consulting services and $40/hour for drafting services. These are conservative values for the consulting market. We have used conservative unit rates to remain more competitive.

5.2.3 Promotion Strategy

We will be using the Internet extensively in our sales promotion. Together with a well targeted direct mail and e-mail campaign, we will make all the major players in the marketplace aware of our presence.

We will focus our limited advertising budgets to promote community sponsored events. We will also offer technical services at discount rates to non-profit organizations.

When travelling to remote communities, we will contact the local principals in elementary and high schools offering them a speaker on structural engineering as a career choice.

StructureAll Ltd. will apply for the Northwest Territories Business Incentive Policy. This policy is directed at those firms resident in the Northwest Territories and provides incentives with respect to evaluation of services.

5.3 Sales Strategy

Success in a consulting market is focused on client service and typically translates into repeat business. We will avoid the pitfall of buying a project, only to find the scope of work far exceeds renumeration.

When a potential client questions the cost of a project, we explain the benefits and refer to our proposal which clearly outlines the tasks to be performed. If the budget is for less money, then we must offer less service.

Billing rates are not negotiated. One exception to this rule would be for not-for-profit organizations where marketing can be traded for services in kind.

5.3.1 Sales Forecast

The following table and chart summarizes forecasted sales. We expect sales to remain at a constant level after three months of operation. We predict the first two months of operations will be slow. Revenues will be limited while a generic quality management plan is formulated and basic office administration tasks are completed.

Direct unit costs for the first year have been set at 30 % of unit revenues, which yields a 70 % gross margin. In the third year of operations, we plan to increase gross margin to 80 % as a result of providing a more efficient service to our clients.

Our unit rate for basic consulting services has been set at $80/hour. This is a conservative assumption based on published salary guideline levels for engineering professionals. Our unit rate for CADD services is $40/hr.

Sales Forecast

Unit Sales	FY 2000	FY 2001	FY 2002
Project Consulting	690	750	800
Project Management	240	260	280
Home Inspections	96	110	120
Computer Aided Drafting Services	890	1,000	1,050
Total Unit Sales	1,916	2,120	2,250

Unit Prices	FY 2000	FY 2001	FY 2002
Project Consulting	$80.00	$80.00	$80.00
Project Management	$80.00	$80.00	$80.00
Home Inspections	$80.00	$80.00	$80.00
Computer Aided Drafting Services	$40.00	$40.00	$40.00

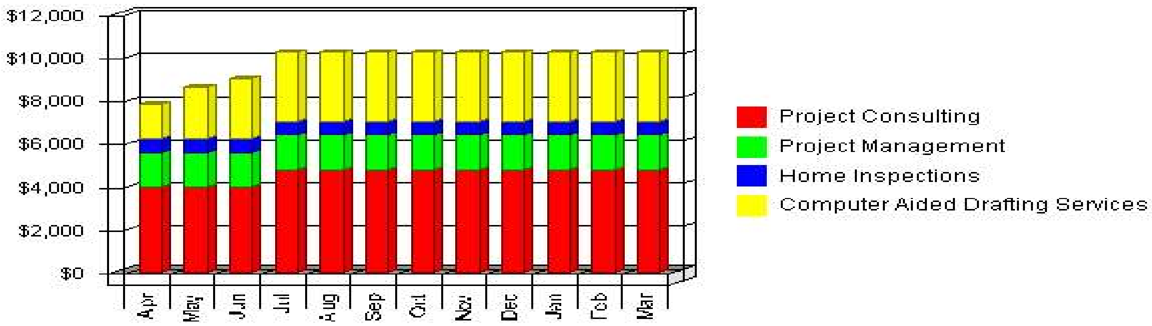
Sales

Project Consulting	$55,200	$60,000	$64,000
Project Management	$19,200	$20,800	$22,400
Home Inspections	$7,680	$8,800	$9,600
Computer Aided Drafting Services	$35,600	$40,000	$42,000
Total Sales	$117,680	$129,600	$138,000

Direct Unit Costs	FY 2000	FY 2001	FY 2002
Project Consulting	$24.00	$20.00	$16.00
Project Management	$24.00	$20.00	$16.00
Home Inspections	$24.00	$20.00	$16.00
Computer Aided Drafting Services	$12.00	$10.00	$8.00

Direct Unit Costs	FY 2000	FY 2001	FY 2002
Project Consulting	$16,560	$15,000	$12,800
Project Management	$5,760	$5,200	$4,480
Home Inspections	$2,304	$2,200	$1,920
Computer Aided Drafting Services	$10,680	$10,000	$8,400
Subtotal Direct Cost of Sales	$35,304	$32,400	$27,600

Sales Monthly



5.4 Milestones

The accompanying table lists important program milestones, with dates and managers in charge, and budgets for each. The milestone schedule indicates our emphasis on planning for implementation.

What the table doesn't show is the commitment behind it. Our business plan includes complete provisions for plan-vs.-actual analysis, which will be updated monthly to compare the variance and plan for course corrections.

Milestones

Milestone	Start Date	End Date	Budget	Manager	Department
Complete Incorporation	4/1/1999	4/15/1999	$500	PN	Administrative
Acquire Tradename for Internet Website	3/6/1999	3/6/1999	$400	PN	Administrative
Submit Business License Application to City	4/1/1999	4/16/1999	$250	PN	Administrative
Acquire WCB Coverage	4/1/1999	4/16/1999	$50	PN	Administrative
Apply for Staad-Pro Core Financing	4/1/1999	4/16/1999	$0	PN	Administrative
Acquire E&O Insurance	4/1/1999	4/16/1999	$1,200	PN	Administrative
Other	1/1/1999	1/1/1999	$0	ABC	Department
Totals			$2,400		

Management Summary

6.0 Management Summary

StructureAll Ltd. will initially have one employee who is also acting as general manager. Phil Nolan will be responsible for all daily operations in the firm.

6.1 Management Team

Philip Nolan, P. Eng. has eighteen years of progressive and responsible engineering experience. Phil will be responsible for soliciting clients, marketing, promotion, and all daily aspects of running the business. He graduated from McGill University in Montreal, Quebec in 1981 with a Bachelor of Engineering degree. Following graduation in 1981, Phil worked for consulting engineers in Toronto, Ontario on a variety of transportation planning projects.

In 1982, Phil moved to Yellowknife where he worked for the GNWT as a Project Engineer. Phil gained experience working on a host of community development and transportation related projects, including Little Buffalo River Bridge, Bridge Inspections, and Bridge Rehabilitations. Phil was with the GNWT for six years.

From 1988 to 1991, Phil worked for Foundation Co. of Canada Ltd., a large multi-national contracting firm as a project engineer where he gained experience in the use of explosives at the Magpie River Hydro Development and continued gaining experience on several bridge projects.

In 1992, Phil worked for Reid Crowther & Partners Ltd. out of Edmonton, Alberta on a host of bridge design and rehabilitation projects, including the Whitemud Ravine Pedestrian Bridges.

From 1993 to 1995, Phil was self employed as a private consultant offering services in quality control and assurance for building construction where he gained considerable experience in Preserved Wood Foundations and their use in residential and commercial applications.

In May of 1995, Phil joined the Ferguson Simek Clark (FSC) team of professionals and was responsible for all structural design, including quality control and assurance services for schools, arenas, health centres, and other buildings. Phil will be the principal designer of all projects at StructureAll Ltd. Phil is currently working on a contract basis for Ferguson Simek Clark.

6.2 Management Team Gaps

StructureAll Ltd. will require administrative support to ensure clients are billed on a timely basis. We will be looking to an outside source for ensuring the books are kept in order and up to date.

Self sufficiency in computer aided drafting capabilities will require Phil to become more familiar with AutoCADD 2000 as a drafting tool. We will invest in continuing education to fulfill this need. We have accounted for this in the business plan.

6.3 Personnel Plan

The following table summarizes our personnel expenditures for the first three years, with compensation increasing from $50K the first year to $70K in the third. The detailed monthly personnel plan for the first year is included in the appendices.

Personnel Plan	FY 2000	FY 2001	FY 2002
Name or title	$0	$0	$0
Other	$0	$0	$0
Total People	0	0	0
Total Payroll	$0	$0	$0

Financial Plan

7.0 Financial Plan

The financial plan which follows summarizes information regarding the following items:
Important Assumptions.
Key Financial Indicators.
Break-Even Analysis.
Projected Profit and Loss.
Projected Cash Flow.
Projected Balance Sheet.
Business Ratios.

7.1 Important Assumptions

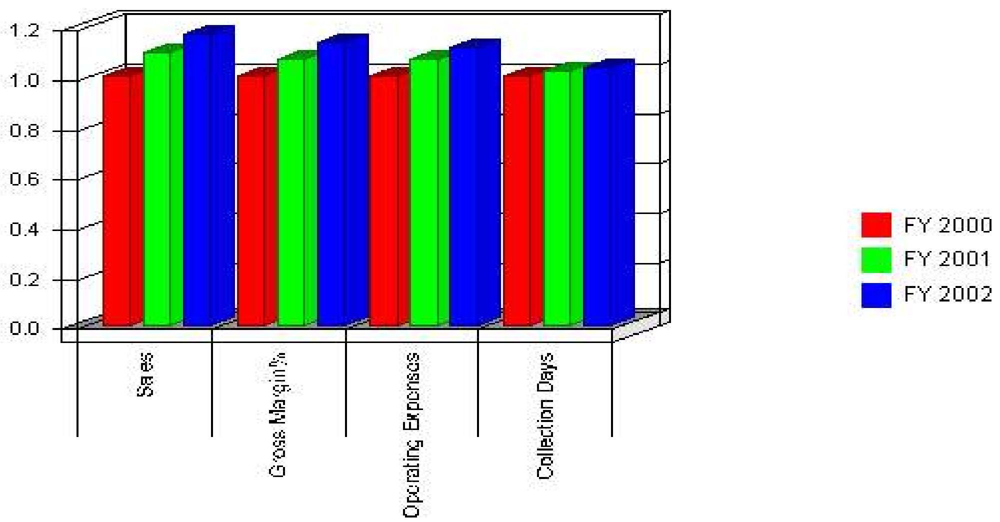
The financial plan depends on important assumptions, most of which are shown in the following table as annual assumptions. The monthly assumptions are included in the appendices.
Some of the more important underlying assumptions are:
We assume a strong economy, without major recession.
We assume the creation of Nunavut will not dramatically change the delivery of engineering services.
Interest rates, tax rates, and personnel burdens are based on conservative assumptions.

General Assumptions	FY 2000	FY 2001	FY 2002
Plan Month	1	2	3
Current Interest Rate	10.00%	10.00%	10.00%
Long-term Interest Rate	10.00%	10.00%	10.00%
Tax Rate	16.25%	15.00%	16.25%
Sales on Credit %	100.00%	100.00%	100.00%
Other	0	0	0

7.2 Key Financial Indicators

The following benchmark chart indicates our key financial indicators for the first three years. We foresee modest growth in sales and a marginal reduction in operating expenses for the years presented.

Benchmarks

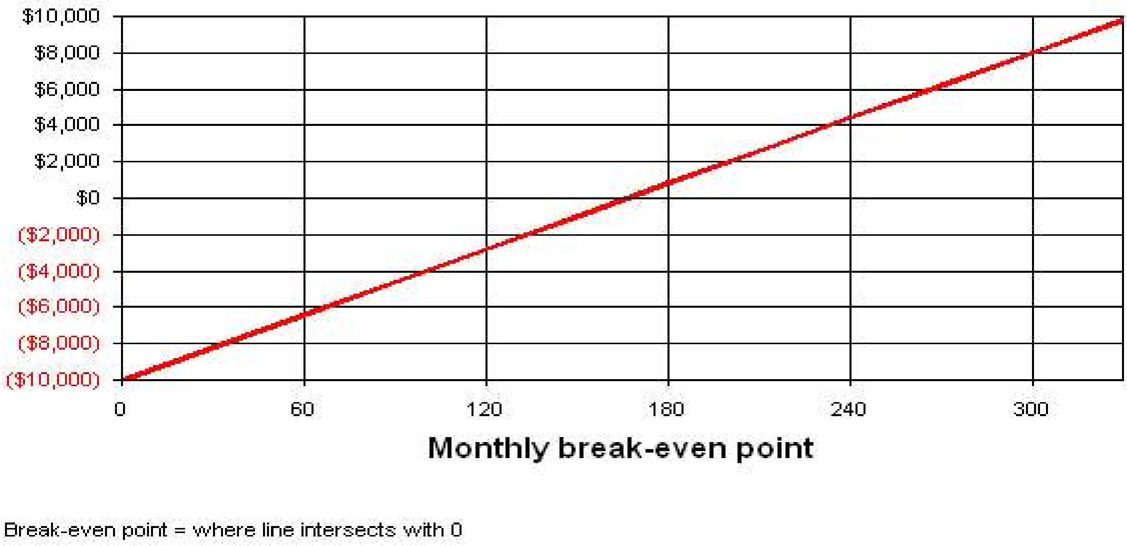


7.3 Break-even Analysis

The following table and chart summarize our break-even analysis. With estimated monthly fixed costs of $6,500, billing targets of $10,000 per month will cover our costs. We don't really expect to reach break-even until a few months into the business operation.

The break-even assumes unit variable costs at 30 percent of unit revenue. The unit revenue value of $60/hour is an aggregate measure for all the types of services which will be offered.

Break-even Analysis



Break-even Analysis:

Monthly Units Break-even	167
Monthly Revenue Break-even	$10,000

Assumptions:

Average Per-Unit Revenue	$60.00
Average Per-Unit Variable Cost	$0.00
Estimated Monthly Fixed Cost	$10,000

7.4 Projected Profit and Loss

The gross margin for a service-based business is a reflection of the efficiency at which those services are offered. In the initial year of operations, we have targeted a gross margin of 70 %. This is not an unreasonable figure for a consulting business. For the second and third year of operations, we have targeted gross margins of 75 % and 80 % to indicate overall improved efficiency at service delivery. Net Profit/Sales is determined to be 7.8 % the first year, increasing to 9.8 % the second year and 11.0 % the third year. In order to fulfill the requirements of the mission statement and simultaneously reduce start up costs, we have made arrangements to purchase software on quarterly repayment options:
Staad-Pro Core is a structural engineering design and drafting suite offered through Research Engineers Ltd. This program fulfills the need to carry out three-dimensional analysis and design requirements and is a key feature of the business plan. This program supports Canadian codes and standards. We have contacted the authorized Canadian reseller (Detech Corporation Ltd.) and will made arrangements to purchase this tool on four payments of $1,550 over the first year of operations.

Errors and Omissions Insurance is required for all consultants working on behalf of the Territorial Governments. Through Falconair Insurance, we have received a quotation of $1,200/year for this coverage. The first year's premium payments are included in the start-up costs, with subsequent years indicated at the same annual premium.

Website hosting fees are included as quarterly payments to Internic.com, the Web host. As part of this service, we will have at our disposal file transfer protocol capabilities. This feature permits us to place electronic media on the Internet for our clients and strategic allies.

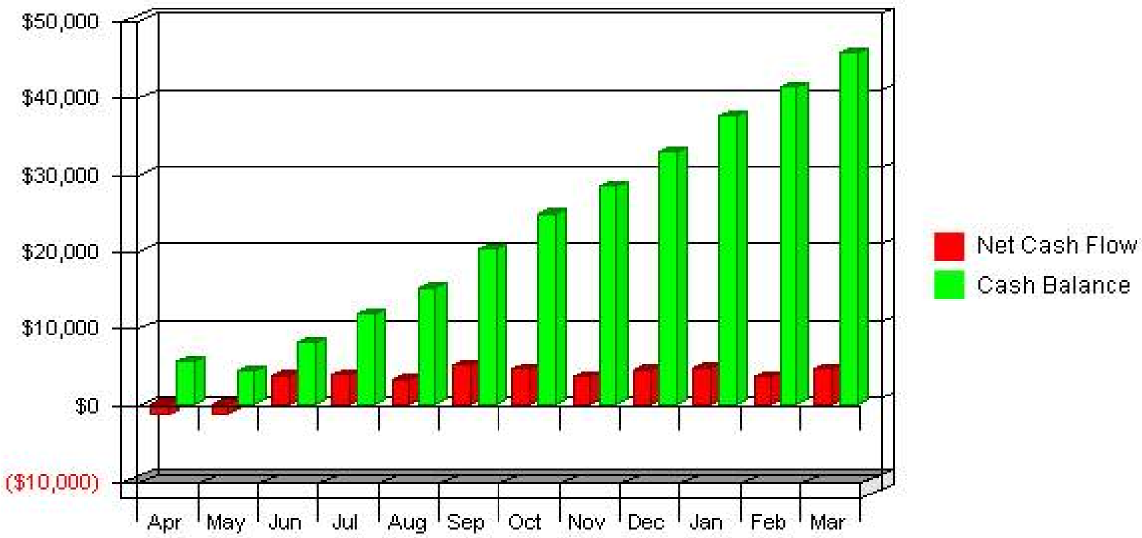
Pro Forma Profit and Loss	FY 2000	FY 2001	FY 2002
Sales	$117,680	$129,600	$138,000
Direct Cost of Sales	$35,304	$32,400	$27,600
Other	$0	$0	$0
Total Cost of Sales	$35,304	$32,400	$27,600
Gross Margin	$82,376	$97,200	$110,400
Gross Margin %	70.00 %	75.00 %	80.00 %
Expenses:			
Payroll	$0	$0	$0
Sales and Marketing and Other Expenses	$9,450	$9,750	$9,750
Depreciation	$1,800	$1,800	$1,800

WebSite Hosting Fees	$380	$380	$380
Telephone/Fax	$2,400	$2,400	$2,400
Software Purchases (Staad-Pro Core)	$6,200	$300	$300
Utilities	$1,200	$1,200	$1,200
Errors and Omissions Insurance	$0	$1,200	$1,200
Rent	$0	$4,800	$4,800
Payroll Taxes	$7,500	$9,000	$10,500
Other	$0	$0	$0
Total Operating Expenses	$28,930	$30,830	$32,330
Profit Before Interest and Taxes	$53,446	$66,370	$78,070
Interest Expense	$179	$495	$830
Taxes Incurred	$8,319	$9,881	$12,552
Net Profit	$44,949	$55,994	$64,689
Net Profit/Sales	38.20 %	43.21 %	46.88 %

7.5 Projected Cash Flow

Cash flow projections are critical to our success. The monthly cash flow is shown in the illustration, with one bar representing the cash flow per month, and the other the monthly balance. The first few months are critical. It may be necessary to inject additional capital in this time-frame if the need arises. The annual cash flow figures are included here and the more important detailed monthly numbers are included in the appendices.

Cash



Pro Forma Cash Flow	FY 2000	FY 2001	FY 2002
Cash Received Cash from Operations:			
Cash Sales	$0	$0	$0
Cash from Receivables	$102,661	$128,079	$136,928
Subtotal Cash from Operations	$102,661	$128,079	$136,928
Additional Cash Received			
Sales Tax, VAT, HST/GST Received	$0	$0	$0
New Current Borrowing	$0	$0	$0
New Other Liabilities (interest-free)	$0	$0	$0
New Long-term Liabilities	$3,300	$3,300	$3,400
Sales of Other Current Assets	$0	$0	$0
Sales of Long-term Assets	$0	$0	$0
New Investment Received	$0	$0	$0
Subtotal Cash Received	$105,961	$131,379	$140,328

Expenditures	FY 2000	FY 2001	FY 2002
Expenditures from Operations:			
Cash Spending	$5,673	$5,516	$5,112
Payment of Accounts Payable	$61,581	$66,393	$66,661
Subtotal Spent on Operations	$67,254	$71,908	$71,773
Additional Cash Spent			
Sales Tax, VAT, HST/GST Paid Out	$0	$0	$0
Principal Repayment of Current Borrowing	$0	$0	$0
Other Liabilities Principal Repayment	$0	$0	$0
Long-term Liabilities Principal Repayment	$0	$0	$0
Purchase Other Current Assets	$0	$0	$0
Purchase Long-term Assets	$0	$0	$0
Dividends	$0	$0	$0
Subtotal Cash Spent	$67,254	$71,908	$71,773
Net Cash Flow	$38,707	$59,471	$68,555
Cash Balance	$45,707	$105,178	$173,733

7.6 Projected Balance Sheet

The balance sheet in the following table shows managed but sufficient growth of net worth and a sufficiently healthy financial position. The monthly estimates are included in the appendices.

Pro Forma Balance Sheet

Assets

Current Assets	FY 2000	FY 2001	FY 2002
Cash	$45,707	$105,178	$173,733
Accounts Receivable	$15,019	$16,540	$17,612
Other Current Assets	$0	$0	$0
Total Current Assets	$60,726	$121,718	$191,345

Long-term Assets

Long-term Assets	$0	$0	$0
Accumulated Depreciation	$1,800	$3,600	$5,400
Total Long-term Assets	($1,800)	($3,600)	($5,400)
Total Assets	$58,926	$118,118	$185,945

Liabilities and Capital

Current Liabilities	FY 2000	FY 2001	FY 2002
Accounts Payable	$3,677	$3,575	$3,314
Current Borrowing	$0	$0	$0
Other Current Liabilities	$0	$0	$0
Subtotal Current Liabilities	$3,677	$3,575	$3,314
Long-term Liabilities	$3,300	$6,600	$10,000
Total Liabilities	$6,977	$10,175	$13,314
Paid-in Capital	$20,000	$20,000	$20,000
Retained Earnings	($13,000)	$31,949	$87,942
Earnings	$44,949	$55,994	$64,689
Total Capital	$51,949	$107,942	$172,631
Total Liabilities and Capital	$58,926	$118,118	$185,945
Net Worth	$51,949	$107,942	$172,631

7.7 Business Ratios

Business ratios for the years of this plan are shown below. Industry profile ratios based on the Standard Industrial Classification (SIC) code 8711, Engineering Services, are shown for comparison.

Ratio Analysis

	FY 2000	FY 2001	FY 2002	Industry
Profile				
Sales Growth	0.00 %	10.13 %	6.48 %	7.10 %

Percent of Total Assets				
Accounts Receivable	0.00 %	0.00 %	0.00 %	3.70 %
Other Current Assets	0.00 %	0.00 %	0.00 %	38.30 %
Total Current Assets	103.05 %	103.05 %	102.90 %	77.40 %
Long-term Assets	–3.05 %	–3.05 %	–2.90 %	22.60 %
Total Assets	100.00 %	100.00 %	100.00 %	100.00 %
Current Liabilities	6.24 %	3.03 %	1.78 %	44.50 %
Long-term Liabilities	5.60 %	5.59 %	5.38 %	11.70 %
Total Liabilities	11.84 %	8.61 %	7.16 %	56.20 %
Net Worth	88.16 %	91.39 %	92.84 %	43.80 %
Percent of Sales				
Sales	100.00 %	100.00 %	100.00 %	100.00 %
Gross Margin	70.00 %	75.00 %	80.00 %	0.00 %
Selling, General & Administrative Expenses	62.22 %	65.24 %	69.07 %	81.80 %
Advertising Expenses	0.51 %	0.58 %	0.54 %	0.20 %
Profit Before Interest and Taxes	45.42 %	51.21 %	56.57 %	2.50 %
Main Ratios				
Current	16.51	34.04	57.74	1.69
Quick	16.51	34.04	57.74	1.37
Total Debt to Total Assets	11.84 %	8.61 %	7.16 %	56.20 %
Pre-tax Return on Net Worth	102.54 %	61.03 %	44.74 %	6.00 %
Pre-tax Return on Assets	90.40 %	55.77 %	41.54 %	13.60 %

Additional Ratios	FY 2000	FY 2001	FY 2002
Net Profit Margin	38.20 %	43.21 %	46.88
Return on Equity	86.53 %	51.87 %	37.47 %

Activity Ratios			
Accounts Receivable Turnover	7.84	7.84	7.84
Collection Days	43	44	45
Inventory Turnover	0.00	0.00	0.00
Accounts Payable Turnover	17.75	18.54	20.04
Payment Days	21	20	19

Total Asset Turnover	2.00	1.10	0.74
Debt Ratios			
Debt to Net Worth	0.13	0.09	0.08
Current Liab. to Liab.	0.53	0.35	0.25
Liquidity Ratios	FY 2000	FY 2001	FY 2002
Net Working Capital	$57,049	$118,142	$188,031
Interest Coverage	299.00	134.08	94.06
Additional Ratios			
Assets to Sales	0.50	0.91	1.35
Current Debt/Total Assets	6 %	3 %	2 %
Acid Test	12.43	29.42	52.43
Sales/Net Worth	2.27	1.20	0.80
Dividend Payout	0.00	0.00	0.00

Note:

Executive Summary: Write this last. It's just a page or two of highlights.
Company Description: Legal establishment, history, start-up plans, etc.
Product or Service: Describe what you're selling. Focus on customer benefits.
Market Analysis: You need to know your market, customer needs, where they are, how to reach them, etc.
Strategy and Implementation: Be specific. Include management responsibilities with dates and budgets. Make sure you can track results.
Web Plan Summary: For e-commerce, include discussion of website, development costs, operations, sales and marketing strategies.
Management Team: Describe the organization and the key management team members.
Financial Analysis: Make sure to include at the very least your projected Profit and Loss and Cash Flow tables.

Exercise 3. Using the information from Business Plan fulfill the following tasks.

1. Create a company and imagine the sphere of your business. Make a business plan summary pointing out the principles of your activity and urgency of your business.
2. Make a Power Point presentation of your business plan.

UNIT 8

INTERNATIONAL BUSINESS ETIQUETTE AND ETHICS

Discuss the following questions.

1. Why do we need business etiquette?
2. What rules of business behavior do you know?
3. Do you know any communicational taboos?
4. Have you ever been in the situation when you didn't know how to behave? How did you cope?

Terms and Vocabulary

essence	сущность
mean	средство
vice versa	наоборот
to revolve	вращаться
pillar	основа, главная идея
attitude	поведение
speak volumes	передавать значимую информацию
uncouth	грубый, невежливый
to prosper	преуспевать
trait	характерная черта
integrity	целлостность
boundary	граница
framework	основа
arrogant	высокомерный
sensitivity	чувствительность
underlie	лежать в основе чего-л
astray	заблудившись, сбившись с пути

Exercise 1. Read the text and do the exercises.

BUSINESS ETIQUETTE

Business etiquette is in **essence** about building relationships with people. In the business world, it is people that influence your success or failure. Etiquette, and in particular business etiquette, is simply a **means** of maximising your business potential.

If you feel comfortable around someone **and vice versa**, better communication and mutual trust will develop. This comfort zone is realized through presenting yourself effectively. Business etiquette helps you achieve this.

Business etiquette **revolves** around two things. Firstly, thoughtful consideration of the interests and feelings of others and secondly, minimising misunderstandings. Both are dependent upon self conduct. Business etiquette polishes this conduct.

Business etiquette varies from region to region and country to country. For the international business person, focusing too deeply on international business etiquette would leave no time for business. However, there are some key **pillars** upon which good business etiquette is built. Here are the principles of business etiquette:

Behaviour
Your manners and **attitude** will **speak volumes** about you. They will point to your inner character. If you come across selfish, undisciplined or **uncouth** your relationship is unlikely to **prosper.** Appropriate business etiquette promotes positive **traits.**

Honesty
A reputation for delivering what you say will deliver goes a long way in the business world. Remember, a reputation for **integrity** is slowly gained but quickly lost. Understanding a particular country's business etiquette provides a **framework i**n which you can work without fear of crossing **boundaries** in terms of agreements, promises and contracts.

Character
Your character refers to what you as an individual bring to the business table. Proper business etiquette allows you to exhibit your positive qualities. For example, knowing when to be passionate and not emotional or self-confident without being **arrogant.** Just through learning another's business etiquette you demonstrate an open-mindedness which will earn respect.

Sensitivity

Sensitivity and consideration **underlie** all good business etiquette. Being prepared for foreign ways and methods and responding thoughtfully is achieved through experience and business etiquette know-how. By avoiding misunderstandings and misinterpretations through business etiquette you lay foundations for a strong business relationship.

Diplomacy

Avoiding thoughtless words and actions protects you from negative consequences. Impulse often leads a business person **astray**. Business etiquette encourages the careful thought of the interests of others and choosing acceptable forms of expression.

Appearance

Dressing appropriately, standing and sitting in the right place at the right time, good posture and looking physically presentable are all elements in making a good impression. Business etiquette teaches you how to suitably present yourself and what to avoid.

(Frederick W.C., Davis K., Post J. E. "Business Ethics")

Exercise 2. Answer the following questions.

1. What is business etiquette?
2. What role does a comfort zone play?
3. What are the things round which the business etiquette revolve?
4. Is it necessary to concentrate deeply on business etiquette?
5. What are the main principles of business etiquette?
6. Among all the principles, what do you think is the major one? Why?

Exercise 3. Match synonyms in columns A and B.

A	**B**
1. in essence	a) on the contrary
2. vice versa	b) basis
3. to revolve	c) self sure
4. pillar	d) in the main
5. uncouth	e) characteristic feature
6. trait	f) to circle
7. integrity	g) strange
8. arrogant	h) develop

9. astray i) lost
10. prosper j) honesty

Exercise 4. Translate the following sentences into English.

1. Бизнес этикет поможет вам избежать непонимания и ложной интерпретации некоторых вопросов, а так же заложит основу прочным партнёрским взаимоотношениям.
2. Для увеличения потенциала развития вашего бизнеса, просто необходимо владеть основами бизнес этикета.
3. Избежание бессмысленных слов и действий защитит вас от негативных последствий.
4. Бизнес этикет учит вас, как выгодно представить себя и чего избегать.
5. Ваш характер отражает то, что вы как личность привнесёте в бизнес.

Exercise 5. Imagine that you are business partners to be. Divide into two groups and choose one person who will introduce each person in the group. The others should tell about themselves, following the principles of business etiquette, while hearing his/her name.

ex. A. This is Helena Ivanova, staff supervisor of our company.
B. Thank you Mr. Johns for introducing me to our partners. I've been working with this company for 5 years. During the work I…..

Listen to each other carefully and comment on speech and behavior mistakes if there were any.

Exercise 6. Watch the film "Guide to International Business Etiquette" and do the quiz.

***Choose the right variant (sometimes several variants are possible*:**

1. Good first impression includes communicating well and
   a) understanding the protocols of business
   b) knowing foreign languages
   c) being a well-paid person
2. Every culture has it's own way of
   a) making money
   b) doing business

c) making conversation

3. Always say good bye
   a) when leaving the room
   b) to every person you met
   c) if you said hello to somebody
4. According to the video "People are most valuable resource because…
   a) help reach your goals
   b) are easily motivated
   c) become your friends , customers , employers, suppliers
5. Standing straight makes you feel
   a) healthier
   b) happier
   c) more power
6. Slouching Poor Eye contact, crossing arms are
   a) negative signals
   b) impolite behavior
   c) poor education
7. Introduction is started from
   a) the first person you see
   b) the closest person to you
   c) the most important person
8. Why should you hold a glass of red wine by the bottom
   a) because it is the most comfortable way
   b) not to spill the wine
   c) because it is better when it is warm
9. What are tree things to remember when starting a small talk
   a) find out the commonalities
   b) ask names
   c) complimenting
10. Why a business card should be given with the right hand?
    a) because most persons are right-handed
    b) because it is a hand of respect in most cultures
    c) because it is very polite

Exercise 7. Read the text and do the exercises.

Business Ethics

When one is dealing with ethics, clear thinking is extremely important, because most ethical issues and problems are controversial, involving emotional questions of right and wrong behavior. A good first step is to have a clear definition of ethics.

What Is Ethics?
Ethics is a set of rules that define right and wrong conduct. These ethical rules tell us when our behavior is acceptable and when it is disapproved and considered to be wrong. Ethics deals with fundamental human relationships. Ethical rules are guides to moral behavior. For example, all societies have ethical rules forbidding lying, stealing, deceiving, and harming others, just as they also have ethical rules that approve of honesty, keeping promises, helping others, and respecting the rights of others. Such basic rules of behavior are thought to be essential for the preservation and continuation of organized life.

For many people, religious beliefs and organizations are a major source of ethical guidance and moral meaning. The family institution also imparts a sense of right and wrong to children as they grow up, as do schools and other similar influences such as television. The totality of these learning experiences creates in each person a concept of ethics, morality, and socially desirable behavior. Ethical rules are present in all societies, all organizations, and all individual persons, although they may vary greatly from one to another. Your ethics may not be the same as your neighbor's; or one particular religion's notion of morality may not be identical to another's; or what is considered ethical in one society may be forbidden in another society. In spite of this diversity, ethics is a universal human trait. All people everywhere need rules to govern their conduct, rules that tell them whether their actions are right or wrong, moral or immoral, approved or disapproved.

What is Business Ethics?
Business ethics is not a special set of ethical rules different from ethics in general and applicable only to business. Business ethics is the application of general ethical rules to business behavior. If a society's ethical rules say that dishonesty is unethical and immoral, then anyone in business who is dishonest with employees, customers, creditors, stockholders, or competitors is acting unethically and immorally. If protecting others from harm is

considered to be ethical, then a business firm that recalls a defective and dangerous product is acting in an ethical way.

In the TG&Y episode, both the buyers who took the bribes and the bribers acted unethically because they deceived others, took unfair advantage of them, and then concealed their own selfish actions. They broke the rules of fair play. Likewise, the banks that allowed laundered money to [low through their accounts not only broke the law but protected criminals who harmed society and who brought tragedy into the lives of drug users and addicts. The supervisor who failed to give an employee advance notice of being fired was not breaking the law, but she felt unethical in not telling the whole truth. When business firms or people in business violate the rules that define right and wrong behavior, they are acting unethically, and they also may be acting illegally.

Why Is Business Ethics Important?

Why should business pay attention at all to ethics? What prevents a business firm from piling up as many profits as it can, in any way it can, regardless of ethical rules? In most cases, the general public expects business to exhibit high levels of ethical performance and social responsibility. Parker Brothers spent $ 10 million in recalling the toy that was involved in the death of two children because company executives knew that its customers and the general public would approve its attempts to protect children's lives, even though the likelihood of further accidents was remote.

A second factor encouraging business firms and their employees to act ethically is to prevent harm to society. One of the strongest-ethical principles is stated very simply: "Do no harm." A company that is careless in disposing of toxic chemical by-products that may cause disease and death is breaking this ethical injunction. Many ethical rules operate to protect society against various types of harm, and business is expected to observe these commonsense ethical principles.

A third reason for promoting ethical behavior is to protect business firms from abuse by unethical employees or unethical competitors. Bribery and kickback schemes penalize honest business firms: "One New York apparel vendor says he lost a $4 million account with one of the nation's largest retailers because he, unlike one competitor, didn't bribe the buyer with $ 20,000 cars and pricey stereo systems."

High ethical performance also protects the individuals who work in business. Employees resent invasions of privacy (such as unjustified polygraph tests) or being ordered to do something against their personal convictions (such as "midnight dumping" of toxic wastes) or working under hazardous conditions (such as entering unventilated coal mines). Businesses that treat their employees with dignity and integrity reap many rewards in the form of high morale and improved productivity.

(W. C Fredefick, K. Davis, J. E. Post)

Exercise 8. Read the explanations of the words and try to guess the translation.

sue (smb for smth) *(v)* – to make a legal claim, especially for an amount of money, because of some loss or damage that one has suffered
charge (with) *(v)* – to bring an especially criminal charge against; accuse
kickback – (slang) money paid, usually secretly or dishonestly, to someone in return for doing something
bribe *(n)* – something especially money, offered or given in bribing
illicit *(adj)* – (done) against a law or a rule
embezzle *(v)* – to steal (money that is placed in *one's* care)
forbid *(v)* – to refuse to allow; command against, especially officially or with the right to be obeyed
govern *(v)* – to control and direct the affairs
conceal *(v)* – to hide; keep from being seen or known
penalize *(v)* – to punish for breaking a law or rule
hazardous *(adj)* – (especially of an activity) which contains risks or danger
weed smb/smth out *(phr v)* – to get rid of (people or things of unacceptable quality) in order to improve smth.

Exercise 9. Complete the sentences using the active vocabulary.

1. She was to be included in the investigation for accepting ....
2. The new tax laws ... people who earn less than & 7,000 a year.
3. The manager ... $ 1,000 from the bank where he worked.
4. He was the robbery.
5. If you do not return our property we will....
6. The country was ... by a small elite of military officers.
7. They were convicted of racketeering and were ordered to repay $ 100 million in ... profits.
8. It was a ... occupation for him.

Exercise 10. Give synonyms to the following words and word combinations.

in cash
vendor
transaction
lay off
enforcement
lawbreakers
to govern their conduct
ethical performance
abuse
remote
pricey
ethical injunction

Exercise 11. Work in groups and discuss the problem of major ethical principles that can be violated by the employees and employers.

Exercise 12. Discuss these questions before reading the article.

1. What to your mind is the role of the large oil companies in price hikes?
2. What do you know about the bribery scandal connected with oil contracts in Kazakhstan?
3. Have you ever heard about Exxon's case? Speak about it.

Exercise 13. Read the article, do the exercises.

Big Oil's Dirty Secrets

EVEN as it celebrates soaring profits — thanks to higher prices during the war and soaring share prices, now war is over, the oil industry faces a new danger largely of its own creation. It will surprise nobody to learn that oil and ethics mix about as well as oil and water. But, just as the tobacco industry and Wall Street gained a false sense of security because for years they got away with well-known practices of an ethically shady nature, only to pay a hefty price later, so too oil's hour of reckoning may be approaching.

There are several reasons, including a high-profile bribery scandal; the growing political sensitivity of the oil industry; changing attitudes to corporate governance; and some potentially explosive lawsuits. The bribery scandal, which seems certain to grow larger as more details emerge, concerns the battle to win oil contracts in Kazakhstan. During the 1995, several big oil firms fought for the right to exploit the oil riches of the region, including Chevron Texaco, on whose board Condoleezza Rice served prior to joining the Bush administration. And, if prosecutors are to be believed, executives at some firms behaved over-zealously as this battle raged.

This week, Swiss investigators were reported to have added a bribery and money-laundering probe involving, among others, Credit Agricole, a French bank, to continuing American investigations into alleged Caspian corruption. Last month, a grand jury in New York issued indictments against two Americans —James Giffen, an independent banker with close ties to the Kazakh president, Nursultan Nazarbayev, and Bryan Williams, a former executive of Mobil. Both deny wrongdoing. America's Justice Department is also looking into whether Mobil, now merged with Exxon, took part in a plan to pay $ 78 m from American and European oil firms into Swiss bank accounts belonging to Mr. Nazarbayev, among others. Exxon Mobil, the world's biggest oil firm, says it knows of no wrongdoing.

Oiling the Wheels

This is already the largest investigation by American authorities into alleged bribery abroad. As it unfolds, it seems certain to provide plenty of colorful stories that will keep it in the spotlight. It involves well-known Russian businessmen and politicians, payments for speedboats and fur coats, and — if only because they too were involved in bidding for Kazakh contracts — other big oil firms besides Mobil, including firms with connections to senior Bush administration officials other than Miss Rice.

It may also provide the sternest test yet of America's Foreign Corrupt Practices Act (FCPA), which outlaws bribery. When the act was introduced in 1977, many American oil firms groused that the law handicapped them against foreign competitors when dealing in the undemocratic and unscrupulous parts of the world where oil is often found. That fear was not entirely groundless, as is clear from the current trial of former officials of France's Elf Aquitaine (now part of Total), where bribery seems to have been a core competency. Some American oil-industry executives privately grouse that, if anybody is found guilty, it will be due to carelessness.

The FCPA, they admit, can be skirted by careful use of "signature bonus" payments to middlemen brokering contracts and via "arm's-length" transactions involving law firms based, more often than not, in London. On the other hand, argues Scott Horton of Patterson Belknap, a New York law firm, the FCPA has prompted American oil firms, though generally opposed to transnational laws on corporate behaviour, to support efforts led by the OECD to impose an international ban on bribery.

The current scandal in the Caspian can only bolster such efforts to bring some transparency to this mucky business. But will it also lead to a greater questioning of some of the techniques used to get around the FCPA? Amy Jaffe, of Texas's Rice University, insists that the current investigation "is going to force every legal department at every major oil firm to ensure they have a clear picture of what their agents, advisers and everyone else in foreign countries are doing. The Giffen case will define what you can and can't do." Big oil is also facing legal troubles over its famed love of nature. This week, lawyers for aggrieved indigenous folk filed suit against Chevron Texaco in Ecuador. For a decade, legal activists have been trying to sue Texaco for dumping contaminated water in open ponds in that country's rain forest that, they claim, harmed both health and the environment. The firm denies wrongdoing, noting that there were no specific laws in Ecuador when it operated there that forbade its practices.

At first, the litigants pursued their claim in American courts, but a judge finally bounced the case back to Ecuador as the proper jurisdiction for the matter. That appeared to be a victory for the oil firm, but in order to have the trial moved south, Chevron Texaco had to agree to respect the ruling of the Ecuadorian court. If it does not, the American judge has retained the right to step into the matter once again. Joseph Kohn, a lawyer for the villagers, is already talking of $ 1 billion as his team's estimate for cleaning up the damage allegedly done by the firm — even before any compensation for suffering and so on.

But legal attacks on alleged human rights abuses committed overseas may prove to be the most nettlesome of all for the oil industry. Consider the sort of public denial prompted by a lawsuit filed last month against an American oil firm: "Occidental has not and does not provide lethal aid to Colombia's armed forces." Even if the firm does indeed prove not to have provided "lethal aid," it faces a high-profile trial exposing its relationship with a regime with an, ahem, uneven record on human rights. Similarly, Exxon is being accused of complicity in abuses committed by the Indonesian military in Aceh, and Unocal stands accused of benefiting from forced labour deployed by the military government in Myanmar. Both firms have consistently denied any wrongdoing.

These cases are tests of America's Alien Tort Claims Act (ATCA). As the law dates back to 1789, its critics note that it does not deal with the precise circumstances of today's cases: it was probably intended to give foreigners a legal forum when in America, rather than offer a domestic remedy for American misdeeds abroad. Oil industry lobbyists have been pushing Congress to repeal the ATCA.

Last year, the Bush administration took the unusual step of intervening in a law^suit brought by the International Labour Rights Fund (ILRF) against Exxon, arguing that applying the ATCA in this case might hinder America's efforts to fight terrorism. Even so, points out the ILRF'S Terry Collingsworth, starting in 1980, this statute has indeed been applied in human-rights cases where foreign states or victims have been involved. Now, particularly with two separate cases related to Myanmar in American courts, it may end up applying to corporations that are judged to be "knowingly complicit" in abuses.

Could this be enough to transform an industry that is famously shameless, not least in America? Maybe. A few big legal losses, lots of bad headlines, and an impending Presidential election with an oilman on the ballot might work wonders.

("The Economist")

Exercise 14. Match up these words from the article with their meanings.

1) to hinder;	a) keen;
2) mucky;	b) to support, strengthen or increase;
3) hefty price;	c) to complain, grumble;
4) reckoning;	d) dirty;
5) zealous;	e) charging someone officially with an offence in law;
6) to allege;	f) calculation;
7) indictment;	g) to state or declare without proof or before finding proof;
8) to bolster;	h) a person on one side or the other in a noncriminal case being decided by a law court;
9) litigant;	i) large amount of money;
10) to grouse.	j) to stop or delay the advance or development of a person or activity.

Exercise 15. After reading the article, test your memory.

1. What new danger does the oil industry face?
2. What did the grand jury in New York issue against two Americans? And why?
3. What is the largest investigation by American authorities called? What can it involve and provide?
4. How did the American firms work after introducing the Foreign Corrupt Practices Act (FCPA) in 1977?
5. Does 'big oil' face legal troubles? What are their characteristics?
6. What cases became tests of ATCA?

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ENVIROMENTAL CONTROL IN PETROLEUM ENGINEERING

HYDROGEOLOGY

N.V. Sukhorukova

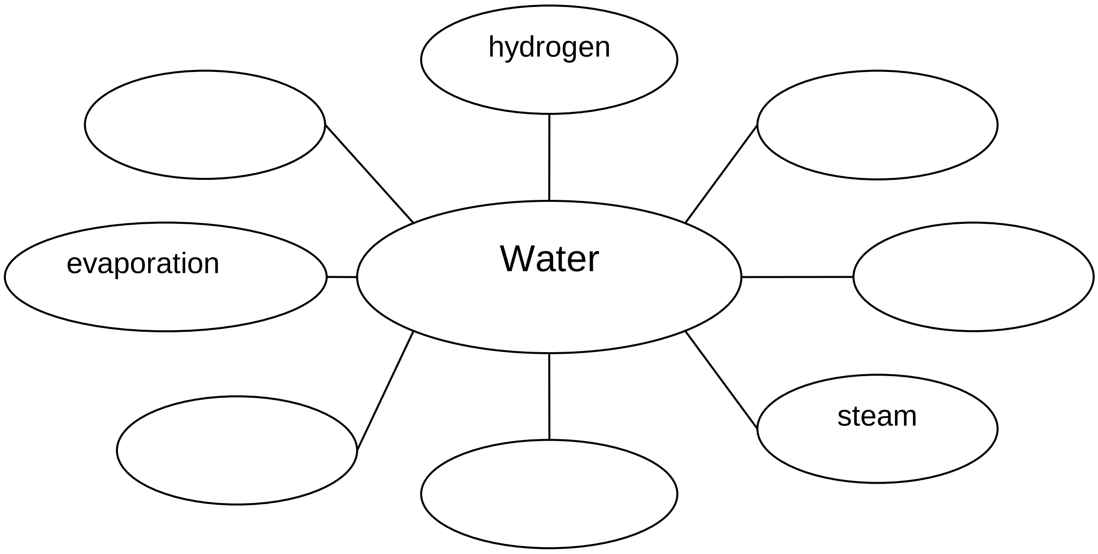
UNIT 1

WATER – NATURE'S TREASURE OR …?

Water is the medium of life: without the cycling of water biochemical cycles could not exist, ecosystems could not function and life could not be maintained. An abundance of water in liquid form makes the Earth unique, no other planet in the solar system has this feature.

Lead-in

What comes to your mind if you see or hear the word "water"? Complete the following spidergram with the words associated with water and share the information with your fellow students:



Explain your associations.

Read the following quotations and comment on them.

" Water! One cannot say that you are necessary for life: you are life itself."

A. de St-Exupery

"How inappropriate to call this planet Earth, when clearly it is Ocean."

Arthur C.Clarke

- Discuss in pairs
- Change your opinion with other groups
- Prepare multipoint conversation. You have time limit **–** 5 minutes

Quiz. Test yourself. The first letter is given.

1. When water falls in small frozen crystals, it's called ***s***____________.
2. When the snow begins to melt, it's called ***s***______________.
3. If the slush freezes again and becomes hard and solid, it's called ***i***________.
4. The combination of rain and snow is known as ***s***_________.
5. Small round lumps that fall during a thunderstorm are called ***h***________.

6. The water forming on the leaves and flowers is ***d***_______in warm weather.
7. The same in cold weather is ***f***_________.
8. The water united into a liquid body which is relatively motionless may be a ***p***________, a ***p***_________, a ***l***_______, a ***s***______, or even an ***o***______.
9. While the water moves, it may be a ***b***_______, a ***c***_______ or ***s***_______, or a river.
10. When water comes out of the tap, it is just ***p***_______ water.

1. Answer the following questions. Work in groups of four.

- Is life on Earth possible without water? Why?
- What are the main characteristics of water?
- Where does water occur?
- What is the composition of water?
- What is hydrogen?
- What is oxygen?
- How does water change with temperature?
- What is evaporation?

2. ***Read the text «What is Water» and find out whose ideas were closest to the facts.***

What is Water?

When scientists wonder whether there is life on other planets, they often ask this question: "Is there water there?" Life as we know it would be impossible without water.

Water is a tasteless, odorless, colorless compound that makes up a large proportion of all living things. It occurs everywhere in the soil, and exists in varying amounts in the air.

Living things can digest and absorb foods only when these foods are dissolved in water. Living tissue consists chiefly of water. What is water made of? It is a simple compound of two gases: hydrogen, a very light gas; and oxygen, a heavier, active gas.

When hydrogen is burned in oxygen, water is formed. But water does not resemble either of the elements which compose it. It has a set of properties all its own.
Water, like most other matter, exists in three states: a liquid state, which is the common form; a solid, called "ice"; and a gas, called "water vapor". In

which one of these forms water shall exist depends ordinarily on the temperature.

At 0 degrees centigrade, or 32 degrees Fahrenheit, water changes from the liquid to the solid state, or freezes. At 100 degrees centigrade, or 212 degrees Fahrenheit, it changes from the liquid to the gaseous state. This change from liquid, visible water to the invisible water gas is called "evaporation".

Thus, if a piece of ice is brought into a warm room, it starts to become liquid or melt. If the room is warm enough, the little puddle of water formed from the melting ice finally disappears. The liquid is changed into water vapor. When water is cooled, it expands just before it reaches the freezing point.

Water as it occurs in nature is never pure in the true sense. It contains dissolved mineral material, dissolved gases, and living organisms.

(N.G.Kitkova "What is water?" 2004, Manager)

3. ***Work in pairs. Here are the answers to some questions about the text. What are the questions?***

1. Tasteless, odorless, colorless compound.
2. A simple compound of two gases: hydrogen and oxygen.
3. In three states.
4. At 32 degrees Fahrenheit.
5. From the liquid to the gaseous state.
6. Freezing point.
7. It contains dissolved material, dissolved gases and living organisms.
8. Evaporation.
9. If the room is warm enough.

10 Gas.

4. ***Work in pairs. One student reads the given statements, the other pretends that he does not hear and asks him/her to repeat. Take turns.***

Example:

STUDENT A: When water falls from clouds it's called a rain.
STUDENT B: Where did you say it falls from?

or

What form did you say it falls in?

STUDENT A: I said it falls from clouds.

or

STUDENT A: I didn't. But it falls in a liquid form.

1. When water falls in small frozen crystals, it's called snow.
2. When the snow begins to melt, it's called slush.
3. If the slush freezes again and becomes hard and solid, it's called ice.
4. The combination of rain and snow is known as sleet.
5. Small round lumps that fall during a thunderstorm are called hail.
6. The water forming on the leaves and flowers is a dew in warm weather.
7. The same in cold weather is frost.
8. The water united into a liquid body which is relatively motionless may be a puddle, a pond, a lake, a sea, or even an ocean.
9. While the water moves, it may be a brook, a creek or stream, or a river.
10. When water comes out of the tap, it is just plain water.

5. Listen to the text about water and decide if you would agree with the following statements. Write "Yes" or "No" in the box next to each statement and be ready to explain your answers.

1. Water is the most abundant substance on the Earth._____
2. We can not change one form of water into another by simply changing the conditions.____
3. The three forms of water are all the same chemical substances. ___
4. A change of state involves making new substances.____
5. Water can be decomposed into its elements by electrolysis.___
6. Water vapour is usually defined as steam._____
7. Water's chemical symbol is H2O.___
8. Water can be synthesized by burning hydrogen in the air.___

6. Listen again and answer the following questions.

1. What makes water similar to other substances?
2. How is water in the form of gas called?
3. Can we call solid water ice?
4. What should we do to change one form of water into another? Give examples.
5. Why can't water be an element?
6. To make water from its elements is considered to be a hazardous activity. Can you explain why?

7. What is “artificial water”?
8. Name properties of “artificial water”.

7. ***Read the situations suggested, choose the one you like, make up a dialogue and act it out.***

- At the International Usov Conference you’ve just attended in Tomsk Polytechnic University one of the participants has made a report “Aquifer overexploitation”. In your opinion it is actual. You are telling him/her this after the conference and you are discussing some details you’ve become interested in.
- Two students have just read an article “Water pollution” taken from “National Geography”.
- A journalist is interviewing a famous scientist who has presented a new approach to solving water problems.
- You were given an assignment to test water from a tap. You offer a few solutions to the problem speaking with your lab instructor.

8. ***Role play.***

- ***Imagine that you are one of the water states: ice, gas or water vapor. What’s happening to you?***
- ***You are invited to the talk show with Andrei Malachov. “Water Pollution” is the topic of the programme. Choose the role and discuss the suggested problem. You have 15 minutes to do the task.***

<u>Roles suggested:</u>
Anchorperson- Andrei Malachov
Hydrologist (polluted drinking water is a major problem in many places around the world)
Chairman, Natural Resources and Ecology Committee, Federal Assembly of the Russian Federation (federal laws to protect water resources)
Ecologist (major categories of water pollutants)
Famous politician - Vladimir Zhirinovsky (promise that you’d solve all water resources problems if you were a president)
Other guests

9. ***You are a citizen of a big city who is very concerned with water resources problems. Write an article. Touch upon the following aspects.***

- What is the present day condition of a river/ lake in your city/ region?
- What role does it play in the life of your city/ region?
- Are there any ecological problems with it? What are they?
- What is being done to solve them by the authorities/ organizations (for example – Greenpeace)?
- What do you suggest to solve the above-mentioned problems?

WORDLIST

ENGLISH	RUSSIAN
brook	ручей
creek	бухта, узкий морской залив; устье реки
compound	смесь, соединение
evaporation	испарение
expand	расширять
exist	существовать
hydrogen	водород
odor	запах
odorless	без запаха
oxygen	кислород
puddle	лужа
pond	пруд, маленькое озеро
slush	грязь, слякоть
sleet	дождь со снегом, гололёд
solid	твёрдый
steam	пар
tasteless	без вкуса
tissue	ткань
vapor	пар

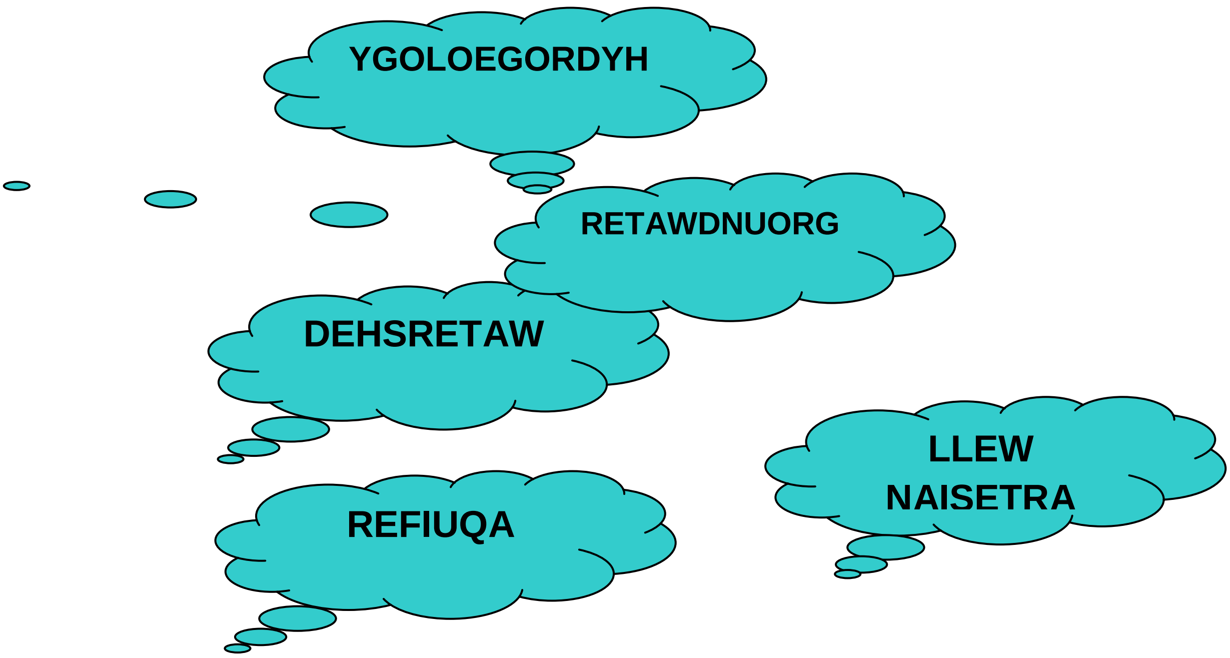
UNIT 2

HYDROGEOLOGY

Hydrogeology like most earth sciences is an interdisciplinary subject. Hydrogeology is a branch of the earth sciences dealing with the flow of water through aquifers and other shallow porous media.
In other words, (*hydro*- meaning water, and -*geology* meaning the study of the Earth) is the area of geology that deals with the distribution and movement of groundwater in the soil and rocks of the Earth's crust, (commonly in aquifers).

Lead-in

Look at the following words in the clouds. The letters are scrambled. Can you guess what the words are? Use all letters.



Write down everything that comes to your mind about hydrogeology. Write only words or quick phrases, but not sentences. You have 3 minutes to do the task.

Terms and Vocabulary

fracture	трещина
gradient	угол наклона, склон
circuitous	окольный, обходной
Reynolds number	число Рейнольда
interplay	взаимодействие
facet	сторона
aquifer	водоносный слой
porous media	пористая среда
pertinent	имеющий отношение
civil engineering	гражданское строительство
soil science	почвоведение
fluid mechanics	механика жидкости
inertia	инерция
Laplace equation	уравнение Лапласа
simulate	имитировать
heat conduction	теплопроводность
heat transfer	теплообмен
uncoupled processes	несвязанные процессы
soil moisture	влажность почвогрунта
viscous	вязкий
viscosity	вязкость (жидкости, газа)
diffusion	диффузия
steady flow	установившийся поток; равномерный поток
transient flow	неустановившийся поток

1. Pay attention to the pronunciation of the following words.

[i:] media, depletion, deterioration, beneath
[e] porous
[o:] encompass, water
[ə:] surface, circulate, circulation, occur, diverse, circuitous, pertinent, inertia
[æ] aquifer, evaporation, apply, application, fracture
[ju:] diffusion, nutrient, estuary, solute
[ai] hydrology, hydrogeology, hydrogen, diverse, derive, science
[ei] availability, equation, vapour
[^] occurrence, ultimately, conduction, reductionist
[k] mechanics, viscous, chemistry, occur

2. Read the following word formations and learn their pronunciation.

apply-application	nature- natural
change-interchange-interchangeably	theory-theoretical
climate-climatic-climatology	occur-occurrence
chemistry-chemical	structure-structural
distribute-distribution-distributor-distributive	hydrology-hydrological-hydrogeologist- non-hydrogeologist
distinct-distinction	

3. Read the text "Hydrogeology: Key Terms and Concepts", do the exercises

Hydrogeology

Hydrogeology (*hydro*- meaning water, and -*geology* meaning the study of the Earth) is the area of geology that deals with the distribution and movement of groundwater in the soil and rocks of the Earth's crust, (commonly in aquifers). The term geohydrology is often used interchangeably. Some make the minor distinction between a hydrologist or engineer applying themselves to geology (geohydrology), and a geologist applying themselves to hydrology (hydrogeology).

Hydrology is the science of water occurrence, movement and transport. Hydrogeology is the part of hydrology that deals with the occurrence, movement and quality of water beneath the Earth's surface. Because hydrogeology deals with water in a complex subsurface environment, it is a complex science. On the other hand, much of its basic terminology and principles can be understood readily by non-hydrogeologists.

Hydrogeology (like most earth sciences) is an interdisciplinary subject; it can be difficult to account fully for the chemical, physical, biological and even legal interactions between soil, water, nature and society. The study of the interaction between groundwater movement and geology can be quite complex. Groundwater does not always flow in the subsurface down-hill following the surface topography; groundwater follows pressure **gradients** (flow from high pressure gradient to low) often following **fractures** and conduits in **circuitous** paths. Taking into account the **interplay** of the different **facets** of a multi-component system often requires knowledge in several diverse fields at both the experimental and theoretical levels. This being said, the following is a more traditional (reductionist viewpoint) introduction to the methods and nomenclature of saturated subsurface hydrology, or simply hydrogeology.

Hydrogeology, as stated above, is a branch of the earth sciences dealing with the flow of water through **aquifers** and other shallow **porous media** (typically less than 450 m or 1,500 ft below the land surface.) The very shallow flow of water in the subsurface (the upper 3 m or 10 ft) is **pertinent** to the fields of **soil science**, agriculture and **civil engineering,** as well as to hydrogeology. The general flow of fluids (water, hydrocarbons, geothermal fluids, etc.) in deeper formations is also a concern of geologists, geophysicists and petroleum geologists. Groundwater is a slow-moving, viscous fluid (with a **Reynolds number** less than unity); many of the empirically derived laws of groundwater flow can be alternately derived in **fluid mechanics** from the special case of Stokes flow (viscosity and pressure terms, but no **inertial** term).

The mathematical relationships used to describe the flow of water through porous media are the diffusion and **Laplace equations**, which have applications in many diverse fields. Steady groundwater flow (Laplace equation) has been **simulated** using electrical, elastic and **heat conduction** analogies. Transient groundwater flow is analogous to the diffusion of heat in a solid, therefore some solutions to hydrological problems have been adapted from **heat transfer** literature.

Traditionally, the movement of groundwater has been studied separately from surface water, climatology, and even the chemical and microbiological aspects of hydrogeology (**the processes are uncoupled)**. As the field of hydrogeology matures, the strong interactions between groundwater, surface water, water chemistry, **soil moisture** and even climate are becoming more clear.

(www.Wikipedia)

4. Fill in the gaps with the correct preposition.

Hydrogeology is the area of geology that deals _________the distribution and movement _______ groundwater in the soil and rocks of the Earth's crust**.**
It is difficult to account__________ the chemical, physical biological and even legal interactions between soil water, nature and society.
Scientists should take _____ account the interplay of the different facets of a multi-component system,
Many laws of groundwater flow can be derived _______fluid mechanics.

Some solutions to hydrological problems have been adapted _______ heat transfer literature.

5. Complete the sentences.

1. Taking into account ___________________________________.
2. As stated above ______________________________________.
3. Traditionally ____.
4. As the field of hydrogeology matures _______________________.
5. Because ____.
6. On the other hand ______________________________________.

6. Give English equivalents to Russian words.

1. Hydrogeology is the **(раздел)** of geology that **(занимается, имеет дело с)** the distribution and movement of groundwater in the soil and rocks of the Earth's crust, **(как правило)** in aquifers.
2. Some make the **(незначительное отличие)** between a hydrologist or engineer applying themselves to geology **(geohydrology),** and a geologist applying themselves to hydrology (hydrogeology).
3. It can be difficult to **(рассматривать, считать)** fully the chemical, physical, biological and even legal interactions between soil, water, nature and society.
4. The study of the **(взаимодействие)** between groundwater movement and geology can be quite complex.
5. **(Принимая во внимание)** the interplay of the different facets of a multi-component system often requires knowledge in several diverse fields at both the experimental and theoretical levels.
6. Hydrogeology**, (как упомянуто выше),** is a **(раздел)** of the earth sciences dealing with the flow of water through aquifers and other shallow porous **(среда)**.
7. Groundwater is a slow-moving, **(вязкая)** fluid (with a Reynolds number less than unity); many of the **(законы, установленные эмпирическим путём)** of groundwater flow can be alternately derived in fluid mechanics from the special case of Stokes flow **-(вязкость)** and pressure terms, but no inertial term.
8. Steady groundwater flow **(уравнение Лапласа)** has been simulated using electrical, elastic and heat conduction analogies.
9. Traditionally, **(движение подземных вод)** has been studied separately from surface water, **(климатология)**, and even the chemical and microbiological aspects of hydrogeology.

10. **(С развитием гидрогеологии),** the strong interactions between groundwater, surface water, water chemistry, soil moisture and even climate are becoming more clear.

7. What are the subjects of the following sciences?

1. Hydrology	deals with is concerned with	flow of water through aquifers and other shallow porous media.
2. Hydrogeology		farming
3. Topography		planning, building and repair of roads, bridges, large buildings.
4. Civil engineering		all aspects of the waters of the Earth: their circulation; their chemical and physical properties; and their reaction with the environment, including their relation to living things.
5. Agriculture		describing an area of land, or making maps of it.

8. Answer the following questions.

1. How is hydrogeology defined?
2. What term can be also used to define hydrogeology?
3. Can you explain why hydrogeology is an interdisciplinary subject?
4. How is hydrogeology related to other fields of science?
5. Can you innumerate key hydrogeology terms?
6. What difficulties can be named in the study of the interaction between groundwater movement and geology?
7. What is groundwater?
8. Name types of groundwater flow.
9. What is a traditional study of groundwater?
10. What is the difference between hydrology and hydrogeology? Why is hydrogeology a complex study?

9. Pay attention to the terms and expressions in the text.

invertebrate zoology	зоология, изучающая беспозвоночных животных
invertebrate paleontology	палеонтология, изучающая беспозвоночных животных
subterranean water	грунтовые воды, подземные воды
Cretaceous	меловой период
Cretaceous chalk aquifer	водоносный горизонт мелового периода
augment (v)	усиливать; повышать, поднимать, увеличивать, расширять
saline	солевой, соляной (содержащий соль или представляющий собой соль)
groundwater contour	граница грунтовых вод
percolation	просачивание, фильтрация
impervious bed	водонепроницаемый слой
water-bearing	водоносный
water-bearing formations	водоносные формации
basin	бассейн, резервуар; водоем, водохранилище
water-level observations	наблюдения за уровнем воды
gradient	отклонение, угол наклона
hydrogeologic(al) map	гидрогеологическая карта

10. ***Read the text 'Joseph Lucas and the term 'Hydrogeology" and decide if the given statements are true or false.***

1. The term hydrogeology was first mentioned in 1802.
2. Jean-Baptiste Lamarck is known as the founder of invertebrate zoology.
3. 70 years passed before the term hydrogeology was mentioned again in the scientific literature.
4. Lucas used the word hydro-geological in his work devoted to water-bearing formations in the south of England.
5. Lucas was a member of the Royal Commission on Water Supply.
6. Prestwich did his best to improve the water supply of London.
7. Joseph Lucas made an important contribution to science.
8. Hydrogeological map can not be considered the only Lucas contribution to science.
9. Lucas ideas were innovative for his time.
10. Asset done by Joseph Lucas was properly appreciated.

Joseph Lucas and the Term "Hydrogeology"

The first use of the word hydrogeology, or more correctly "hydrogeologie", as he was writing in French, can be traced back to Jean-Baptiste de Lamarck, writing almost 200 years ago *(Lamarck 1802)*. Lamarck was born in 1744 and devoted the first part of his life to the study of botany. At the age of 50 he was appointed to a Professorship at the Museum d'Histoire Naturelle in Paris, not of botany but of **invertebrate zoology**, which he had not specially studied previously. In this position he recognized the importance of relating living animals to fossil material and is now acknowledged as the founder of **invertebrate paleaontology.**

It was perhaps as a result of his paleaontological work that he became interested in some of the wider problems of geology. He published his ideas in 1802 in a small volume of 268 pages which he called "Hydrogeologie". It never reached a second edition and according to Geikie *(1906)* appears to have excited little interest among his contemporaries. The subtitle of his book concisely describes its theme as: studies on the influence of water on the surface of the Earth, on the reasons for the existence of ocean basins, of their position and their successive transport on to different parts of the globe, finally on the changes that these lively bodies exert on the nature and state of the surface.

Thus the term hydrogeology was used to describe the role of water in shaping the surface of the earth and was not applied in any sense to the study of underground water.

It was to be over 70 years before the term again appeared in the scientific literature when it was used by Joseph Lucas, a junior officer in the Geological Survey in Britain. Lucas joined the Survey in January 1867 as a young man of 20 and was assigned to mapping the Carboniferous, Permian, and Jurassic Formations of northeast England. According to the memorandum that he submitted to accompany his unsuccessful application for the Professorship of Geology at Oxford *(Lucas 1888)* his interest in "**subterranean water** systems" was aroused by Joseph Prestwich's Presidential Address to the Geological Society in 1872. Prestwich had been a member of the Royal Commission on Water Supply which reported in 1869 and chose for part of his address the subject "Our Springs and Water Supply" *(Prestwich 1872)*. The Royal Commission received conflicting evidence on the amount of groundwater that was available from the underlying **Cretaceous Chalk aquifer** to **augment** the water supply of London. The debate between the scientists who recognised that heavy abstraction could lead to reduced water levels and **saline** intrusion and the engineers who visualized an almost limitless reservoir was extremely acrimonious and continued throughout the nineteenth century *(Mather 1998).*

Lucas realized that little hard information existed on the water-bearing formations in the south of England and in January 1873 started to collect and make observations to the south of London. After 18 months of work, and on the basis of the data that he had collected, he proposed a scheme for the improvement of London's water supply *(Lucas 1874).* This consisted of a series of galleries driven along the strike at the base of the main water-bearing formations in order to capture groundwater otherwise discharged as springs or seepages. Galleries many kilometres in length were visualized. The scheme was never implemented and the small 86-page quarto volume probably would have been forgotten but for the fact that it includes the first British map showing **groundwater contours**. Contours on the upper surface of the water in the Chalk were plotted for two periods during 1873. In an appendix, Lucas also uses the word hydro-geological. It is used only once as the heading of a section entitled "Objects and Mode of Constructing a Hydro-geological Survey of the Water-bearing Formations". In this section he discusses the parameters to be measured; rainfall, evaporation, **percolation,** spring discharges, and the "height of the water line" and considers how these can be used to determine the quantity of water passing under the overlying **impervious beds.**

The term hydro-geology was immediately taken up by Prestwich, whose Presidential address had inspired Lucas. Prestwich had already produced a map of the London basin which included groundwater information. His ideas for improving the water supply of London had been accompanied by a map and sections illustrating the relative positions and areas of the principal **water-bearing formations**, in which individual strata were marked according to their permeability *(Prestwich 1851).* In 1876 he produced a further report, this time on Oxford, which included a **"Hydro-geological map** of the **basin** of the Thames above Oxford". As with his previous map, this did not include water-level contours but categorized formations on the basis of their permeability and this time also included the positions of major springs which might be harnessed to supply Oxford *(Prestwich 1876).*

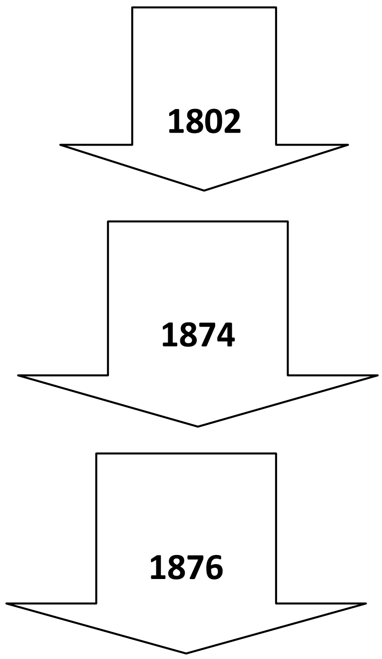
Lucas continued to develop his ideas and his work brought him to the attention of engineers involved in water supply. On 28 November 1876 he gave his first scientific presentation at the Institution of Civil Engineers on

"The Chalk Water System" *(Lucas 1877).* He records in this paper that his observations had extended over four years, ranging over about 200 square miles, on which almost every accessible well had been measured.

The work of Joseph Lucas can be seen as the culmination of some 50 years of systematic **water-level observations**. This started with measurements of individual wells in 1819 *(Bland 1832)*, and continued with the preparation of cross-sections in which levels in a line of wells were drawn to demonstrate **a gradient** in the Chalk aquifer from the hills north of London southwards towards the River Thames (*Clutterbuck 1842, 1843).* The contribution of Lucas was that he made observations over a large area and was able to bring these together in the form of a hydrogeological map. He claimed to have founded the science of hydrogeology *(Lucas 1888)* and certainly made an innovative contribution which probably deserves more recognition than it has received.

(L.M.Bolsunovskaya, V.N.Demchenko "Uchebno-metodichwskoe posobie", 2005 Tomsk)

11. These dates are the stages of hydrogeology term development. What do they stand for?



12. Fill in the chart with the necessary information from the text.

Jean-Baptiste de Lamarck		**Joseph Prestwich**		**Joseph Lucas**	
Date	**Input**	**Date**	**Input**	**Date**	**Input**

13. Pay attention to the pronunciation of the following terms.

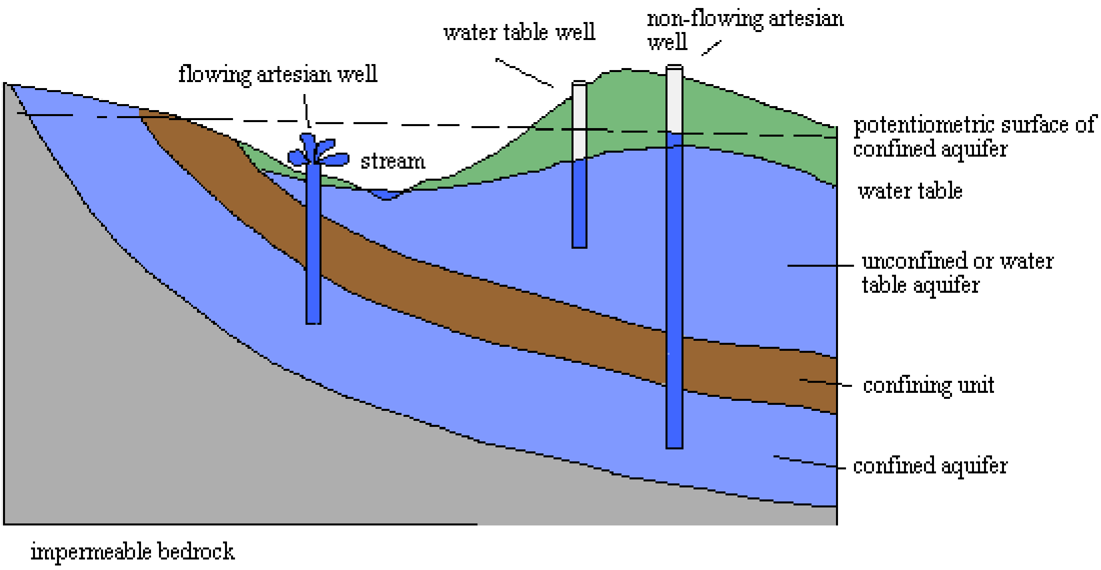
bedrock	коренная подстилающая порода
yield (v)	пропускать
gravel	гравий; галька, галечник
confined / artesian aquifer	напорные воды
potentiometric	регулирующий, потенциометрический
water table well	наблюдательная/ режимная скважина
water table	уровень подземных вод
confining layer	водоупор (водоносного пласта); кровля (водоносного пласта)
perched aquifer/ groundwater	верховодка; подземные воды, не связанные с нижележащими запасами
outwash	склоновая эрозия; смыв
lens	чечевицеобразная залежь
sandwich	помещать посередине, вставлять
intercept	задерживать, преграждать
laterally	сбоку
unconfined aquifer	безнапорные воды
evapotransporation	суммарное испарение (испарение плюс транспирация)
consolidated rock	сцементированная порода
precipitation	осадки
capillary fringe	капиллярная зона
confining layer	водоупор (водоносного пласта); кровля (водоносного пласта)

14. Read the following short texts and fulfill the after-reading exercises. Pay attention to the diagrams and underlined words.

Ground Water Aquifer

A water-bearing layer of rock or sediment capable of **yielding** usable quantities of water; composed of unconsolidated materials such as sands and **gravel**, or **consolidated rock** such as sandstone or fractured limestone.

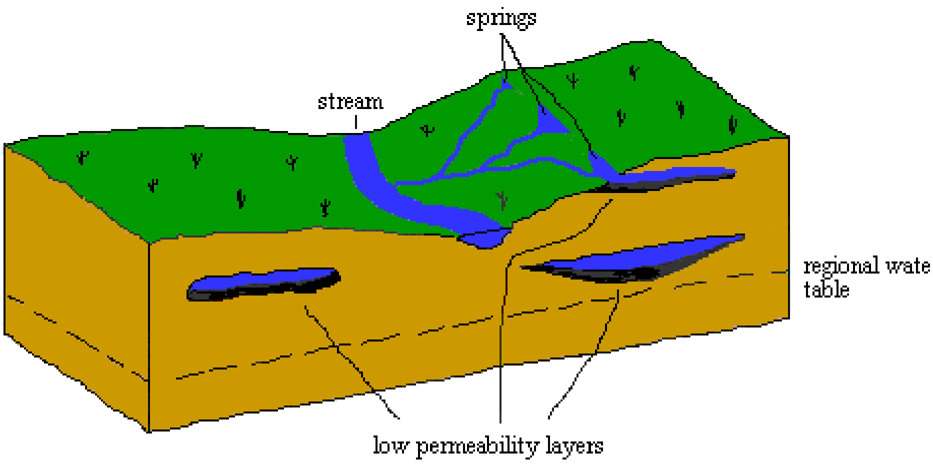
Confined or Artesian Aquifer



stream – водоток; река ; water table well – наблюдательная/ режимная скважина; (non) flowing artesian well – (не) проточная артезианская скважина; water table – уровень подземных вод; potentiometric surface – потенциометрическая поверхность, confined aquifer – напорные воды; impermeable bedrock – непроницаемая подстилающая порода

An aquifer in which ground water is held under pressures greater than atmospheric pressure by upper and lower **confining layers**, forcing water to rise in wells to heights above the top of the aquifer (artesian wells). Also known as **artesian aquifer**.

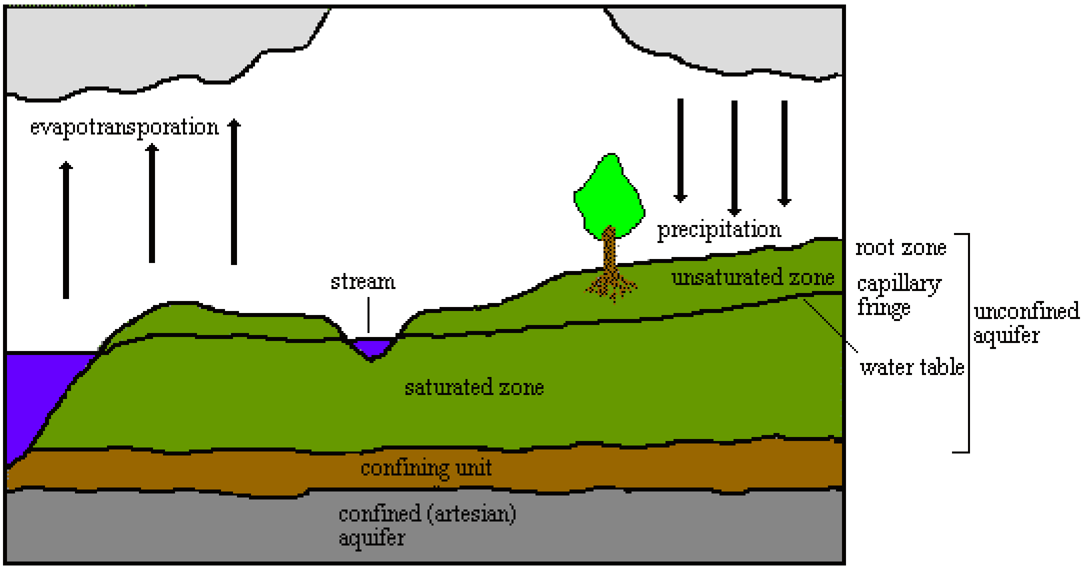
Perched Aquifer



stream - водоток; река; springs - родник; regional table water – местная наблюдательная/ режимная; low permeability layer - низкий проницаемый пласт

An aquifer in which a ground water body is separated from the main ground water below it by an impermeable layer (which is relatively small laterally) and an unsaturated zone. Perched aquifers are common in glacial **outwash**, where **lenses** of clay formed in small glacial ponds are present. They are also common in volcanic depositional sequences where weathered ash layers of low permeability are **sandwiched** between high permeability basalts. Water moving downward through the unsaturated zone will be **intercepted** and accumulate on top of the lens before it moves **laterally** to the edge of the lens and seeps downward to the regional water table or forms a spring on the side of a hillslope.

Unconfined Aquifer



evapotransporation – суммарное испарение; stream – водоток; река; precipitation – осадки; (un)saturated zone – (не) насыщенная зона; water table – уровень подземных вод; ,unconfined aquifer – безнапорные; capillary fringe – капиллярная зона; confined (artesian) aquifer – напорные воды

An aquifer under atmospheric pressure which is only partially filled with water. The top of the saturated area is known as the **water table.** It is also known as a water table aquifer.

(<u>www.Wikipedia</u>)

15. Read the texts once more carefully and choose the correct alternative for these words and word combinations.

1.sideways
2. erosion
3. stop \ catch smth
4. be in a very small space between two other things
5. confined aquifer
6. rain, snow belong to
7. vaporization
8. water table

16. Find the words in texts with the opposite meaning to the following ones.

1. permeable
2. artesian aquifer
3. saturated zone
4. hillrise

17. Match the words in the right column with the words in the left one.

1. saturated	A. aquifer
2. artesian	B. bedrock
3. permeability	C. zone
4. atmospheric	D. pressure
5. impermeable	E. layers
6. depositional	F. table
7. unconsolidated	G. sequences
8. fractured	H. outwash
9. water	I. limestone
10. glacial	J. materials

18. Read underlined key hydrogeology terms and fulfill the after-reading exercises.

Artesian well – a well whose source of water is a confined (artesian) aquifer. The water level in artesian wells stands at some height above the water table because of the pressure (artesian pressure) of the aquifer. The level at which it stands is the potentiometric (or pressure) surface of the aquifer. If the potentiometric surface is above the land surface, the well is a flowing artesian well.

Capillary fringe – the area of the saturated zone just above the water table in which water is held in the soil by surface tension.

Cone of depression – the conical-shaped depression of the water table around a pumping well caused by the withdrawal of water; a valley in the water table. Because of pumping, ground water in the vicinity of the well will deviate from the natural direction of ground water flow and flow towards and into the well.

Confining layer – layer of geologic material which hampers the movement of water into and out of an aquifer. Examples are unfractured igneous rock, metamorphic rock, and shale, or unconsolidated sediments such as clays. This is also known as a confining bed.

Consolidated rock – solid rock that underlies soils; consists of mineral or rock particles of different sizes and shapes that have been welded into a mass by heat and pressure or by chemical reaction. This rock must contain interconnected pores or fractures to serve as an aquifer.
Discharge – the volume flux of water**.**
Drawdown – the vertical drop of the water level in a well caused by ground water pumping; also, the difference between the water level before pumping and the water level during pumping.
Ground water – water found in the saturated zone of the subsurface.
Ground water aquifer – a water-bearing layer of rock or sediment capable of yielding usable quantities of water; composed of unconsolidated materials such as sands and gravel, or consolidated rock such as sandstone or fractured limestone.
Overwithdrawal – withdrawal of ground water from an aquifer at a rate that exceeds the recharge rate of that aquifer. Can lead to lowered water table, saltwater intrusion and sinkholes.
Permeability – the capacity of a porous rock, sediment, or soil to transmit ground water. It is a measure of the inter-connectedness of a material's pore spaces and the relative ease of fluid flow under unequal pressure.
Pores – the spaces between particles within geological material (rock or sediment) occupied by water or air.
Porosity – is defined as the ratio of the volume of voids to the volume of aquifer material. It refers to the degree to which the aquifer material possesses pores or cavities which contain air or water.
Recharge area or zone – Recharge is the process that allows water to replenish an aquifer. This process occurs naturally when rainfall filters down through the soil or rock into an aquifer. Artificial recharge is achieved through the pumping (called injection) of water into wells or by spreading water over the surface where it can seep into the ground. The land area where recharge occurs is called the recharge area or recharge zone.
Salt water intrusion – the process by which over-pumping from an aquifer creates a flow imbalance within an area, which results in salt water encroaching into and contaminating a freshwater supply.
Saturated zone – the subsurface zone in which all pores in the aquifer are filled with water.
Spring – a place where ground water naturally comes to the surface at the intersection of the water table and land surface.
Subsidence – the sinking or depression of the land surface as a result of too much ground water withdrawal (or overwithdrawal of any mined fluid such as petroleum).

Surface water – water found on the land surface in streams, ponds, marshes, lakes or other water bodies.
Unconsolidated material – material derived from the disintegration and erosion of consolidated rocks on the land's surface, as well as sediments deposited by coastal and glacial processes. Unconsolidated materials include, in order of increasing grain size, clay, silt, sand, and gravel.
Underground water – all water beneath the land surface. It includes water in the saturated and unsaturated zones.
Unsaturated zone – the subsurface zone in which the geological material contains both water and air in pore spaces. The top of the unsaturated zone typically is at the land surface, otherwise known as the vadose zone.
Watershed – all the land area and water within the confines of a drainage divide in which all surface runoff will pass through an identifiable outlet, such as a stream or river.
Water table – the top of an unconfined aquifer below which the pore spaces are generally saturated; the level in the saturated zone at which the pressure is equal to the atmospheric pressure.
Water table well – a well in which the source of water is an unconfined water table aquifer.

19. Match the English term with the Russian one.

1. capillary fringe	A. откачка
2. overwithdrawal	B. оседание почвы
3. drawdown	C. безнапорные воды
4. watershed	D. режимная скважина
5. permeability	E. капиллярная зона
6. subsidence	F. напорные воды
7. discharge	G. разгрузка
8. unconfined aquifer	H. водоупор
9. water table well	I. проницаемость
10. artesian aquifer	J. понижение уровня вод
11. confining layer	K. уровень подземных вод
12. water table	L. водораздел

20. Match the terms with the definitions.

1. artesian well	A. a place where ground water naturally comes to the surface at the intersection of the water table and land surface.
2. consolidated rock	B. a valley in the water table.
3. spring	C. the vertical drop of the water level in a well caused by ground water pumping; also, the difference between the water level before pumping and the water level during pumping.
4.cone of depression	D. the spaces between particles within geological material (rock or sediment) occupied by water or air.
5. subsidence	E. the process by which over-pumping from an aquifer creates a flow imbalance within an area, which results in salt water encroaching into and contaminating a freshwater supply.
6. drawdown	F. a well whose source of water is a confined aquifer.
7. ground water aquifer	G. all the land area and water within the confines of a drainage divide in which all surface runoff will pass through an identifiable outlet, such as a stream or river.
8. pores	H. this rock must contain interconnected pores or fractures to serve as an aquifer.
9. salt water intrusion	I. the sinking or depression of the land surface as a result of too much ground water withdrawal.
10. saturated zone	J. all water beneath the land surface. It includes water in the saturated and unsaturated zones.
11. underground water	K. the subsurface zone in which all pores in the aquifer are filled with water.
12. watershed	L. a water-bearing layer of rock or sediment capable of yielding usable quantities of water.

21. Listen to the text where a commentator is talking about a hydrologist job. You will hear it twice. Answer the questions by saying whether the following statements are True (T) or False (F).

Mark it on the answer sheet. You have 30 seconds to read the questions.

1 Hydrologists use various techniques and sophisticated equipment to monitor changes in water cycles.
2 The work of hydrologists is not so significant in flood control.
3 One of the crucial area in the work of hydrologists is environmental preservation.
4 Experienced hydrologists spend little time in the lab.
5 Certification in hydrology is recommended for most advanced employments.

22. Listen to the text once again. For questions 1–10 complete the gaps. You can use no more than 3 words. Before listening, look at the sentences and try to work out what kind of information you will need to listen for to fill each gap.

Water is one of the ____________ 1 resources.

Hydrologists are scientists who study the water in our ____________ 2

as work in Katrina showed flooding is a ____________ 3 in parts of our country.

They use ____________ 4 and equipment to monitor changes in water cycles.

The work of hydrologists is especially important in ____________ 5

They study ____________ 6

Environmental

| 7 |

is another crucial area.

| 8 | tend to spend much of their time in the lab.

Here they conduct tests,

| 9 | , record results and compile data.

| 10 | in hydrology is recommended for most advanced employments.

23. Look at the diagrams below and describe them. Use the following words and word combinations.

1. ground water, conical-shaped depression, pumping well, vicinity, deviate from.
2. beneath the land surface, saturated zone, unsaturated zone, filled with.
3. source of water, water table, unconfined aquifer, water level, some height above, the level at which.

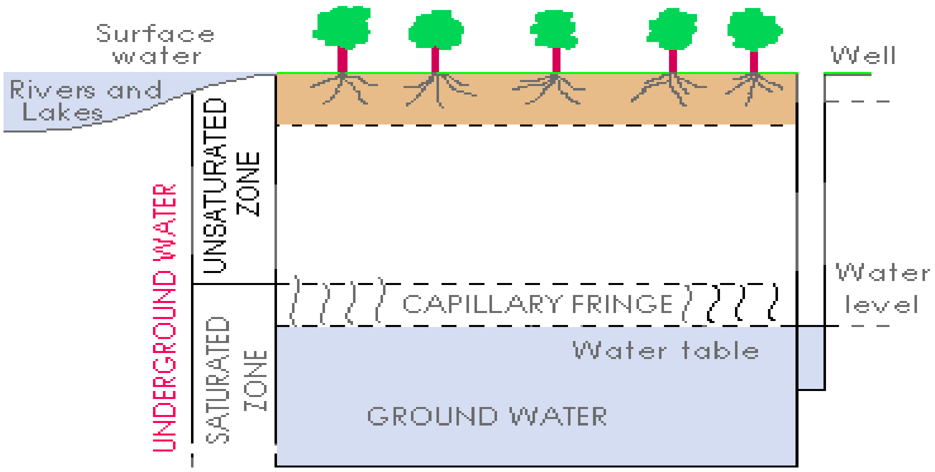


Fig. 1

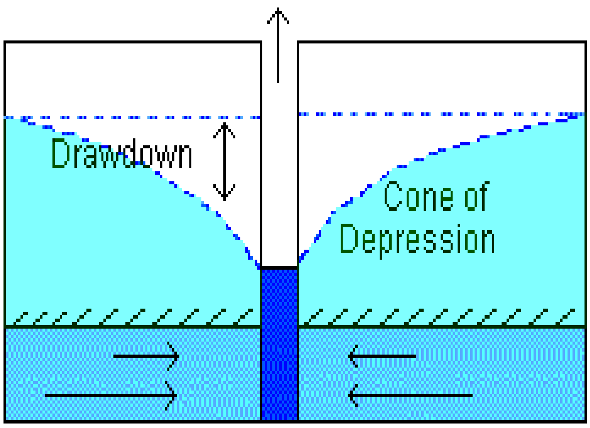


Fig. 2

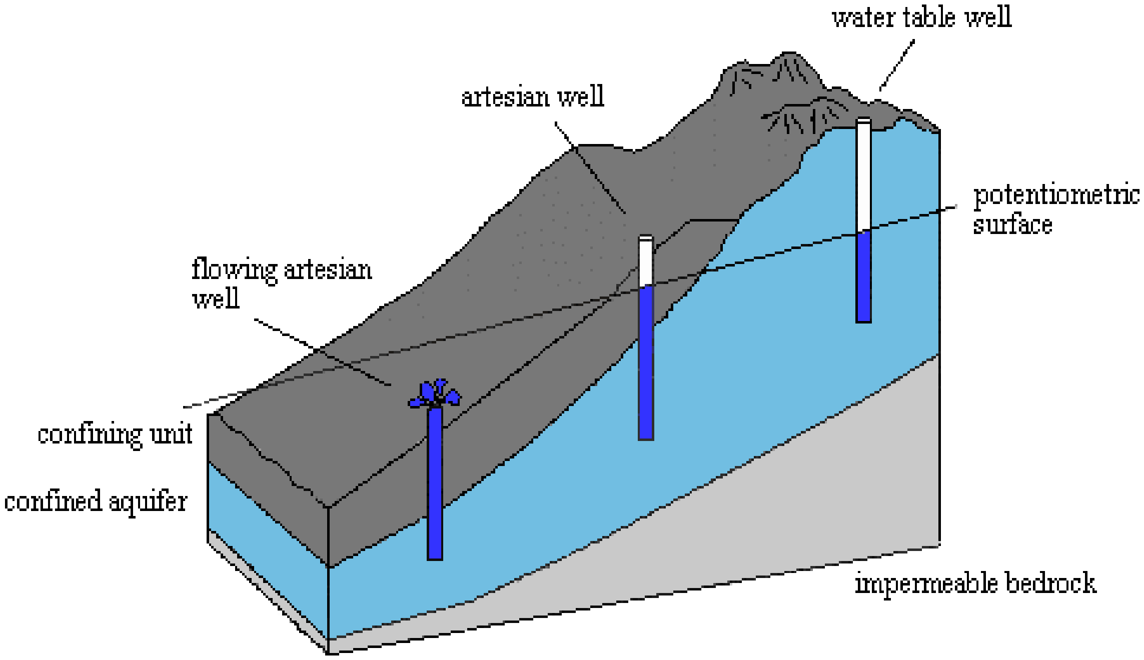


Fig.3

WORDLIST

ENGLISH	RUSSIAN
aquifer	водоносный слой, водоносный горизонт
artesian well	артезианский колодец; артезианская скважина
bedrock	коренная подстилающая порода
capillary fringe	капиллярная зона
circuitous	окольный, обходной
civil engineering	гражданское строительство
climatology	климатология
confined aquifer/ layer	водоносный пласт, ограниченный водоупором; напорный водоносный пласт
cretaceous	меловой период
depletion	уменьшение, истощение (запасов)
deterioration	ухудшение (состояния или качества) ; порча, повреждение

depression	понижение местности, низина, впадина, углубление, долина
diffusion	Распространение, диффузия, рассеивание
discharge	разгрузка
drawdown	1) снижение (понижение) уровня (вод) 2) сработка, опорожнение (водохранилища)
equation	выравнивание; стабилизация
evaporation	испарение
evapotranspiration	суммарное испарение (испарение плюс транспирация)
facet	сторона
fluid mechanics	механика жидкости
fracture	трещина, разлом, излом; разрыв
geohydrology	гидрогеология, геогидрология
gradient	отклонение, угол наклона
gravel	гравий; галька, галечник
groundwater	подземные воды
heat conduction	теплопроводность
heat transfer	теплообмен; теплоотдача
hydrocarbons	углеводороды
hydrogeology	гидрогеология
hydrology	гидрология
hydrogeological map	гидрогеологическая карта
inertia	инерция, инертность
invertebrate	беспозвоночное животное
intercept	останавливать, задерживать
interplay	взаимодействие
laterally	со стороны, сбоку
lens	чечевицеобразная залежь
outwash	склоновая эрозия; смыв
overwithdrawal	откачка
pertinent	уместный; подходящий
percolation	просачивание, протекание
perched aquifer	верховодка
permeability	проницаемость
porosity	пористость
porous media	пористая среда
potentiometric	регулирующий, потенциометрический

recharge area	область питания
Reynolds number	число Рейнольда
saturated zone	зона аэрации
saline	солёный
salt water intrusion	интрузия солёных вод
simulate	имитировать, моделировать
spring	источник
subsidence	оседание почвы
subterranean water	грунтовые воды, подземные воды
surface water	поверхностные воды
unconfined aquifer	безнапорные воды
unconsolidated material	рыхлосвязанные породы
underground water	подземные воды
water-bearing	водоносный
water-level observations	наблюдения за уровнем воды
water-table	1) водная поверхность 2) уровень грунтовых вод
water-table well	наблюдательная скважина
watershed	водораздел

UNIT 3

THE CIRCULATION OF WATER IN THE INTERIOR OF THE EARTH

The term *hydrologic cycle* (from the Greek *hydro*-, meaning "water") refers to the complex system whereby water circulates among its various reservoirs at and near the surface of the Earth. The hydrologic cycle is the global-scale, endless recirculatory process linking water in the atmosphere, on the continents, and in the oceans.

Lead-in

Work in pairs. Look at the following diagrams. What do they show? How would you entitle them? Ask questions to find out more information.

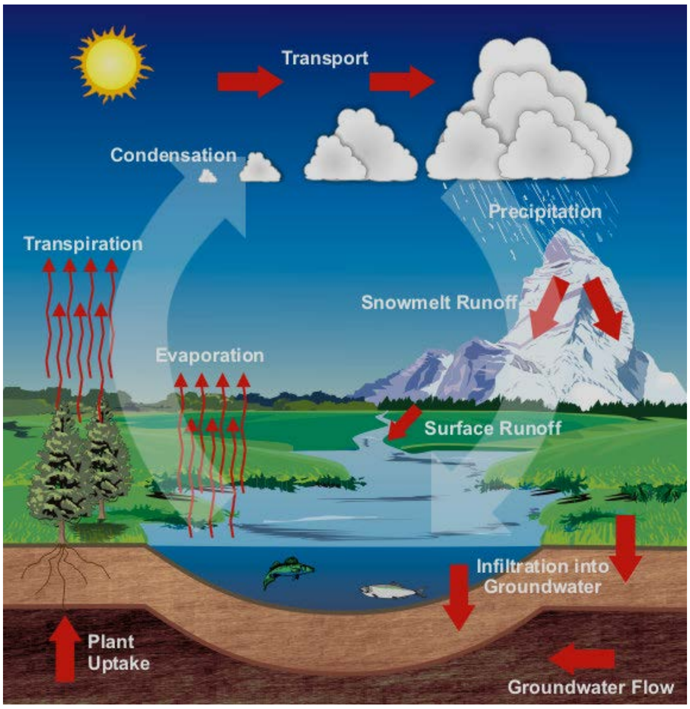


Fig. 1. Hydrologic cycle

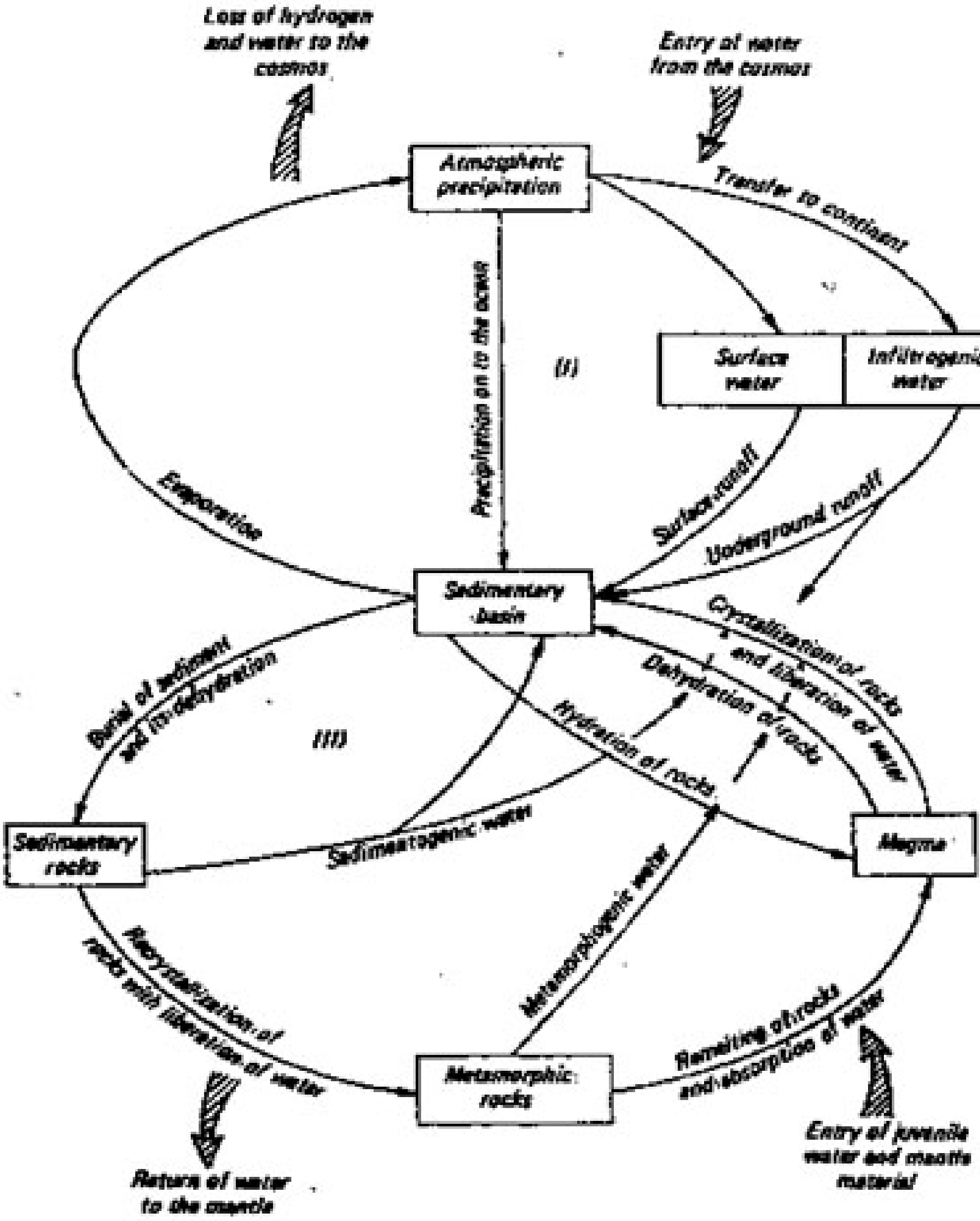


Fig. 2. Cross-section of hydrologic cycle

Look at the figure of the hydrologic cycle below. What do the given values mean?

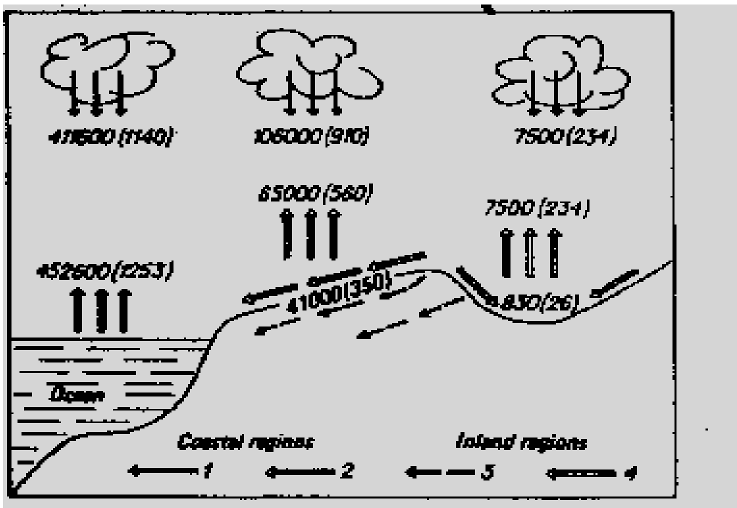
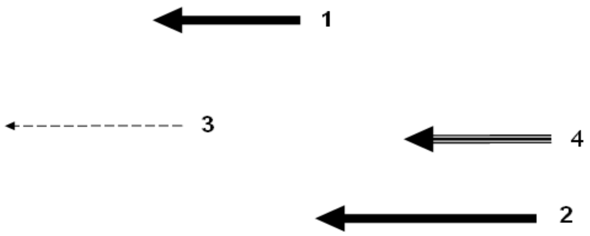
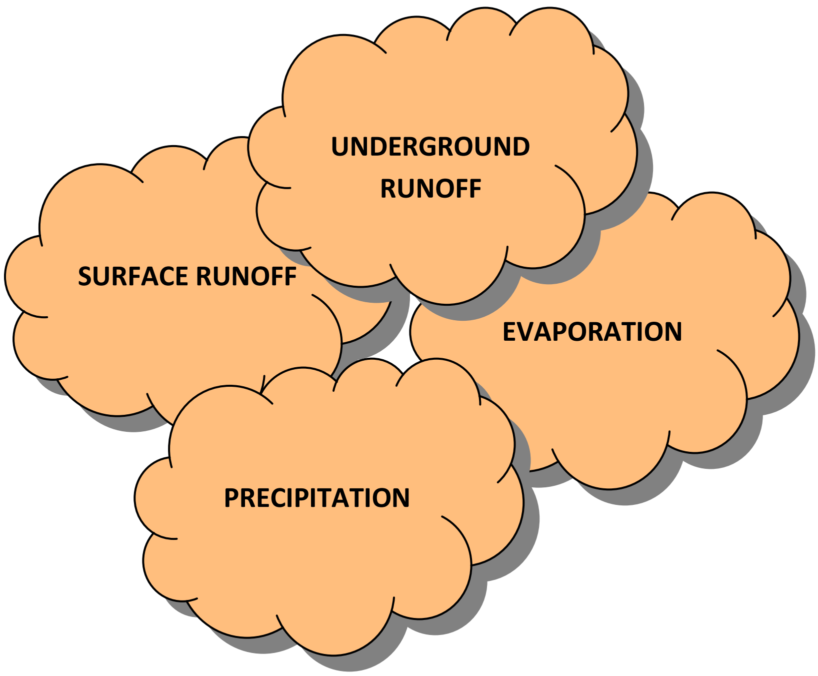


Fig. 3. Hydrologic cycle

What do the arrows on the figure mean? Match the terms (in clouds) with the arrows.





1. Read the following word formations and learn their pronunciation.

evaporate – evaporation – evaporative
precipitate – precipitation – precipitable
accumulate – accumulation – accumulative
infiltrate – infiltration – infiltrated
circulate – circulation – circulatory – recirculatory
store – storage – stored
saturate – saturation – saturated
retain – retaining
charge – recharge – discharge

2. Read the text "Hydrologic cycle". Pay attention to the diagram. Do the exercises after the text.

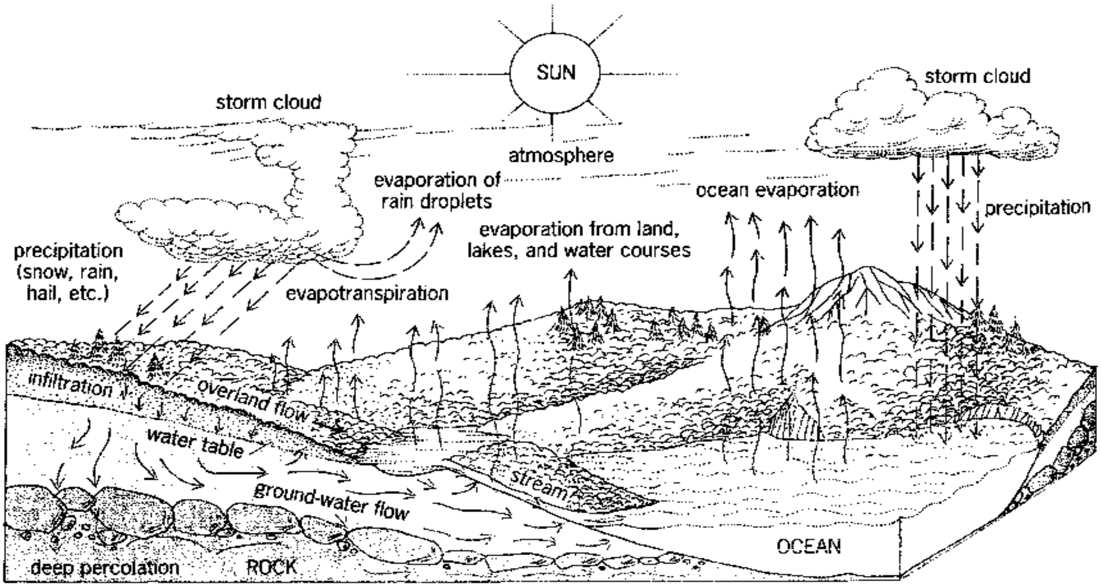


Fig. 4. Diagram of the hydrologic cycle

Hydrologic Cycle

The term *hydrologic cycle* (from the Greek *hydro-*, meaning "water") refers to the complex system whereby water circulates among its various reservoirs at and near the surface of the Earth. These reservoirs include the oceans, the atmosphere, underground water, surface water, glaciers, and the polar ice caps. The hydrologic cycle pervades our terrestrial existence, playing a key role in many natural phenomena. It is directly coupled to the Earth's energy cycle, because solar radiation combines with gravity to drive the global circulation of water. This circulation, in turn, plays an important role in the heat balance of the Earth's surface.

The hydrologic cycle is also closely linked to the geosphere and its rock cycle. Water erodes geologic materials, and the breakdown of these materials releases many chemical constituents that in turn define the chemical nature of the water. Water can also build geologic formations, through both chemical and mechanical depositional processes. Water is essential to all life forms in the planetary biosphere. Even the slightest differences in the volumes and chemical compositions of natural waters can have a tremendous impact on biologic communities. As such an essential natural resource, water is of major concern in local, regional, and international law, and has been at the root of many international conflicts.

(Patricia A.Maurice Earth Systems:Processes and Issues, 2000,Cambridge University Press)

3. Match the English term with the Russian one.

1. precipitation	A. град
2. percolation	B. поток, течение
3. water table	C. выпадение осадков
4. infiltration	D. испарение
5. evapotranspiration	E. подземный сток
6. hail	F. суммарное испарение
7. stream	G. поверхностный сток
8. evaporation	H. уровень подземных вод
9. groundwater flow	I. просачивание
10. overland flow	J. инфильтрация

4. Match the terms with their definitions.

1. evaporation	A. The movement of rain or melting snow into the soil at the Earth’s surface
2. evapotranspiration	B. The sum of all processes by which water changes phase (from solid or liquid) to vapor and is returned to the atmosphere
3. infiltration	C. The physical process involving a phase change from liquid to vapor by which water is returned to the atmosphere

4. precipitation	D. The physical process by which water changes phase from liquid to vapor, is released through the stomata of a plant, and returns to the atmosphere
5. transpiration	E. The dominant process by which water vapor in the atmosphere is returned to the Earth's surface either as liquid drops(e.g. rain) or solid particles (e.g. snow) under the influence of gravity

5. Fill in the gaps with the missing words. Don't change the form given.

gravity distribution crust hydrological atmosphere circulation vapor

Water in liquid and solid form covers most of the **1._______**of the Earth. By a complex process powered by **2._________** and the action of solar energy, an endless exchange of water, in **3.** __________, liquid, and solid forms, takes place between the **4.** ___________, the oceans, and the crust. Water **5.** ____________ in the air and in the oceans, as well as over and below the surface of landmasses. The **6.** _____________of water in the planet is uneven. General patterns of circulation are present in the atmosphere, the oceans, and the landmasses, but regional features are very irregular and seemingly random in detail. Therefore, while causal relations underlie the overall process, it is believed that important elements of chance affect local **7.** ________events.

(*Encyclopedia of Science and Technology)*

6. For questions 1–10 read the text below. Use the words in the box to the right of the text to form one word that fits in the same numbered space in the text. The exercise begins with an example (0).

Example:

DIFFERENT	**0**

The motion of water can be described at many **0._________** scales. The fundamental concept of hydrology is the **hydrological cycle** – the global-scale, **1.** __________ recirculatory process linking water in the atmosphere, on the continents, and in the oceans. We can think of this **2.** ________ process in terms of reservoirs or compartments that store water (the oceans, atmosphere, etc.) and the **3._________** of water between them. Within the **4._________** compartments of the	**0. DIFFER** **1. END** **2.CIRCULATE** **3. MOVE** **4. VARY**

5.______________ cycle, water can be stored in any one of these **6.** ______ phases or stages: gas (vapor), liquid, or solid. For example, water in the atmosphere can exist as vapor (the **7.** _________ of water vapor is expressed as **8.** ________), in liquid (cloud droplets, rain drops), or in solid phase (ice crystals, snowflakes). Similarly, all three phases of water can be found on and below the land surface. Movement of water from one **9.___________** to another can occur in any of the three phases. For example, the movement of water between the oceans and atmosphere occurs in vapor phase **10.______________** from the ocean surface), liquid phase (rain onto the ocean surface), and solid phase (snowfall onto the ocean surface)	**5. HYDROLOGY** **6. SEPARATION** **7.CONCENTRATE** **8. HUMID** **9. COMPART** **10. EVAPORATE**

7. You are going to hear a report about the hydrologic cycle. Before you listen, discuss the following questions.

1. Try to guess what percentage of water is concentrated in oceans, glaciers and ice caps.

2. The world per capita use of water in 1975 was about 185,000 gal/yr. And the total human use of water was about 10^{15}gal/yr. What do you think is world use of water nowadays?

8. Listen to the tape to see if you were right. For questions 1–7 decide whether the statements are true or false.

1. The evaporation of water from the oceans, freshwater sources, plants, and soils is the natural process, which we call the hydrologic cycle.

2. The water in the atmosphere cycles slowly.

3. Water transportation from distant mountains through aqueducts and groundwater pumping cause precipitation increase in semi-arid cities.

4. 40 % of water that falls by precipitation on land every year returns to the subsurface runoff.

5. Watershed is the fundamental unit of the landscape.

6. Drainage basin is the antonym of catchment.

7. More than 99 % of Earth's water in its natural state is generally suitable for beneficial human use.

8. All our freshwater resources are produced by only 0,001 % of the total water on Earth.

9. Water can be found at a number of locations at or near Earth's surface.

10. The residence time of water may be only 9 days.

***9. You are going to hear a conversation between two students. Listen and choose the best title. The notes and terms will help you to understand the conversation better*.**

WATER IN OUR LIFE

THE COMPOSITION OF WATER

THE WATER CYCLE

NOTES

You see – видишь ли
Getting down on paper – записываю
Kind of – что-то вроде
You know what? – Знаешь что?
Wait a tick – Подожди минутку
Fire away – Начинай
To get the figures – записать цифры
Mind you – Слушай внимательно
I've got that – Я понял
Go on, will you? – Продолжай же!
You know – знаешь ли
That's incredible – невероятно
Did you get it all down? – Ты все записал?
My pleasure! – Всегда готов помочь!
Have a good day. – Всего хорошего.

Terms and vocabulary

circulation	циркуляция
deadline	последний срок
to deposit	отлагаться
dew	роса
hail	град
hurricane	ураган
major constituent	главный компонент
recently	недавно
relatively	относительно
to release	освобождаться
to sublime	сублимировать
thunderstorm	гроза

10. Look at these incomplete sentences from the conversation between Susan and Nick and try to remember who said them. Write S for Susan and N for Nick. Then listen to the complete sentences and fill in the missing words.

1. On water? Well, I'm working on it right now. …….. ……… …….. ……… the most essential facts.
2. You know what? There' s something that might be of interest. It's from a ….. ….. ……
3. Mind you, it's about …. ….
4. But how does it happens? First, it …. …. ….., lakes, rivers, soil and plants.
5. Wait a tick. Did you say …. …. ….?
6. That's right. And …. …. …. and ice into the atmosphere.
7. Second. The sun supplies the energy needed for …. …. …..
8. Well. Water then returns to the Earth as …. …. …..
9. You see, you may also write as … … …. if you like.
10. What about energy release by …., ….. and ….?

11. Listen to the dialogue for the third time if necessary and answer the following questions.

1. What article is Nick writing?
2. What information does Susan give to Nick?
3. What are the forms of water that Susan names?
4. What figures does Susan cite?
5. When will Nick's article go to press?

12. Discussion – ***You have to give a lecture on "Hydrologic cycle". Use the keys and diagram.***

Keys:

1. Atmospheric water in circulation
2. Formation of storm clouds
3. Precipitation (snow, rain, hail, etc.)
4. Evaporation of precipitation in transit and moisture diffusion
5. Net precipitation on Earth surface
6. Snow storage and melt
7. Infiltration
8. Deep percolation
9. Ground –water flow and storage

10. Overland flow and depression
11. Evaporation of intercepted and surface water
12. Evapotranspiration
13. Surface storage in lakes and reservoirs
14. Evaporation from lake surfaces
15. Surface streams
16. Evaporation from streams
17. Ground-water exchange from channel storage (base flow and return)
18. Ground-water exchange from channel storage (base flow and return)
19. Ground-water flow to ocean
20. Ground-water flow to ocean
21. Storage in the ocean
22. Evaporation from ocean surfaces

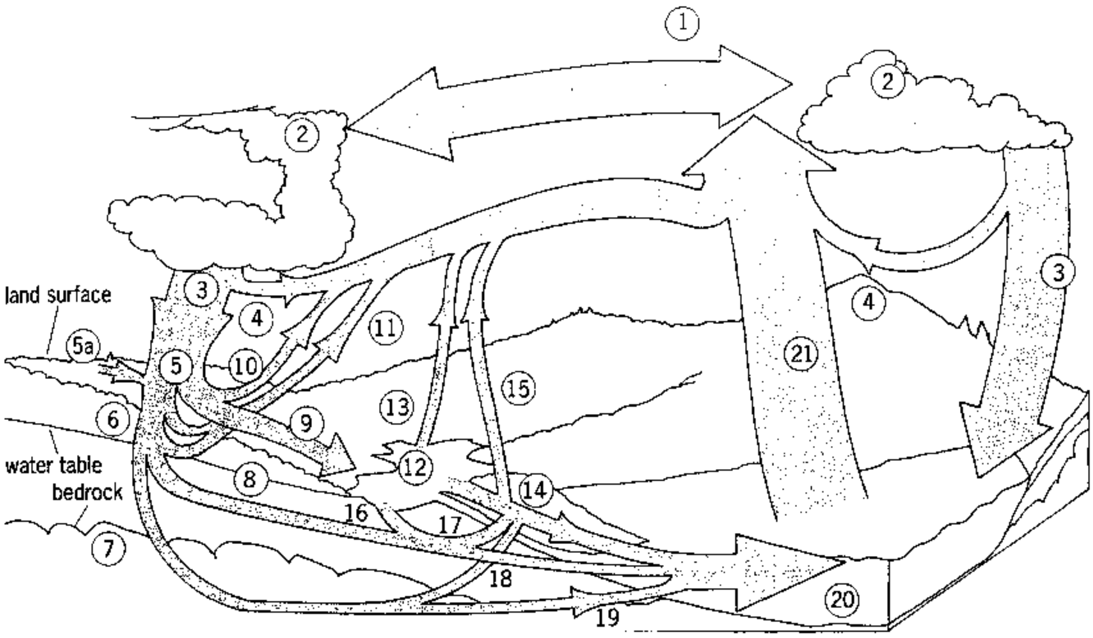


Fig.5. Diagram Water flow scheme of the hydrologic cycle.

13. Now look at the keys for 45 seconds, try to learn the terms. Close your course book and write down the words. Be honest! The person who has more words is the winner.

14. Look at the schematic illustration of the hydrologic cycle for 30 seconds and then try to draw it. Afterwards ask your partner to describe it.

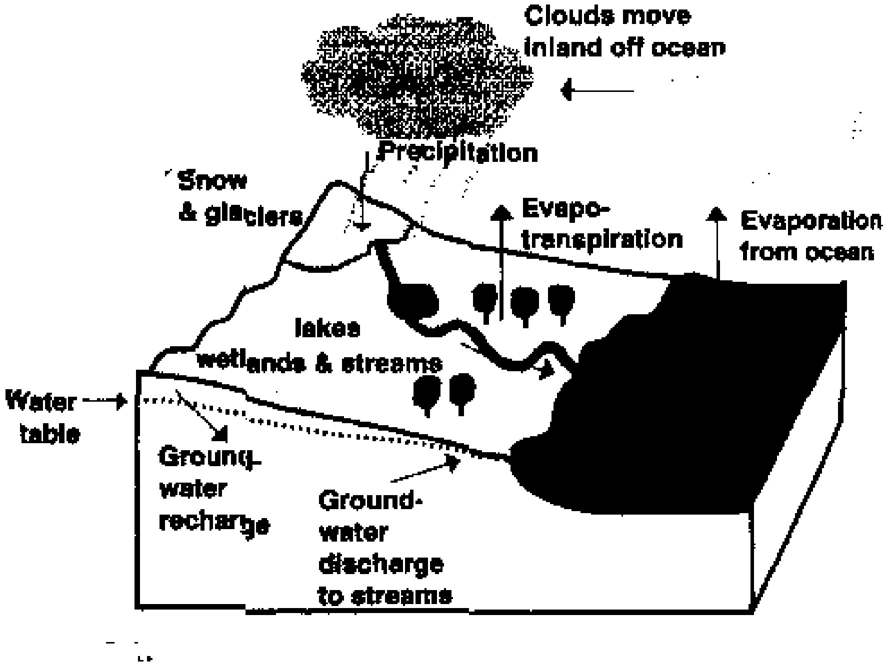


Fig.6. Schematic illustration of the hydrologic cycle

15. Work in groups and discuss your opinions. Can your group reach an agreement? Read the quotation of the famous hydrogeologist B.L.Lichkov and share your ideas.

“The circulation of natural water on the planet, although not as yet completely understood, must be recognized by all as critically significant for hydrogeology, and for the land areas; the primary significance must be given to their moisture content. Thus, a new hydrogeology must be constructed on three principles – the unity of water, its circulation, and the moisture content of the land. In a word, the circulation of water is one of the cornerstones of modern hydrogeology”

(B.L. Lichkiov)

STAGE 1 – group work responding to problem discussion. During these stage, each group will discuss the problem separately.
STAGE 2 – sharing ideas of response to the problem. One person from each group should move to another; so that each group has a member with different information. Now the members of each new group share their ideas.
STAGE 3 – now each of you should jot down all the information you remember.

- Jig-saw plan (1–2 minute) short one-point talk
- Multi-point conversation (5 minutes)

16. Now prepare a presentation "The Hydrological Cycle" for the Student Science Conference. The following plan and phrases will help you.

Plan

1. Plan and carry out your presentation.
2. Define the subject of your presentation.
3. Think of the introduction of your presentation.
4. Try to anticipate questions during the preparation of your presentation.

USEFUL PHRASES AND EXPRESSIONS

INTRODUCTION.

The subject of my presentation is…
What I'm going to talk about today is….
I'd like to give you a brief overview of….
The reason I am here today is to talk about…

STRUCTURING

- I've divided my topic into (three) main sections…..
- My presentation will be in (three parts)…
- First of all, then, after that, lastly, finally.

MOVING TO A NEW POINT

- Turning now to…..
- What I'd like to talk about now is…
- Now I would like to describe…
- Now let's move on to the next point which is…

SUMMARIZING AND CONCLUDING

- To sum up…
- To recapitulate what I've been saying…
- So. To go over the main points again…
- I'd like to conclude by saying.

ENDING A PRESENTATION

- Thanking you in advance.
- If there are any questions, I'll be pleased to answer them.

WORDLIST

ENGLISH	RUSSIAN
circulation	круговорот
circulatory	циркулирующий
condensation	сжижение; конденсирование, конденсация
compartment	отсек
cornerstone	краеугольный камень
crust	кора
glacier	ледник
gravity	сила тяжести
groundwater discharge	1) разгрузка (выклинивание) подземных вод 2) расход подземных вод; эксплуатационные запасы подземных вод
groundwater recharge	искусственное пополнение подземных вод
groundwater flow	1) подземный сток

	2) поток подземных вод; движение подземных вод
hail	град
humid	влажный, мокрый
hydrologic cycle	круговорот воды
infiltration	инфильтрация; просачивание, проникновение
intercepted water	объём [наполнение] водохранилища
moisture content	влагосодержание, абсолютная влажность
overland flow	сухопутный сток
percolation	1) просачивание, протекание 2) процеживание, фильтрование; фильтрация
pervade	распространяться; проникать; заполнять, наполнять, пропитывать
plant uptake	поглощение воды растениями
precipitation	выпадение осадков
recirculatory process	рециркуляционный процесс
reservoir	резервуар; бассейн; водохранилище
saturation	насыщение, насыщенность
storage	сохранение
stream	поток, течение
terrestrial	земной
transpiration	испарение
underground runoff	подземный сток
vapor	пар; пары; испарения

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INTERNET RESOURCES

www.en.wikipedia.org

GEOECOLOGY

I.A. Matveenko

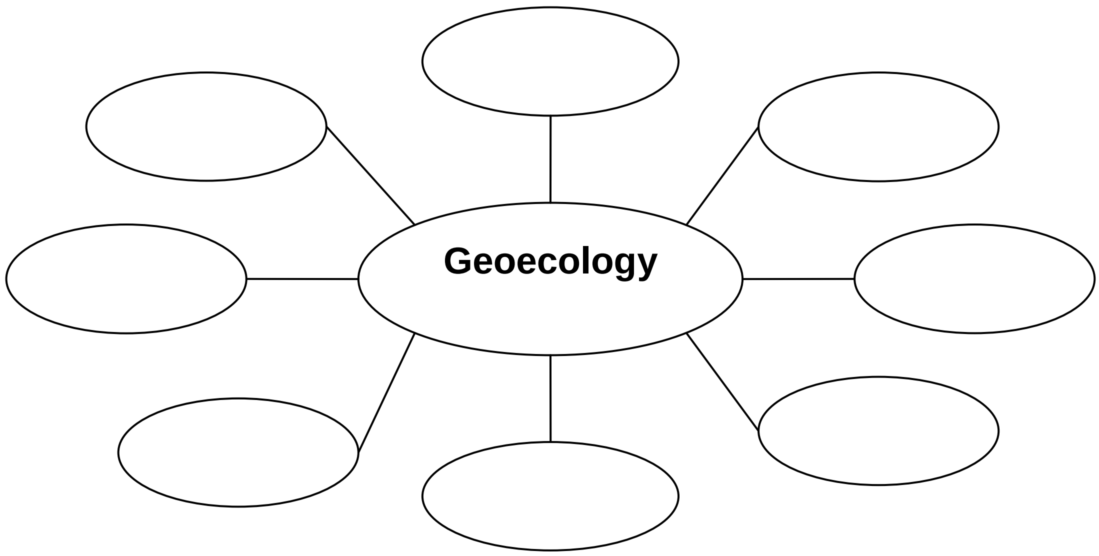
UNIT 1

GEOECOLOGY

The biosphere is a complex system of energy use and material cycling. This system functions on energy flowing from the Sun and it gives off energy (primarily as heat) to space.

Lead-in

Fill in the spidergram with the word associated with geoecology.



Explain these connections.

Terms and Vocabulary

biosphere	биосфера
concept	концепция, понятие
emerge	появляться
layer	слой
biotic	биотический, живой
abiotic	абиотический, неживой
biota	биота (флора и фауна района)
ecosystem	экосистема

remediation	восстановление
magnitude	величина

1. Pay attention to the pronunciation of the following words.

biosphere	[	biota	[bai′əutə]
biotic	[bai	satellite	[′sæt(ə)lait]
abiotic	[,eıbai	ecosystem	[,i

2. Read the text, do the exercises.

The idea of **biosphere** appeared more than a century ago, but at first it found a little application, until it was developed by the Russian scientist V.I. Vernadsky. It is his **concept** of the biosphere that we accept today.

The first living cell **emerged** between 4 billion and 3.8 billion years ago. At present biosphere includes vast numbers of plants, animals, and other life-forms of our planet, many of them are yet to be discovered. Biosphere is a relatively thin life-supporting **layer** around the Earth containing living organisms, which is strongly influenced in its composition, structure and energetic by the living organisms. The part of the biosphere containing the highest concentration of living matter – the Earth’s thin and fragile “film of life” – varies from a few meters in deserts and tundra to a hundred meters in a tropical forest region and oceans.

The biosphere is a complex system of energy use and material cycling. This system functions on energy flowing from the Sun and it gives off energy (primarily as heat) to space.

We can divide the biosphere into two parts, living and nonliving, or **biotic** and **abiotic.** The biotic part of the biosphere consisting of fauna and flora is known to be called **biota.** We can further divide the abiotic portion into three parts: the solid Earth or lithosphere, liquid water or hydrosphere, and the atmosphere.

Ecology is a branch of science which deals with the world of nature – including its human component – at certain levels of biological organization. It is the study of the living organisms interactions with each other and with their environment. Particular concern of the ecologists is with the “higher” levels of life organization: from populations to biosphere. The functional unit in ecology is the **ecosystem** because it comprises all interactions of communities with both their living (biotic) and their nonliving (abiotic) environments.

Ecology is a multidisciplinary science. Facts about ecological systems are drawn from biology, geology, chemistry, physics, and other sciences. Originally ecology was considered to be environmental biology. Modern ecology has to deal with environmental problems caused by human activities.

Geoecology is an interdisciplinary science, probably best translated as environmental sciences. Geoecology is not a synonym for physical geography. It is not dealing solely with the abiotic aspects of ecology. Geoecologists are rather **“**specializing in interdisciplinarity**”**, studying the interactions and interrelations abundant in our environment. Geoecologists work in the industry, for municipal, regional or federal authorities, in universities and research institutes, in foreign aid programs, and as freelance consultants or engineers. Broad education combined with high-quality specialized training allows geoecologists to work in fields such as environmental analytics, waste disposal, contaminated sites **remediation** as well as agriculture and forestry.

People have always affected the natural environment. But the population growth along with the industrial world economy during the last two centuries has increased the **magnitude,** complexity and rate of these modifications. Today environment is not just modified by human action: it is radically transformed. Global **satellite** observations of the Earth have revealed that about 60 % of land surface is to some extent damaged by industrial, agricultural, and other human activities, whereas no more than 40 % of land remains intact.

Humankind is entering a new era in its evolution characterised by a new relationship with nature. Understanding of how biosphere works, and how it reacts to the global environmental change is of fundamental importance.

(Положинцев Б. И. Introduction to ecology. СПб., 1999)

3. Find the synonyms for the following words in the text.

To influence, to include, large, to emerge, to change, mankind, to release, field of science, to be concerned with.

4. Translate the following word groups.

Global satellite observations, industrial world economy, tropical forest region, living organisms interaction, life organization levels, atmosphere layers, nature balance, population growth.

5. Suggest as many word combinations as possible.

(A) *layer* (thick, of water, around the Earth, of gas, outer, thin, containing living matter);
(B) *environment* (clear, physical, parts of, modified, healthy, biotic, damaged, intact);
(C) *interactions* (between, humankind, nature, stable, communities, global, constant, living organisms, environment).

6. State the functions of "it" in the following sentences. Translate them into Russian.

1. It is Vernadskiy's concept of the biosphere that geoecologists use today.
2. Today environment is not just modified by human action: it is radically transformed.
3. It is rather topical to study the living organism interactions with each other and with their environment.
4. Understanding of how biosphere works, and how it reacts to the global environmental change is of fundamental importance.
5. It is the "higher" levels of life organization: from populations to biosphere that is of particular concern for geoecologists.
6. It is important to research all interactions of communities with both their living (biotic) and their nonliving (abiotic) environments.

7. Translate it into English.

a) Современная концепция биосферы была разработана русским ученым В.И. Вернадским более 50 лет назад (present-day, develop).

Биосфера – это слой вокруг Земли, который преобразован живыми организмами (transform).

Биосфера – слой вокруг Земли, который содержит все живое вещество на нашей планете (contain).

Жизнь на Земле возникла около 3.8 миллиарда лет назад (emerge).

b) Биосфера – это сложная система преобразования энергии и круговорота веществ (cycling).

Биосфера «работает» на энергии, поступающей в нее от Солнца (run on energy).

Толщина слоя биосферы, содержащего наивысшую концентрацию живого вещества, варьируется от нескольких до сотен метров (film of life, vary from … to).

c) Геоэкология – междисциплинарная наука, основанная на экологии, геологии, биологии и многих других науках (interdisciplinary).

Взаимодействие человека с природой имеет глобальный и постоянный характер (interaction).

Человек воздействует на окружающую среду и изменяет ее (affect).

Биосфера реагирует на эти воздействия (react).

d) Сегодня окружающая среда коренным образом преобразована в результате деятельности человека (radically, as a result of).

Около 60 % природных экосистем суши в той или иной степени разрушено в результате сельскохозяйственной, промышленной и других видов деятельности человека (to some extent, damage).

Не более 40% суши еще осталось нетронутой (intact).

8. Read the text below, use the word given in capitals at the end of each line to form a word that fits in the space in the same line.

Example: 0 – impossible.

These days it is **(0)** … to open a newspaper without reading about the	**possible**
damage we are doing to the environment.	
The Earth is being **(1)** … and the future looks bad. What can each of us do?	**threat**
We cannot clean up our **(2)** …rivers and seas overnight.	**pollution**
Nor can we stop the **(3)** … of plants and animals.	**appear**
But we can stop adding to the problem while **(4)** … search	**science**
for answers, and laws are passed in nature's **(5)** … .	**defend**
It may not be easy to change your lifestyle **(6)** …, but some steps are easy to take: cut down the amount of	**complete**
(7) … you do, or use as little plastic as possible.	**drive**
It is also easy to save energy, which also reduces **(8)** … bills.	**house**
We must all make a personal **(9)** … to work for the future	**decide**

of our planet if we want to **(10) …** a better world for our grandchildren. **ensure**

9. What are the subjects of the following sciences?

1. hydrology	… deals with	a). the study of the living organisms interactions with each other and with their environment
2. mineralogy		b). the water and air at or above the solid surface of the Earth. There include the study of the water on and within the ground
3. geomorphology	… is concerned with	c). study of the interactions and interrelations in our environment on the bases of ecology and geology
4. geoecology		d). the physical-chemical makeup of the solid Earth, which include the study of minerals
5. ecology	… treats	e). the study of landforms with the description of the features of the present terrestrial surface and an analysis of the processes that give rise to them
6. applied Earth sciences		f). current practical applications beneficial to society. These include the study of fossil fuels, oil reservoirs, mineral deposits.

10. Here are some definitions. What are they? Complete the sentences.

… is the layer around the Earth in which all living organisms exist.
… is the sum total of all liquid and frozen water on or near the Earth's surface.
… is a region of gases, airborne particles, and water vapour enveloping the Earth.
… is the solid Earth with rocks, soils, and sediments on its crust.

11. Answer the questions.

1. How do you define biosphere?
2. What is biota?
3. When did the first living cells appear on the planet?
4. What are the limits of the "film of life"?
5. What does modern ecology deal with?
6. What is geoecology?
7. What fields can geoecologist work in?
8. What major factor has increased the intensity and scale of the biosphere transformations over the past two centuries?
9. Do you think the biosphere transformations caused by human activity are reversible?

12. Listen to the interview with a senior research engineer called Dr. Michael Blomberg. Dr. Blomberg gives his opinions on future trends in science and technology.

1. What predictions does Dr. Blomberg make about technological progress? Make a list.
2. Classify these predictions in three columns according to how strongly Dr. Blomberg expresses his belief that they will happen.

STRONG BELIEF	BELIEF (not strongly held)	UNCERTAIN (it could happen)

3. What questions does the interviewer put to Dr. Blomberg?
4. Now prepare three questions that you would ask Dr. Blomberg if you were present at the interview.
5. Do you agree with Dr. Blomberg's ideas? Say what developments you foresee in science and technology over next fifty years.

(Johnson C.N. & D. General Engineering. Prentice Hall, Europe, 1998)

13. Work in pairs. Discuss the following quotations about ecological problems.

1. Nature pardons no errors. *(R.W. Emerson. Essays)*
2. Our remedies oft in ourselves do lie which we ascribe to heaven.
(W. Shakespeare. All's Well That Ends Well)
3. As soils are depleted, human health, vitality and intelligence go with them.
(Bromfield Louis Writer (1896–1956)).

4. Only when the last tree is cut; only when the last river is polluted; only when the last fish is caught; only then will they realize that you cannot eat money. *(Indian proverb).*
5. Man has lost the capacity to foresee and to forestall. He will end by destroying the earth. (*Albert Schweitzer).*

WORDLIST

abiotic	абиотический, неживой
abundant	распространенный
biosphere	биосфера
biota	биота (флора и фауна района)
biotic	биотический, живой
concept	концепция, понятие
deal with	иметь дело с, рассматривать
ecosystem	экосистема
emerge	появляться
influence	влияние
layer	слой
magnitude	величина
remediation	восстановление
waste disposal	удаление отходов

UNIT 2

THE IMPACT OF MINING AND OIL EXTRACTION ON THE ENVIRONMENT

Coal, oil and gas – fossil fuels – are called conventional fuels because people are accustomed to using them. Today, approximately 80 % of the energy consumed worldwide comes from burning petroleum, natural gas, and coal. However, coal is the dirtiest fuel to burn because it has many impurities which influence the environment.

Lead-in

Discuss the questions.

1. What impacts of mining and mineral extraction on the atmosphere, hydrosphere and biosphere do you know?
2. What stages of mineral extraction from the subsurface do you know?

Comment upon the following statements. How do you think they are connected with the theme of the lecture?

1. In its broadest ecological context, economic development is the development of more intensive ways of exploiting the natural environment.

~Richard Wilkinson

2. Waste is a tax on the whole people.

~Albert W. Atwood

Terms and Vocabulary

Contamination	загрязнение
Gangue	пустая порода, породные примеси
Tailings	хвосты, шлам
Ablation	абляция, вынос
Retention	удержание
Particulate	частица
Enrichment	обогащение
Processing	обработка
Runoff	сток
Smelter	плавильная печь
Waste tip	отвальная куча, отвал
Precipitator	осадитель, фильтр

1. Pay attention to the pronunciation of the following words.

metalliferous [ˌmetəˈlɪfərəs]   pyrometallurgical [ˈpaɪrəuˌmetəˈlə

Humans have extracted minerals, particularly the metalliferous ores, since ancient times, and the extraction and refining of metals have played a major role in human development. The mining and **processing** of minerals have increased through time, due to population growth and the greater utilization of raw materials for manufacture. Many areas of past mining activity, in both the Old and New Worlds, bear witness to these extractions in the form of abandoned workings and extensive **waste tips**. Modern mineral extraction technology is generally far more efficient than past practices, and in many countries such processes are heavily regulated to limit the degree of contamination from extractive industries. However, historical mineral extraction involved less efficient technologies and in those times virtually no environmental regulations were in place. Long-abandoned mineral workings are currently the cause of serious environmental pollution in many countries.

A large number of different materials are extracted from the Earth ranging from fuels such as oil and coal, industrial minerals such as clays and silica, aggregates for building and roadstone, and minerals for fertilizers as well as sources of non-metals. However, the major cause of concern is the metalliferous ores that are used as sources of metals and metalloids.

The extraction and subsequent processing of ores can be summarized as follows:

Mining → crushing/grinding
→ concentration of ore mineral
→ smelting/refining.

Ores are extracted from the Earth by either subsurface mining, open pit surface techniques, or in a few cases by solution mining, which carries with it risk of groundwater pollution. Both subsurface and surface extraction result in waste material, which is generally piled on the surface in the vicinity of mine. However, while such waste piles, which frequently contain ore minerals, are sources of environmental contamination, it is the subsequent processing of the ores that result in the greatest environmental problems.

The crushing and grinding (comminution) of mineral processing has the objective of separating the ore minerals from the waste, generally referred to as **gangue**. To effect separation, the mined ore is finely crushed to liberate individual ore mineral grains to enable concentration of the sought after ore mineral. The very fine waste material left after this concentration process is referred to as tailings, and this material can contain, along with the gangue minerals, residual amounts of the ore minerals and can be a serious source of pollution. The **tailings** are very fine hence are subject to wind **ablation** and can easily transported by **surface runoff**. At many mine sites tailings have been left open to the environment resulting in serious contamination of surrounding soil and water.

Following the mining and processing of the ores, the resultant concentrate is transported to a **smelter.** Pyrometallurgical smelting involves roasting of the ore concentrate at high temperatures with the subsequent emission of large quantities of potentially harmful elements. The smelter emissions can be in the form of gases, such as sulphur dioxide, aerosols, and larger **particulates.** Modern smelter stacks are fitted with electrostatic **precipitators** and other dust recovery mechanisms, which results in the **retention** of most of the particulates, but some gaseous and aerosolic emissions are still released into the atmosphere. Although any larger particulates released are likely to be deposited close to the source, aerosols and gases can be transported long distances and as a result the smelting of ores has far wider aerial impact than the mining and processing of these ores.

(From Essentials of Medical Geology. Elsevier Inc., 2005)

3. Translate the words paying attention to the word formation.

To extract – extraction – extractable – extractive
Result – to result in – to result from – resultant
Abundance – abundant
To concentrate – concentrate – concentration
Precipitate – precipitation – precipitator
To enrich – enriched – enrichment

4. Give Russian equivalents to the following set-expressions.

To play a major role
To bear witness
To be fitted with
To be likely
To carry risk
To be heavily regulated
To be referred to
To have impact

Make your own sentences with two of the expressions.

5. Match the synonyms.

In the vicinity	Purpose
Impact	Beneficiation
Cause	Different
Enrichment	Medium
Environment	Influence
Objective	Reason
Various	Close to

6. Translate the following word groups.

Ore minerals, ore mineral grains, surface extraction, open pit surface technique, wind ablation, smelter stack, gangue material, surface runoff, groundwater pollution, mineral extraction technology, population growth.

7. Complete the sentences translating the Russian words.

1. Extensive mineral extraction is still (причина беспокойства) in many countries due to environmental pollution it causes. 2. The process of extraction (строго контролируется) to decrease the degree of contamination of the surrounding soils. 3. Significant increase in concentration of some chemical compound is observed (вблизи) local mineral deposits. 4. Many Kemerovo regions (свидетельствуют) to virtually uncontrolled coal extraction. 5. The mined ore is finely crushed (чтобы обеспечить) concentration of the sought after ore mineral. 6. Ancient extraction technologies (приводили к) serious environmental pollution.

8. Match the words with their definitions.

1. Gangue	a). wearing away of a rock or glacier
2. Ablation	b). process of increasing the concentration of desirable properties in minerals, improving them in quality and value
3. Extraction	c). valueless and undesirable material in an ore
4. Smelting	d). process of reduction to small particles by pounding or abrading
5. Grinding	e). process of extracting a valuable material from an ore by heating
6. Enrichment	f). process of getting ore or oil from the deposit

9. Answer the questions.

1. How is mineral deposit concentration reflected in the chemistry of environment?
2. What stages of mineral extraction are considered the sources of environment contamination?
3. Why have mining increased through time?
4. What witness to the extraction of minerals do some areas bear?
5. Has the situation changed from that time?
6. What are the stages of mining and subsequent processing?
7. What is the effect of open pit surface techniques and solution mining?
8. Why is crushing necessary for mineral processing?
9. What consequences of crushing do you know?
10. What is smelting?
11. Why are modern smelters fitted with electrostatic precipitators?
12. What are the consequences of smelting?

10. State whether the sentences are true or false. If true, add the information you know, correct the false ones.

1. Geologists can define mineral deposits by concentration of some elements.
2. Mining and subsequent beneficiation of minerals do not affect the environment.
3. Mineral extraction is a modern human activity.
4. Modern mineral extraction technology is heavily regulated in many countries.
5. The major cause of concern is mineral extraction such as clays and silica.
6. Waste material is the greatest environmental problem.
7. Tailings are subject to wind ablation and can easily transported by surface runoff.
8. Aerosols and gases can be deposited close to the source.

11. Read through the text and find the answers to these questions. Remember, you do not have to understand every word to answer the questions.

A.

1. How are pollutants generally treated? Name four different processes referred to in the text.

2. What are the main causes of air pollution?
3. What is the usual way to control emissions of gas and particles into the atmosphere?
4. Which gas is mentioned as being particularly difficult to control?
5. What industries are affected by regulations to control the emissions of this gas?

Through its interdisciplinary environmental teams, industry is directing large amounts of capital and technological resources both to define and resolve environmental challenges. The solution of the complex environmental problems requires the skills and experience of persons knowledgeable in health, sanitation, biology, meteorology, engineering and many other fields.

Each air and water problem has its own unique approach and solution. Restrictive standards necessitate high retention efficiencies for all control equipment. Off-the-shelf items, which were applicable in the past, no longer suffice. Controls must now be specifically tailored to each installation. Liquid wastes can generally be treated by chemical or physical means, or by a combination of the two, for removal of contaminants with the expectation that the majority of the liquid can be recycled. Air or gaseous contaminants can be removed by scrubbing, filtration, absorption or adsorption and the clean gas discharged into the atmosphere. The removed contaminants, either dry or in solution, must be handled wisely, or a new water- or air-pollution problem may result.

Industries that extract natural resources from the Earth, and in so doing disturb the surface, are being called upon to reclaim and restore the land to a condition and contour that is equal to or better than the original state.

Air quality management. The air contaminants which pervade the environment are many and emanate from multiple sources. A sizable portion of these contaminants are produced by nature. The greatest burden of atmospheric pollutants resulting from human activity comprises carbon monoxides, hydrocarbons, particulates, sulphur oxides and nitrogen oxides, in that order. About 50 % of the major pollutants come from the use of the internal combustion engine.

Industrial and fuel combustion sources together contribute approximately 30 % of the major pollutants.

The general trend in gaseous and particulate control is to limit the emissions from a process stack to a specified weight per hour based on the total material weight processed to assure compliance with ambient air regulation. Process weights become extremely large in steel and cement plants and in large nonferrous smelters. The degree of control necessary in such plants can approach 100 % of all particulate matter in the stack. Retention equipment can become massive both in physical size and in cost. The equipment may include high-energy venturi scrubbers, fabric arresters, and electrostatic precipitators. Each application must be evaluated so that the selected equipment will provide the retention efficiency desired.

Sulphur oxide retention and control present the greatest challenges to industrial environmental engineers. Ambient air standards are extremely low and the emission standards calculated to meet these ambient standards place an enormous challenge on the affected industries. Many copper smelters and all coal-fired utility power plants have large volume, weak-sulphur-dioxide gas streams with limestone slurries or caustic solutions is extremely expensive, requires prohibitively large equipment, and creates water and solid waste disposal problems of enormous magnitude. Installations employing dry scrubbing have been used on very low-sulphur-dioxide gas streams.

Copper smelters are required to remove 85–90 % of the sulphur contained in the feed concentrate. Smelters using the old-type reverbatory furnaces produce large volumes of gas containing low concentrations of sulphur dioxide which is not amenable to removal by acid making. However, gas streams from newer-type flash and roaster-electric furnace operations can produce low-volume gas streams containing more than 4 % sulphur dioxide which can be treated more economically to obtain elemental sulphur, liquid sulphur dioxide, or sulphuric acid. Smelters generally have not considered the scrubbing of weak-sulphur-dioxide gas streams as a viable means of attaining emission limitations because of the tremendous quantities of solid wastes that would be generated.

The task of upgrading weak smelter gas streams to produce products which have no existing market has led to extensive research into other methods of producing copper. A number of mining companies piloted, and some have constructed, hydrometallurgical plants to produce electrolytic-grade copper from ores by chemical means, thus eliminating the smelting step. These plants have generally experienced higher unit costs than smelters and a number have been plagued with operational problems. It does not appear likely that hydrometallurgical plants will replace conventional smelting in the foreseeable future. Liquid ion exchange followed by electrowinning, is also being used more extensively for the heap leaching of low-grade copper. This method produces a very pure grade of copper without the emission of sulphur dioxide to the atmosphere.

B. Read the text again carefully. While reading, look for the answers to these questions.

1. Are these statements true or false?

– Environmental problems require the expertise of people with differing scientific backgrounds.
– There are many devices on the market which can be used to solve all kinds of air and water problems.
– Liquid wastes can be largely recycled after treatment.
– Mining industry is no longer allowed to leave the land surface in a disturbed condition.
– The highest proportion of atmospheric pollutants produced by man comprises carbon monoxides.
– 30 % of air pollutants have natural causes.
– Regulations are concerned with emissions into the atmosphere of gases rather than solids.
– Limestone slurries and caustic solutions are used to control sulphur oxide gas emissions.
– Useful by-products can be obtained by treating gas streams from modern copper smelting operations.
– New methods of producing copper by chemical means have been highly successful.

2. Classify the following items into four lists according to their role in environmental engineering. Then find a heading for each list.

Electrolytic grade copper	Liquid sulphur dioxide
Electrostatic precipitator	Hydrocarbons
Electrowinning	Hydrometallurgical plant
Fabric arrester	Nitrogen oxide gases
Flash furnace	Sulphur dioxide gas
Liquid ion exchange	Sulphuric acid

3. Discuss the following points.

– Why do you think air quality management is important?
– What kinds of air pollution are found in your area? What could be done to control them?

(Johnson C.N. & D. General Engineering. Prentice Hall, Europe, 1998)

12. You will hear a lecture on impact of some trace elements of ore mineral on the environment. For questions 1–5, choose the best answer A, B, or C.

1. Weathering of the ore minerals results in
   a) release of trace elements
   b) release of major ore elements
   c) release of trace and major elements.

2. The sulphide ore minerals represent the most serious threat of environmental contamination because
   a) they are easily oxidised
   b) environment can be seriously impacted
   c) they produce considerably more soluble sulphates

3. A particular problem concerning weathering of sulphide minerals is
   a) iron sulphides
   b) pyrite
   c) marcasite

4. Ochre is
   a) oxides and hydroxides
   b) oxidation products
   c) iron sulphides

5. Acid mine drainage is
   a) oxidation process
   b) acidic solutions
   c) resultant runoff from mines

13. Read the text, tell about the impact of different stages of oil extraction on environment.

Environmental effect of Extracting Delivering, and Using Petroleum Products

Oil and natural gas burn cleaner than coal but are heavy polluters, too. Oil and gas are preferred fuels because coal is so polluting, and because it is less useful for many kinds of engines. But these fuels, too, cause a great deal of pollution. Burning gasoline in automobiles produces air pollution and smog. The effect of smog on vegetation and human health are well documented. In addition, oil used in cars, trucks, and airplanes sometimes spills and soaks into soil. Leaking oil and leaking underground gasoline tanks have caused pollution problems and expensive lawsuits; although it now seems that natural soil bacteria are capable of decomposing most oil.

Refineries, also, pollute. What comes out of the ground from a typical oil well is a thick substance that is a mixture of many chemicals from very heavy tars to very light gasoline and natural gas. A refinery is basically a gigantic chemistry set that separates this “crude oil” into its components and can also convert one form of the crude oil into more useful form, usually converting the heavier chemicals to lighter ones. Refineries have accidental spills and slow leaks of gasoline and other products from storage tanks and pipes. Over years of operation, large amount of liquid hydrocarbons may be released, polluting soil and groundwater below the site.

The pollution continues during delivery. A famous example happened on March 24, 1988, when the supertanker *Exxon Valdez*, carrying 1.2 million barrels of crude oil, ran aground on Bligh Reef in Prince William Sound, Alaska, and broke open. The ship was full of Alaskan crude oil that had been delivered to it through the Trans-Alaska Pipeline, which itself is a controversial way of transporting oil. The oil poured out of ruptured tanks of the tanker at about 20, 000 barrels per hour, spilling a total of about 250,000 barrels (11million gallons) into the sound. An even bigger spill was avoided when the remainder of oil was off-loaded onto another vessel.
The spill killed thousands of fish, birds, and mammals – 13 % of the sound’s harbor seals, 28 % of the sea otters, and 645,000 seabirds died. Within three days, winds began spreading the huge oil slick so widely that there was no hope of containing it. Of the 11 million gallons of spilled oil, about 20 % evaporated and 50 % was deposited on the shoreline. Only 14 % was collected by skimming and other waste recovery. The *Exxon Valdez* spill showed that the technology for dealing with oil spills was inadequate. The spill disrupted the lives of the people who live and work in the vicinity of

Prince William Sound. Even after more than $3 billion was sent to clean up, few people were satisfied with the results.

Long-term effects of large oil spills are probably not devastating. There is no evidence that the Ocean's ecosystems are seriously threatened by oil spills. Nevertheless, the effect can last several decades. Toxic levels of oil have been identified in salt marshes 20 years after a spill.

The *Exxon Valdez* spill led to the Oil Pollution Act of 1990 and new technology. More modern tankers are being built with double hulls designed to prevent or limit the release of oil in case of collision or grounding. We now also have new techniques to collect oil at sea, using floating barriers and skimmers (oil is lighter than water and so floats on water), but even the best methods are difficult to use in high winds and rough seas. Oil on beaches may be collected by spreading absorbent material, such as straw, waiting for the oil to soak in, and then collecting and disposing the oily straw.

(From E. A. Keller, D.B. Botkin. Essential Environmental Science. John Wieley & Sons, Inc., 2007)

Pay attention to the following words:

leak spill
leakage spillage

Unintentional or unauthorized releases of chemicals, gases, or oil are leaks, leakages, spills, or spillages.

14. Tell in what context these figures are mentioned in the text.

14, 3, 1988, 20, 250 000, 28, 645 000, 50, 1 200 000.

15. Complete the sentences according to the text.

1. Oil and natural gas burn cleaner than coal but … .
2. Oil and gas are preferred fuels because …
3. It now seems that natural soil bacteria are capable of … .
4. A thick substance that comes out of the ground from a typical oil well is … .
5. A famous example of oil pollution during delivery is … .
6. Of the 11 million gallons of spilled oil, about 20 % … and 50 % … .
7. There is no evidence that … .

8. We now also have new techniques to collect oil at sea, using … , but ….

16. You are going to hear a report about tanker disasters. Work in pairs. List possible causes of tanker disasters. Do you think that most accidents could be avoided or some are inevitable?

a) Listen to the recording. What are the main causes of disasters mentioned in the report? Did you include them in your list?

b)Listen to the recording again and complete the chart below.

Name	***Date of Sinking***	***Age of Tanker***	***Location***
Aegean Sea			
Exxon Valdez			
Katina P			
Kirki			

c) Work in small groups. You are going to hear various people talking about a tanker disaster in Ex. 17. Before listening, look at the list of people in Ex. 17 and discuss what their attitudes might be. You can use the following words or expressions.

angry	business-like	confident	constructive	cynical
despairing	embarrassed	emotional	exaggerating	neutral
outraged	reassuring	resigned	unconcerned	unperturbed

What sort of comments are these people likely to make?

17. You will hear various people talking about a tanker disaster. You will hear the recording twice.

a) Look at the list of professions enumerated below. While listening to the recording, decide in what order you hear them begin spoken about and complete the boxes with the appropriate letter. Three professions will not be mentioned.

A a Green party campaigner
B a member of the public
C a central government spokesman
D a local inhabitant of a disaster area
E a ship-owner spokesman

F a radio newsreader
G a local official
H an insurance broker

1	
2	
3	
4	
5	

b) Look at the topics listed below. As you listen, put the topics in the order in which you hear them being mentioned and complete the boxes with the appropriate letter. Three topics will not be used.

A providing aid for the local people
B offering compensation payments
C preventing future disasters
D describing effect on local people's lives
E tightening international regulations
F criticising government policies
G keeping transport costs down
H explaining the cause of the accident

6	
7	
8	
9	
10	

18. Imagine you are people from the list in Ex. 17. Act out interviews. Before you begin, decide what attitude you wish to convey by the tone of your voice and the way you speak.

19. Imagine you are fisherman or local hotel owners. Plan and write a letter demanding compensation for loss of trade caused by the oil spills.

(From Rye D., Greenall S. CAE: Listening and Speaking Skills, 2004.)

20. Discuss the following facts and figures.

1. There are more than 24 thousand enterprises in Russia releasing harmful substances into atmosphere and water basins. These substances are not caught and detoxified by technological processes. Nearly 33 % of emissions come from metallurgy, 29 % – from power industry, 7 % – from chemical industry, and 8 % – from coal industry. More than half of the emissions deliver from transport.

2. There are great losses of non-renewable resources. While extracting mineral resources nearly one third of iron ore, 7,6 % of copper ore is lost, not more than 30 % of oil are recovered from oil reservoir. Every year in the Russian Federation 45 billion tons of mining wastes are formed, out of which 20 billion tons are related to the nonutilizable toxic wastes. They are partially stored on the areas of plants or discharged into sewage system or drafts uncontrollably.

21. Discuss the following quotation from the standpoint of the ecological problems in mining and oil production.

1. One of the first laws against air pollution came in 1300 when King Edward I decreed the death penalty for burning of coal. At least one execution for that offense is recorded. But economics triumphed over health considerations, and air pollution became an appalling problem in England.

~Glenn T. Seaborg, Atomic Energy Commission chairman,
Argonne National Laboratory, 1969

2. The system of nature, of which man is a part, tends to be self-balancing, self-adjusting, self-cleansing. Not so with technology.

~E.F. Schumacher, Small is Beautiful, 1973

3. When some high-sounding institute states that a compound is harmless or a process free of risk, it is wise to know whence the institute or the scientists who work there obtain their financial support.

~Lancet, editorial on the "medical-industrial complex," 1973

22. Write a paragraph on one of the topics, be ready to discuss it in group.

1. The Mining extraction and the Human health;
2. The Oil Production and the Human health;
3. Is it possible to develop the civilization without mining industry?

4. The development of society after depletion of mineral resources;
5. It has been known before that it is not advantageous for the Man to destroy the Nature. So, why does he do that?

WORDLIST

Ablation	абляция, вынос
Beneficiation	обогащение (руды)
Contamination	загрязнение
Enrichment	обогащение
Electrowinning	электрохимическое извлечение
Gangue	пустая порода, породные примеси
Impact	влияние, воздействие
In the vicinity	в близи чего-л.
Leak	протечка, утечка
Leakage	течь, утечка
Particulate	частица
Precipitator	осадитель, фильтр
Processing	обработка
Retention	удержание
Runoff	сток
Smelter	плавильная печь
Spill	проливание, разливание
Spillage	утечка, проливание
Tailings	хвосты, шлам
Waste tip	отвальная куча, отвал

UNIT 3

THE PROBLEMS OF POWER GENERATION

The shift from fossil fuels – coal, oil, and natural gas – to other energy sources, such as wind and solar power, will be one of the milestones of the 21st century. For all practical purposes, with increasing use of automobiles worldwide, we could run out usable petroleum in this century. To avoid serious economic and social problems due to oil shortages, we need to find alternatives before we reach that point. The need is great, and the time to act is now.

Lead-in

Discuss the questions.

1. What forms of energy do you know?
2. What ways of generating energy are used in your region? Are there any problems with them?
3. What is the most dangerous way of producing energy in your opinion? Why?
4. What is the safest way of producing energy in your opinion? Prove it.

Discuss the following quotations about ecological problems. Say how they are related to the theme of the unit.

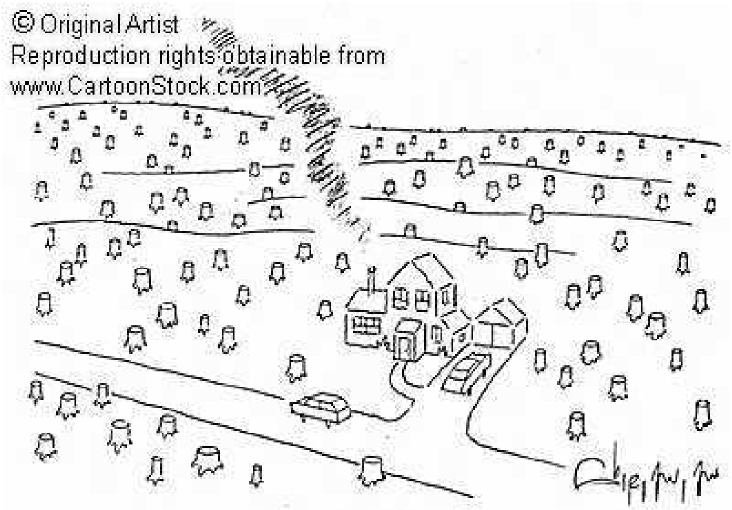
Modern society will find no solution to the ecological problem unless it takes a serious look at its lifestyles.

Pope John Paul II (1920–2005)

Your grandchildren will likely find it incredible – or even sinful – that you burned up a gallon of gasoline to fetch a pack of cigarettes!

Paul MacCready, Jr.

Comment upon the cartoons. How they are related to the topic of the unit.



"Can you believe it? Since we installed our wood-burning stove, we've spent next to nothing on heating oil."

"There's a renewable source the government should use."

TERMS AND VOCABULARY

Combustion	горение
Trace elements	микроэлементы
Retain	удерживаться, сохраняться
Residue	остаток
Fly ash	зольная пыль
Dispose	удалять, устранять
Elevate	повышать, возрастать
Effluent	вытекающий, сточный
Inundate	затоплять, наводнять
Per capita	на душу населения
Notoriety	дурная слава
Acid rain	кислотный дождь

1. a) Pay attention to the pronunciation of the following words.

Combustion [kəm′ bʌstʃ(ə)n]
Notoriety [ˌnəutə′raıətı]
Exposure [ıks′pəuʒə]
Residue [′rezıdju:]

b) Read the names of chemical elements, learn the pronunciation.

Arsenic [a:′senık]
Plutonium [plu:′təunjəm]
Americium [əˈmə:ʃıəm]
Caesium [′si:zıəm]
Iodine [′aıəudi:n]
Antimony [′æntımənı]
Mercury [′mə:kjurı]
Thallium [′θælıəm]
Methylated [ˌmeθı′leıtıd]

2. Read the text, do the exercises.

The production of energy is growing rapidly, both **per capita** and in total. About 90 percent of the energy we use today comes from fossil fuel, just a few percent from nuclear fuel and about 5 percent from hydro-resources. Despite the intensive utilization of oil, gas and coal, and the pessimistic forecasts, their reserves are increasing both overall and per capita.

Globally, fossil fuel (coal, oil, peat) **combustion** provides most of the power generated for industrial and domestic use. Burning of these fuels has achieved **notoriety** in recent years due to the large volumes of carbon dioxide (CO_2) produced, the consequent buildup of this gas in the atmosphere, and its possible contribution to the greenhouse effect on the Earth. In addition, combustion of high sulphur-containing fuels in some areas has resulted in production of sulphur dioxide and sulphur trioxide that, as in the case of smelter emissions (see the previous unit) results in **acid rains**.

An additional environmental consequence of the use of fossil fuels for power generation derives from the many **trace elements** contained in the fuels. Although fossil fuels are predominantly made up of organic matter – the combustion of the carbon in these fuels being the source of energy – they also contain variable amounts of inorganic constituents **retained** in the ash left after the combustion process with some emitted in fine combustion products into the atmosphere. The ash **residue**, called **fly ash**, can contain many potentially harmful elements and therefore needs to be carefully **disposed** of. However, some of the inorganic components are emitted during combustion and can impact the soil, water, and biosphere in the vicinity of the power plant.

Many trace elements have been detected in fossil fuels. For example, in Europe oil and coal combustion contribute significantly to atmospheric deposition of arsenic, cadmium, chromium, copper, nickel, and vanadium. Coal combustion is thought to have made a significant contribution to atmospheric lead deposition in the United Kingdom. Enhanced concentrations of uranium in many coals have resulted in enrichments of this element around coal-fired power stations. **Elevated** concentrations of mercury occur in some oils. Elements enriched in oil such as vanadium have also been found to be elevated in the environment in the vicinity of oil refineries.

Nuclear power generation has been utilized since the mid-1950s and accidental leakages and permitted **effluent** releases have impacted the environment. The nuclear industry is now strictly regulated, but in the early years this was not so and authorized discharges of radioactivity were considerably larger. Radionuclides released at that time still pose a problem. For example, radioactive elements such as americium and plutonium released from Sellafield nuclear power station in Cumbria (England) are still retained in nearby marshy areas.

Although much of the contamination released from nuclear power plants affects only the immediate environment, the catastrophic explosion at Chernobyl in April 1986 caused widespread contamination, which seriously affected the Ukraine with radioactivity spreading over much of Europe and many other parts of the world. For example, radioactive cesium from the Chernobyl accident rained out over upland areas of the UK and high concentrations were found in sheep in the area.

Anthropogenic radioactivity in the environment poses a serious threat to human health. Of particular concern is radioactive iodine, which has been found to move through the food chain rapidly. As a result of exposure to radioactive iodine, humans are prone to increased incidents of thyroid cancer.

Geothermal energy has often been assumed to be a “clean” form of power generation. However, many geothermal areas are associated with volcanic activity and many of the hot springs actively precipitate arsenic, antimony, mercury, and thallium, whereas some geothermal waters contain very high concentrations of boron.

Hydroelectric power generation has led to problems resulting from flooding of areas where soils have been **inundated** it has been found that fish contain elevated concentrations of mercury. The source of the mercury has been found to be the waterlogged soil where this element becomes converted to a methylated form which is bioavailable.

(From Essentials of Medical Geology. Elsevier Inc., 2005)

3. Give Russian equivalents to the following words and set-expressions.

To make a significant contribution
To be strictly regulated
To result in
To be of particular concern
To pose a serious threat
To be associated with
To achieve notoriety
To be prone to

Compose your own sentences with two of the expressions.

4. Match the synonyms.

1. to release	a. combustion
2. to affect	b. to be made up of
3. burning	c. to inundate

4. to consist of	d. to emit
5. to result in	e. to increase
6. to flood	f. to impact
7. to grow	g. to lead in

5. Match the antonyms.

1. Pessimistic	a. Industrial
2. Domestic	b. Result from
3. Per capita	c. Optimistic
4. Result in	d. Lowland
5. Upland	e. Overall

6. Fill in the correct word from the list below.

Exposure	**Inundating**
Combustion	**Prone**
Notoriety	**Elevated**

1. Radioactivity has achieved … after Chernobyl accident (bad fame).
2. The analysis of air composition showed the … concentration of trace elements harmful for human health (high).
3. … to lead is known to damage the brains of young children (action).
4. … of fossil fuels produces large volume of carbon dioxide (burning).
5. City dwellers are known to be more … to heart diseases than countrymen (inclined).
6. After … of large areas they were stated to contain high concentration of mercury (flooding).

7. Fill in the necessary preposition.

1. Combustion of sulphur-containing fuels results … production of sulphur dioxide and sulphur trioxide.
2. Harmful consequence of fossil fuel combustion derives … many trace elements contained in it.
3. Coal combustion makes a significant contribution … atmospheric deposition of harmful substances.
4. Geothermal areas are associated … volcanic activity.
5. Ecological problem of hydroelectric power generation result … flooding of areas.

6. As a result of exposure to radioactivity humans are prone … increased incidents of cancer.

8. Read the examples, join the sentences in every possible way.

Example 1: They tried hard to clean up the lake, but/yet it remains polluted.
Example 2: They tried hard to clean up the lake; however/nevertheless it remains polluted.
Example 3: Although/though/even though they tried hard to clean up the lake, it remains polluted.
Example 4: In spite of/Despite their trying hard to clean up the lake, it remains polluted.

1. Technological progress has stimulated the utilization of solar energy. The use of it poses some problems in gathering the heat from the sun.
2. The fossil fuel is rapidly running out. Some huge reserves remain untouched.
3. There are some difficulties in using solar energy. This energy is used directly as heat to produce high temperature for metallurgical operations.
4. The air in our region is much polluted. Toxic gases are still released into it.
5. The efficiency in the production and transformation of energy increases. The energy problem remains.
6. The utilization of fossil fuel is intensified. The reserves are increasing both overall and per capita.

9. Join the sentences using the words in brackets. Think of other ways of joining them.

1. Nuclear energy is an unlimited source for generating thermonuclear energy. It presents some danger for environment (however).
2. The energy station was fined. It is still releasing toxic gases into the air (despite).
3. The generation of electric power is accompanied by a great loss of energy. Some losses take place when transmitting and using it (in addition).
4. The production of nuclear energy is connected with the danger of accidents. It is connected with the problem of burning nuclear waste. (both … and).

10. Translate the sentences, mind Subjective Infinitive Construction.

1. Burning of fossil fuels is known to produce the large volumes of carbon dioxide which contribute to the greenhouse effect on the Earth.
2. Coal combustion is thought to have made a significant contribution to atmospheric lead deposition in the UK.
3. Though geothermal energy is often assumed to be a “clean” form of power generation, many of the hot springs actively precipitate arsenic, mercury and other harmful substances.
4. Elements enriched in oil such as vanadium have been found to be elevated in the environment in the vicinity of oil refineries.
5. The source of the mercury was found to be the waterlogged soil where this element becomes converted to a methylated form.
6. Combustion of high sulphur-containing fuels is believed to result in production of sulphur dioxide and sulphur trioxide that, in its turn, results in acid rains.

11. Translate the sentences using Subjective Infinitive Construction.

1. Известно, что большая часть энергии производится из полезных ископаемых.
2. Предполагается, что сгорание топлива является причиной парникового эффекта.
3. Оказывается, зольный остаток содержит некоторые вредные вещества.
4. Сообщают, что повышенная концентрация ртути встречается в некоторых видах нефти.
5. Было обнаружено, что радиоактивность отрицательно влияет на здоровье человека.

12. Complete the sentences according to the text.

1. Though the specialists have predicted the running out of natural resources …
2. Burning of fossil fuels has achieved notoriety because of …
3. An additional environmental effect of fossil fuel combustion is …
4. Radionuclides released from nuclear power stations pose a great problem because …
5. The Chernobyl accident seriously affected the environment …
6. Radioactive iodine is of particular concern because …

7. Although geothermal energy is assumed to be ecologically friendly, it is …
8. Generation of hydroelectric power is associated with the problem of ….

13. Answer the questions.

1. What is the problem with energy generation?
2. What energy source is the most popular nowadays? Why?
3. Why has the fossil fuel combustion achieved notoriety?
4. What trace elements are detected in fossil fuels?
5. Why are they considered to be harmful elements?
6. What is the impact of nuclear power generation on the environment?
7. Is geothermal energy really "clean" form of power generation? Prove it.
8. What ecological problems has hydroelectric power generation led to?

14. Read the text, suggest the title to it.

Oil is abundant, but known supplies are dwindling. Next to water, oil is the most abundant fluid in the Earth's upper crust, but most of the proven oil reserves are in a few fields. We are so used to fossil fuels and the devices they power that it is hard to imagine a world without them, but at the rate we are using them and are expected to use them, the reserves will last only a few more decades.

When geologists discuss sources of fossil fuels (or any useful mineral), they distinguish resources and reserves. A mineral *resource* is the entire amount on Earth – sometimes called the *total resource.* A *reserve* is what we can get at now economically, the portion of the resource that we can extract now at a profit. This is sometimes called the *proven reserve.*

The main question is, when will we reach peak production? This is more important than how long oil will last, because after we reach peak production, less oil will be available, leading to shortages and price shocks. Forecasts put peak in world crude oil production between the years 2020 and 2050. Oil production as we know it now is expected to end by about 2090 in the United States, and world production of oil should be nearly exhausted by 2100. Some economists argue that we will never entirely run out of crude oil, because we will reach a point where finding it and extracting it will cost much more than it can sell for, and when that happens it will no longer be used as a fuel, but as a mineral to be made into comparatively expensive products.

Several decades ago, the known available reserve was about 1.6 trillion barrels. Today, the estimate is just 3 trillion barrels. The increase is due primarily to discoveries in the Middle East, Venezuela, and Kazakhstan. Because so much of the world's oil is in the Middle East, oil revenues have flowed into that area, causing huge trade imbalances and many political consequences.

Two other sources of oil play a minor role: oil shale and oil sands. Both are sediments that contain low concentrations of oil, but because they are massive, in total they contain a lot of energy. The use of both is insignificant today, but tar sands could become important as oil from well becomes scarce.

Today for every four barrels of oil we consume, we are finding only one barrel. However, this could improve in the future. Recent studies suggest that about 20 % more oil awaits discovery than predicted a few years ago, and that there is more oil in known fields than we thought. As estimated 3 trillion barrels of crude oil may be recovered from remaining oil resources, while world consumption today is about 30 billion barrels per year. Still, the new oil discovered in known fields will not significantly change the date when world production will peak and production will begin to decline.

(E.A. Keller, D.B. Botkin. Essential Environmental Science. John Wieley & Sons, Inc., 2007)

15. Answer the questions to the text.

1. What is the difference between the terms "resource" and "reserves"?
2. Why is it so important to know when we will reach oil peak production?
3. Why do economists argue that we will never entirely run out of crude oil?
4. Why does oil available reserve grow?
5. What problems did the discovery of oil cause in the Middle East?
6. What are the other sources of oil?

16. Explain the meaning of the following terms in your own words.

Resource, reserve, proven reserve, peak production, oil revenue, oil shale, oil sand.

17. Listen to the discussion of energy crisis.

a) Complete the table.

Speaker	**Position**	**The main ides of his/ her talk. The main advantages and disadvantages of the source mentioned in the speech**
Speaker 1		
Speaker 2		
Speaker 3		
Speaker 4		

b) Answer the questions.

1. Why do we need the alternative sources of energy?
2. What are the alternative sources of energy?
3. What are the disadvantages of nuclear power?
4. What advantages of nuclear power were mentioned in the discussion?
5. What point of view do you agree with? Are you an optimist?

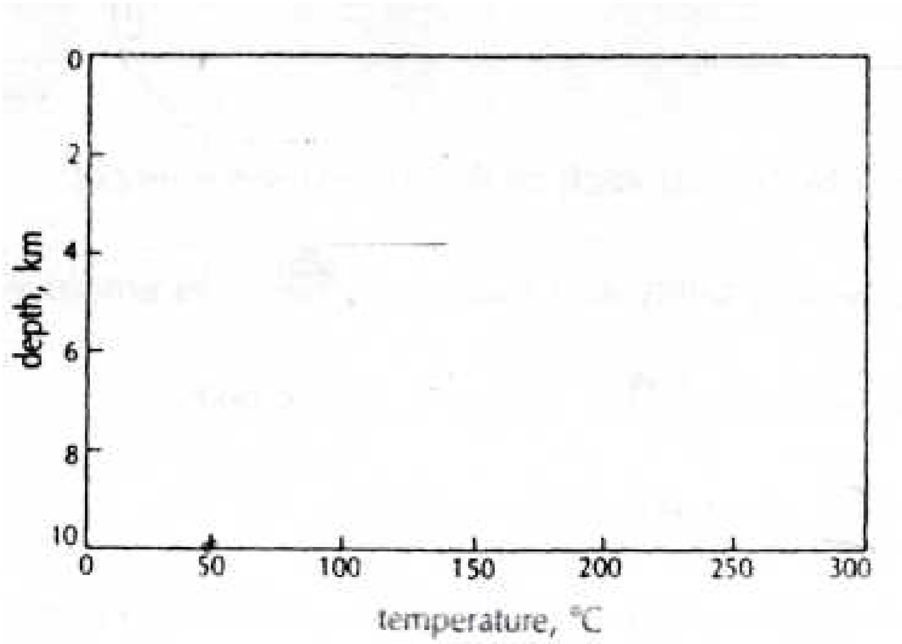
Bernard Hartley & Peter Viney. Streamline Destinations. Oxford University Press, 2008

18. Understanding a lecture

Listen to the lecture, which has been divided into three sections, and then answer the questions below.

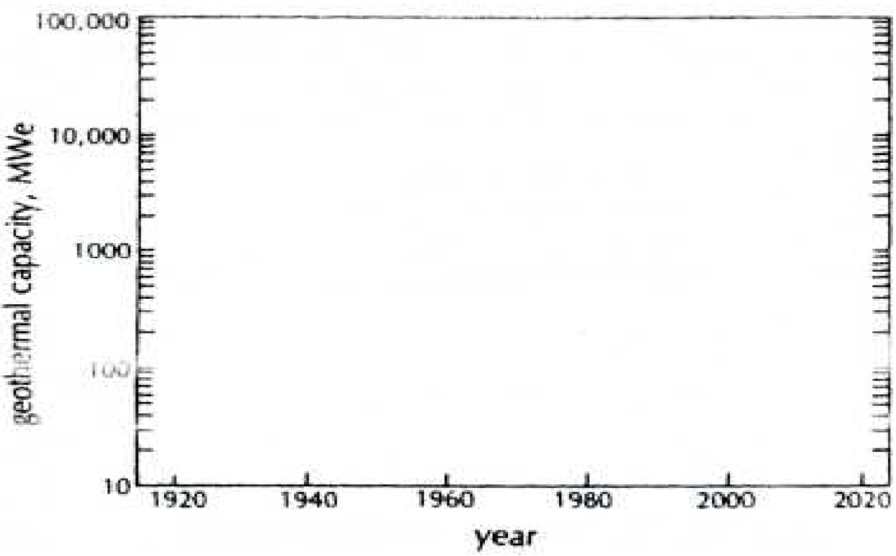
1.
- This lecture is one in a series. What is the series about?
- What is the lecture about?
- Find a suitable sub-heading for each of the three sections.

2. This graph refers to Section 1 of the lecture as Graph 1. Draw the curve of the graph according to the description given in the lecture.



3. These questions refer to Section 2 of the lecture.

- The terms *porous* and *permeability* are used to describe the rock where natural geothermal reservoirs are found. Define the two terms.
- Thermal energy is obtained from underground rocks by ………………
- Are natural geothermal reservoirs . . .?
  - a) found everywhere?
  - b) fairly common?
  - c) not so common?
  - d) rare?
- What are the four conditions which must be met if a source of geothermal energy is to be made economically viable?



4. This graph refers to Section 3 of the lecture as Graph 2. Draw the curve of the graph according to the description given.

5. Discussion.
Could geothermal energy solve some of our energy problems in the future?

Johnson C.N. & D. General Engineering. Prentice Hall, Europe, 1998.

19. Working in pairs, discuss one of the energy source, its advantages and disadvantages, its perspectives:

1. fossil fuels;
2. nuclear power;
3. geothermal energy;
4. hydroelectric power.

Use the expressions:

To result in, to make contribution to, to lead to, to be prone to, to impact, to affect, to achieve notoriety, environmental consequence, to be disposed of, elevated concentration.

20. Organize a students' conference "The modern problems of energy generation.

Make a report on one of the source of energy (4–5 min).
Consider some alternative sources of energy.
Discuss their perspectives for the future.

WORDLIST

Acid rain	кислотный дождь
Arsenic	мышьяк
Combustion	горение
Dispose	удалять, устранять
Effluent	вытекающий, сточный
Elevate	повышать, возрастать
Fly ash	зольная пыль
Inundate	затоплять, наводнять

Mercury	ртуть
Notoriety	дурная слава
Per capita	на душу населения
Prone	склонный, предрасположенный
Residue	остаток
Retain	удерживаться, сохраняться
Release	сброс, утечка
Trace elements	микроэлементы
Thyroid cancer	рак щитовидной железы
Waterlog	затоплять, заболачивать

UNIT 4

THE GREENHOUSE EFFECT

In recent decades, we often hear about the greenhouse effect in somewhat negative terms. The negative concerns are related to the possible impacts of an enhanced greenhouse effect. It is important to remember that without the greenhouse effect, life on earth as we know it would not be possible. While the earth's temperature is dependent upon the greenhouse-like action of the atmosphere, the amount of heating and cooling are strongly influenced by several factors just as greenhouses are affected by various factors.

Lead-in

Discuss the following quotations about ecological problems. Say how they are related to the theme of the unit.

The earth we abuse and the living things we kill will, in the end, take their revenge; for in exploiting their presence we are diminishing our future.

~Marya Mannes, *More in Anger*, 1958

Economic advance is not the same thing as human progress.

John Clapham, *A Concise Economic History of Britain*, 1957

For 200 years we've been conquering Nature. Now we're beating it to death.

~Tom McMillan, *The Greenhouse Trap*, 1990

Our environmental problems originate in the hubris of imagining ourselves as the central nervous system or the brain of nature. We're not the brain, we are a cancer on nature.

~Dave Foreman, *Harper's*, April 1990

TERMS AND VOCABULARY

Incident radiation	падающее излучение
Perturbation	возмущение
Deleterious effect	вредный, отрицательный эффект
Depletion	истощение, износ
Tenuous	тонкий, незначительный
Sewage disposal	удаление, сброс сточных вод

Diversity	разнообразие
Runaway	неудержимый, вышедший из под контроля
To scatter	рассеивать
Repository	хранилище, контейнер
To trap	улавливать
A matter of controversy	предмет разногласия, спора
Abundance	распространение, изобилие

1. Guess the meaning of the words and learn the pronunciation.

energy ['enədʒi]
anthropogenic [ˌænθrəpə'dʒınık]
globe [gləʊb]
concentration [ˌkonsn'treıʃn]
atmosphere ['ætməsfıə]
gravitation [ˌgrævı'teıʃn]

2. Read the text, do the exercises.

Life as we know it on the Earth is entirely dependent on the **tenuous** layer of gas that clings to the surface of the globe, adding about 1 % to its diameter and insignificant amount to its total mass. And yet the atmosphere serves as the Earth's window and protective shield, as a medium for the transport of heat and water, and as source and sink for exchange of carbon, oxygen, and nitrogen with the biosphere. The atmosphere acts as a compressible fluid tied to the Earth by gravitation; as a receptor of solar energy and a thermal reservoir, it constitutes the working fluid of a heat engine that transports and redistributes matter and energy over the entire globe. The atmosphere is also a major temporary **repository** of a number of chemical elements that move in a cyclic manner between the hydrosphere, atmosphere, and the upper lithosphere. Finally, the atmosphere is a site for a large variety of complex photochemically initiated reactions involving both natural and anthropogenic substances.

The energy radiated by the earth has a longer wavelength than **the incident radiation.** Most gases absorb radiation in this range quite efficiently, including those gases such as CO_2 and N_2O that do not absorb the incident radiation. The energy absorbed by atmospheric gases is re-radiated in all directions; some of it therefore escapes into space, but a portion returns to the Earth and reabsorbed, thus raising its temperature. This is commonly called the greenhouse effect. If the amount of an infrared-absorbing gas such as

carbon dioxide increases, a larger fraction of the incident solar radiation is **trapped**, and the mean temperature of the Earth will increase.
Any significant increase in temperature of the oceans would increase the atmospheric concentrations of both water and $CO_{2,}$ producing the possibility of a **runaway** process that would be catastrophic from a human perspective. Fossil fuel combustion and deforestation during the last two hundred years have increased the atmospheric CO_2 concentration by 25 % and this increase is continuing. The same combustion processes responsible for the increasing CO_2 concentration also introduce considerable quantities of particulate materials into the upper atmosphere. The effect of these would be **to scatter** more of the incoming solar radiation, reducing the amount that reaches and heats the earth's surface. The extent to which this process counteracts the greenhouse effect is still a **matter of controversy**; all that is known for sure is that the average temperature of the Earth is increasing.

Carbon dioxide is not the only atmospheric gas of anthropogenic origin that can affect the heat balance of the Earth; other examples are SO_2 and N_2O. Nitrous oxide is of particular interest, since its **abundance** is fairly high, and is increasing at a rate of about 0.5 % per year.

It is produced mainly by bacteria, and much of the increase is probably connected with introduction of increased nitrate into the environment through agricultural fertilization and **sewage disposal**. Besides being a strong infrared absorber, N_2O is photochemically active, and can react with ozone. Any significant **depletion** of the ozone content of the upper atmosphere would permit more ultraviolet radiation to reach the Earth. This would have numerous **deleterious effects** on present life forms, as well as contributing to a temperature increase. The warming effect attributed to anthropogenic additions of greenhouse gases to the atmosphere is estimated to be about 2 watts per m^2, or about 1.5 % of the 150 watts per m^2 trapped by clouds and atmospheric gases. This is a relatively large **perturbation** compared to the maximum variation in solar output of 0.5 watts per m^2 that has been observed during the past century. Continuation of greenhouse gas emission at present levels for another century could increase the atmospheric warming effect by 6–8 watts per m^2.

A less-appreciated side effect of the increase in atmospheric carbon dioxide may be reduction in plant species **diversity** by selectively encouraging the growth of species which are ordinarily held in check by other species that are able to grow well with fewer nutrients. This effect, for which there is already some evidence, could be especially pronounced when the competing species utilize the C_3 and C_4 photosynthetic pathways that differ in their sensitivity to CO_2.

(Lower S. K. Survey of Environmental Geobiochemistry. Simon Fraser University, 2004)

3. Complete the table with the appropriate word-formations.

Verb	***Noun***	***Adjective***
Reduce	–	reductive
–	distribution	distributable
Radiate	radiation	–
Compress	–	–
–	continuation	–

4. Give Russian equivalents to the words and set expressions.

1. compared to
2. to hold in check
3. to move in a cyclic manner
4. to be a matter of controversy
5. to be of particular interest
6. to be known for sure
7. to escape into space

Compose your own sentences with two of the expressions.

5. Translate from Russian into English.

Падающая радиация, поглощать, ловить, вышедший из-под контроля процесс, быть ответственным за, рассеивать радиацию, влиять (2 вар.), представлять особый интерес, внесение удобрений в почву, сброс сточных вод, значительное истощение (уменьшение), повышать температуру (2 вар.), сжигание, улетучиваться в космос, вредное воздействие, также как и, оценивать, излучение газов парникового эффекта, антропогенное происхождение, природное топливо, большое возмущение.

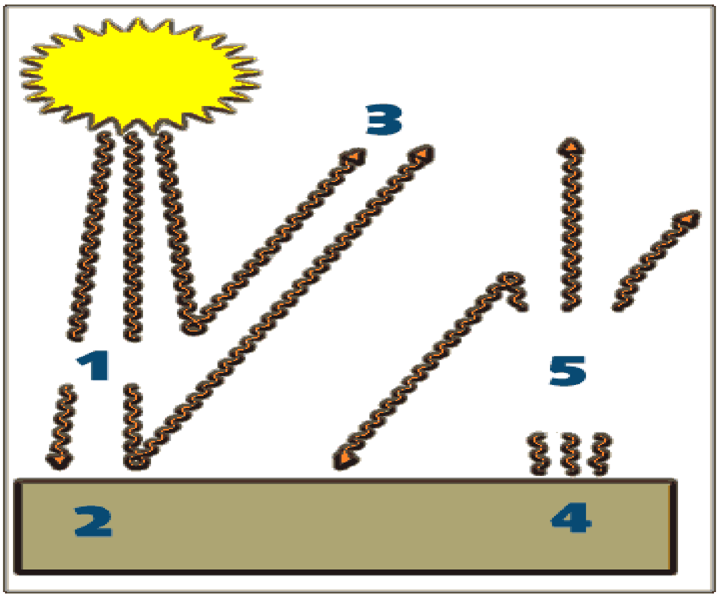
6. Fill in each gap with only one word.

Gases pollute the atmosphere because they are produced **1).** …. quickly to be cleared away naturally **2)**. …. rain, winds or plant life. These poisonous gases **3).** … from several sources such as oil producers, industries which burn fuel, and motor vehicle. When the gases are released, they have two deleterious effects. **4).** …, some of the gases are caught by rain clouds and fall as acid rain, **5)**. … damages the environment. Secondly, if the amount of carbon dioxide increases, a larger fraction of the incident solar radiation is trapped, keeping the heat of the sun close **6)**. … the Earth's surface just **7)**. …. a greenhouse keeps heat in. The increase of carbon dioxide is **8).** … worse by the cutting down **9)**. …. forests. Trees use carbon dioxide, and the fewer trees **10)**. …, the more of this gas remains **11)**. … the air. The USA is now leading an international effort to limit deforestation. In 1996, Washington set goals for industry, and several international agreements **12)**. … already been effective in reducing the production **13).** … harmful gases. Only international cooperation can **14)**. … this problem which, if **15)**. … controlled, may threaten all life on earth.

7. Match the definitions.

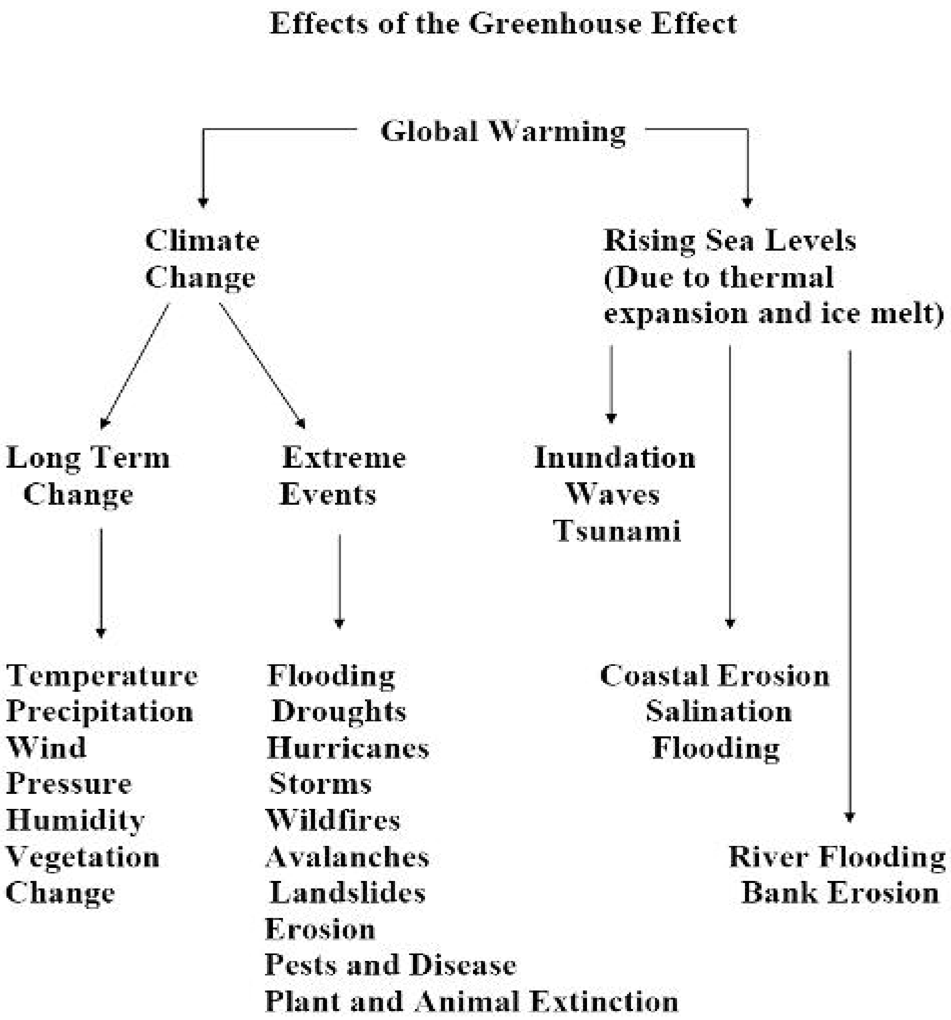
1) greenhouse effect	is	a) the radiation emitted spontaneously during the short period of time
2) perturbation		b) a gradual rise in temperature of the earth's atmosphere, caused by an increase of gases, e.g. carbon dioxide, in the air that trap the warmth of the sun
3) depletion		c) the state or moment of being disturbed
4) incident radiation		d) reduction greatly of the quality, size, power or value of smth
5) lithosphere		e) a layer between the lithosphere and the atmosphere including all water recourses on the Earth
6) hydrosphere		f) an upper solid layer of the Earth including crust and the upper mantle

8. Look at the chart. Put the sentences below in the correct order.



1	a) The greenhouse gases: water vapour, carbon dioxide, methane, nitrous oxide... absorb this infra-red radiation and in turn reradiate it in the form of heat
2	b) The heat is partly absorbed by the earth itself
3	c) The heat on earth comes from the sun
4	d) But a substantial part is reradiated also, into space
5	e) These gases thus ensure that a considerable part of the heat from the sun remains within the atmosphere after all
6	f) The heat absorbed is reradiated by the earth as infra-red radiation

9. Looking at the chart, tell about consequences of greenhouse effect.



10. Answer the following questions.

1. What are the functions of atmosphere?
2. What gases absorb the radiation?
3. What happened to the energy absorbed by the atmospheric gases?
4. Why does the temperature rise on the Earth?
5. What can it result in?
6. What are the reasons of increasing the concentration of CO_2?
7. What other gases that can affect the heat balance of the earth can you name?
8. How do they appear in the environment?
9. What is the result of reaction N_2O with ozone?

10. What are the forecasts for the further increase in the atmospheric warming?

11. Put the sections of the article from the New Scientist into the correct order. The first section is " a" and the last is "g".

Looking on the Dark Side of Global Warming

A …The following chain of events takes a pessimistic view of what could be in store for a world that carries on as it does today, taking estimates from the agreed by the IPCC (Inter-Governmental Panel on Climate Change) scientists.

B. At the same time a "plankton multiplier effect" comes into effect as warmer weather makes the upper level of the oceans more stable. Phytoplankton grow more slowly, because they receive less nutrients, which come from deeper water that now reaches the surface layer more rarely.

C. But in this version of the future, the effect is worse. The depleted ozone layer above the Antarctic and Arctic transmits far more ultraviolet-B radiation to the surrounding seas. This weakens the phytoplankton, further depleting the ocean sink for carbon dioxide, which allows more of the gas to build up in the atmosphere.

D. The oceans, one of the two major carbon dioxide sinks, cannot absorb as much carbon dioxide as they once did. Many scientists believed that this happened suddenly at the end of the last ice age, boosting average temperatures in the North Atlantic by as much as 5 degrees C within a century.

E. The world warms at the accelerated rates predicted by the IPCC as concentrations of carbon dioxide and other greenhouse gases go on building up the atmosphere, without any cuts in emissions. As the oceans warm, they are less able to absorb carbon dioxide from the atmosphere.

F. This is a safe bet: the IPCC report warns of this positive feedback, which arises because carbon dioxide is less soluble in warmer water.

G. This is a major fear, now that ozone depletion has been found to extend into subarctic latitudes in the spring, when phytoplankton bloom …

(Mascull B. Key Words in Science and Technology. The University of Birmingham, 1997)

12. You will hear a lecture on global warming. For questions 1–15, fill in the missing information.

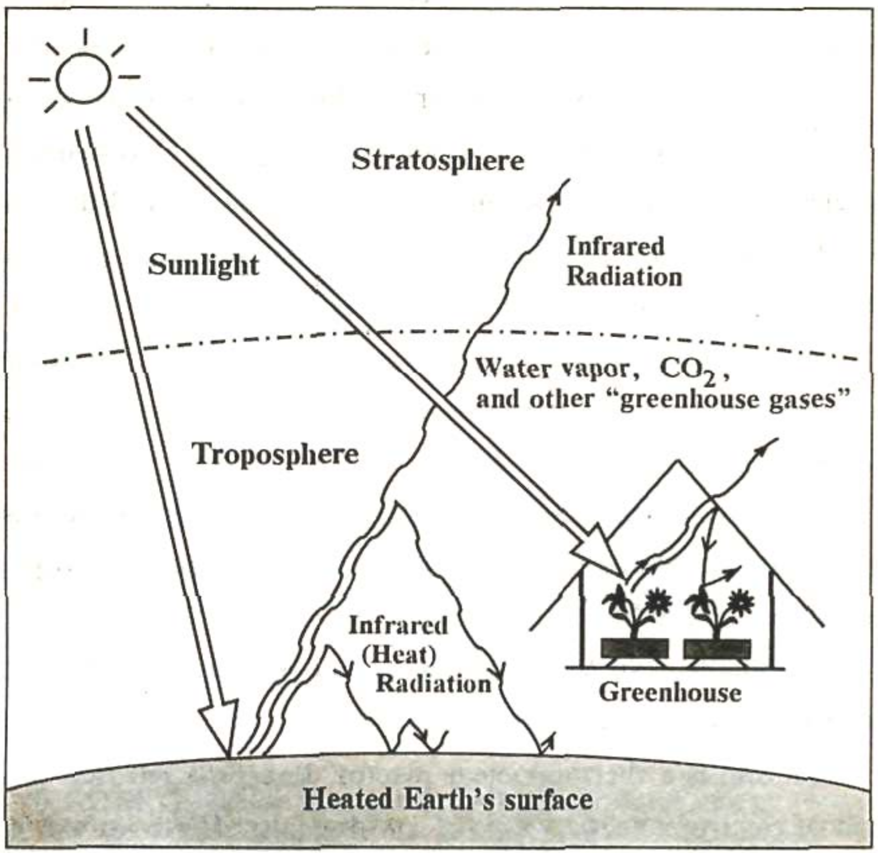
The director of NASA’s Institute for Space Studies James Hansen had a simple message about **1). …** As evidence he presented not just the atmospheric models that for years have predicted climate change, but also **2). …** that show a rise of 0.6 degrees Celsius. And the decade of the nineties, as Hansen pointed out, is by far **3). …**The date was **4). …**, and human-induced global warming had finally emerged as **5). …** that policy-makers could no longer ignore. Although much of the key data had been developed and even published in preceding years, **6). …**. A sober government scientist was publicly stating his conclusion that human-induced greenhouse warming is a reality with which **7). …** .

Against the background of a persistent North American drought and unusually mild European weather, shock waves emanated quickly from Capitol Hill. Hundreds of reports soon followed in magazines and on television programs around the world. Opinion polls soon showed that climate change had become **8). …** . Since Hansen’s testimony, debate has raged in the scientific community and popular press about some of the details of his conclusions. Hansen brought to public attention what is now a strong and largely undisputed consensus of atmospheric scientists: global temperatures are **9). …** during the coming decades.

The Earth’s climate is a product of **10). …** . On Venus, a human being’s blood would boil. On Mars, a person would **11). …** . The difference in temperature is largely due to **12). …** . All three receive huge quantities of solar energy, but the amount that is radiated back into space depends on **13). …** . Some gases tend to absorb the heat in the same way that **14). …**, allowing temperatures to build up. The scorching heat of Venus is a product of an atmosphere composed largely of carbon dioxide. Earth, on the other hand, has **15). …**, only 0.03 percent of which is carbon dioxide. This share has varied only by 40 percent over the past several years, allowing a relatively stable climate conducive to life.

(By Ch. Flavin, from World watch Paper)

13.Tell about the greenhouse effect using this picture.



14. ***You will hear a man talking about a climatic phenomenon called El Niňo. For questions 10–14, choose the best answer (A, B, C or D) which best fits according to what you hear.***

1. The phenomenon known as El Niňo
A) is confined to the Pacific Ocean.
B) affects climate in many parts of the world.
C) resembles global warming.
D) caused the disappearance of the dinosaurs.

2. It was named after
A) Jesus Christ.
B) a fisherman's son.
C) a warm current.
D) a time of year.

3. It is caused by
A) the wind changing direction.

B) the wind losing its force.
C) the water becoming cooler.
D) violent storms.

4. El Niňa is a phenomenon that
A) reserves the effect of El Niňo.
B) produces similar weather conditions.
C) forms part of the same pattern.
D) occurs every four or five years.

5. The effect of El Niňo
A) can be reliably forecast.
B) are sometimes beneficial.
C) are never accurately reported.
D) do not reach the northern hemisphere.

(Fowler W.S. New Fowler proficiency. Listening and speaking, 2003)

15. Discuss the following facts and figures.

1. As a result of human activity 156 mln. tons of sulphur dioxide and 60 mln. tons of nitric oxide are released into atmosphere every year. In the cities where there are many industrial enterprises the air is contaminated even greater. For example, in Tokyo every month 34 tons of soot falls per each square kilometer of the territory, in New-York it amounts 17 tons.
2. As a result of industry and transport development oxygen is used for burning in greater amount. For example, an automobile spends a man's daily rate (суточная норма) of oxygen per 1,5 thousand kilometers. (A man spends 500 liters of air daily on average). A modern jet liner uses 35 tons of oxygen per 1 transatlantic flight.
3. One of the terrible catastrophes in the history of mankind was the accident in Chernobyl in April 1986.There happened destruction, melting, evaporation and emission of nuclear fuel into the atmosphere. In all nearly 50 tons of nuclear material were released into the atmosphere. The mass of radioactive bomb fallen on Hiroshima was 4,5 tons. In Chernobyl the radioactive substances rose at the height up to 11 kilometers, the territory of Ukraine, Belorus, and central regions of Russia were contaminated.

16. Discuss the following problems. Find some additional information to prove your point of view.

1. Can the ozone layer be preserved in the current conditions? If so, in what way?
2. Why does not the contamination of atmosphere disturb the processes taking place in it?

17. Choose any questions. Discuss it in pairs.

1. What will climate change lead to?
2. What is the difference between the greenhouse effect, global warming and climate change?
3. How do we know the greenhouse effect is a reality?
4. What do the experts conclude about climate change?
5. Global warming and climate change? Is there still a debate?
6. How can we predict climate change when we can't even predict the weather?
7. Will all the impacts of the greenhouse effect be negative?
8. What must be done to reduce human contributions to the greenhouse effect?
9. Can the world survive without fossil fuels? What are the alternatives?

WORDLIST

Abundance	распространение, изобилие
Anthropogenic	антропогенный, техногенный
Controversy	разногласие, спор
Deforestation	вырубка, уничтожение лесов
Deleterious effect	вредный, отрицательный эффект
Depletion	истощение, износ
Diversity	разнообразие
Evidence	свидетельство, доказательство
Incident radiation	падающее излучение
Infra-red radiation	инфракрасное излучение
Nutrient	питательное вещество
Perturbation	возмущение
Repository	хранилище, контейнер
Runaway	быстро растущий
To scatter	рассеивать

Sewage disposal	удаление, сброс сточных вод
Tenuous	тонкий
To trap	улавливать
Ultraviolet radiation	ультрафиолетовая радиация

UNIT 5

THE IMPACT OF CHEMICAL ELEMENTS ON HUMAN ORGANISM

Serious health problems and diseases may arise from toxic elements in water, air, soil, and even the rocks on which we build our homes. Almost every part of the human body is affected by one pollutant or another. The same is wildlife.

Lead-in

1. Once the famous physician and alchemist Paracelsus said: “Everything is poisonous, yet nothing is poisonous”. What did he mean? Give your examples.
2. How can harmful substances get into organism? Enumerate all possible pathways.
3. The impact of what substances on human organism do you know? Can you describe it?

Terms and Vocabulary

Host	организм-хозяин, реципиент
Hazard	опасность, риск
Exposure	подвергание воздействию, экспозиция
Excretion	выведение, экскреция
Tissue	ткань
Ingestion	прием пищи, глотание
Uptake	поглощение, ввод
Bolus	пищевая масса, кусок пищи
Scope	рамки, границы
Host defences	иммунная защита организма
Risk assessment	оценка рисков

1. Read the words and learn their pronunciation.

[i:] convenience, excretion, breathing, intravenous
[oʊ] process, scope
[u:] rout, include, remove, evolution
[ai] biology, kinetics, xenobiotics
[dʒ] geology, agent, ingestion

[k] mechanism, chemicals, characterize
[ks] toxicity, acceptable
[ʒ] exposure

2. Try to recognize the following words, learn their pronunciation.

Immunology [ˌɪmjʊ′nolodʒɪ]   Xenobiotics [

Regardless of their effect or origin, the behaviour of xenobiotics in the body can be described by general terms and models reflecting the mechanisms by which exposure occurs and the body handles the chemicals. From the standpoint of evolutionary biology, it is supposed that these mechanisms developed in response to selection pressures indicating either of two biological needs: to detoxify and excrete harmful substances ingested in foods and to metabolize endogenous chemical compounds (such as steroid hormones).

Four terms describe the disposition of xenobiotics: absorption, distribution, metabolism, and **excretion**. Modelled together, the terms indicate the entry, local and overall accumulation, transformation, and removal from the body of the xenobiotic. Because tissue level depend on transport of the xenobiotic to the target organ and the degree to which the xenobiotic partitions or is sequestered into the tissue, the kinetics of the xenobiotics determines the presentation of the xenobiotic to the target organ at the receptor level, where the toxic effect occurs (see Fig.).

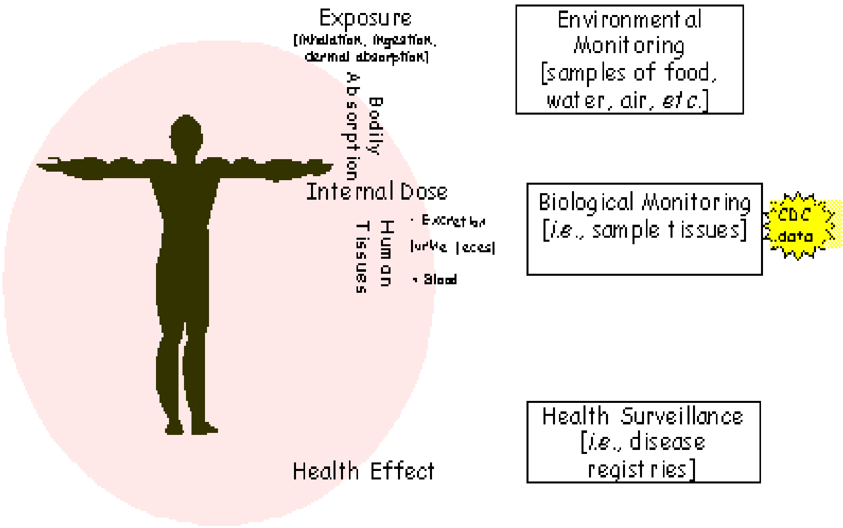
Xenobiotics may enter the body through any of several “portals” or routs of entry. By far the most common opportunities for exposure are skin contact and breathing in the agent. **Ingestion,** resulting from eating or placing objects (e.g. cigarettes) in the mouth in a situation where the object or the hands may have been contaminated, or in suicide attempts, is not a common problem in environmental medicine, but appears from time to time. Other routs of exposure, such as intravenous infusion or implantation of soluble agents, are artificial and seldom seen outside of medical care and experimental studies.

Once the xenobiotic is absorbed and enters the organism, it is transported to capillary level in tissues of the body where it becomes available for **uptake** by the target organ. After one pass through the circulation the xenobiotic is uniformly mixed in arterial blood regardless of its entry. When **a bolus** is absorbed, the peripheral **tissues** are therefore presented with an increasing concentration in the blood which peaks and then declines as the xenobiotic is distributed to tissues throughout the body and removed by metabolism, excretion, or storage.

Many xenobiotics are substrates for intracellular enzyme systems which transform it from the original compound to a series of stable metabolites, often through intermediate unstable compounds. These transformations may have the effect of either “detoxifying”, by rendering the agent toxicologically

inactive, or of “activation”, by converting the native agent into a metabolite that is more active in producing the same or another toxic effect.
The xenobiotic or its metabolite would accumulate and remain within the body, if there were no mechanisms for excretion. Elimination is the term used for removal of xenobiotic from the bloodstream, whether by excretion, metabolism, or sequestration (storage).

(From Essentials of Medical Geology. Elsevier Inc., 2005)



4. Read the following word-formations, translate into Russian.

Toxicology – toxicity – detoxify – toxic – toxicologically
To act – active – inactive – activity – activation
To produce – product – production
To absorb – absorption – absorptive
To transport – transportation – transportive
To metabolize – metabolite – metabolism

5. Give Russian equivalents to the following words and set-expressions.

To play an essential role
To result from
To expand the scope
To provide the framework
Regardless of smth.
In response to

From the standpoint of
Peculiar to

Make your own sentences with two of the expressions.

6. Match the synonyms.

1. response	a. eliminate
2. defence	b. contaminate
3. show	c. route
4. remove	d. indicate
5. occur	e. reaction
6. portal	f. resistance
7. pollute	g. take place

7. Fill in the necessary prepositions.

1. Toxicology is a specialized area of risk assessment identifying the level of hazard peculiar ... a definite chemical exposure.
2. Regardless … its effect behavior of xenobiotic can be described in four terms: absorption, distribution, metabolism, and excretion.
3. Tissue level depends … transport of the xenobiotic to the target organ and the degree of its sequestration into the tissue.
4. … the standpoint of biology the mechanism of handling the chemicals by the body developed …response … selection pressure.
5. Substances that are not normally present in the body and introduced from outside are referred … as xenobiotics … convenience.
6. Scientific principles of toxicology are applied … medical geology.
7. Elimination is a term used for removal of xenobiotic … the organism.
8. Risk assessment is the identification and characterization of the level of risk resulting … exposure of hazards including the uncertainties.

8. Match the words with their definitions.

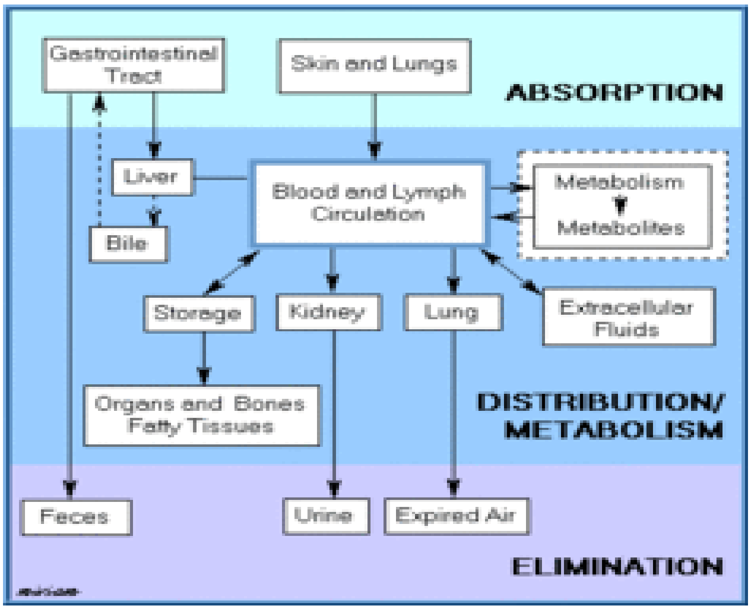
1) xenobiotic	is	a) the process of removal of xenobiotic from the organism
2) absorption		b) a substance involved in metabolism, being either synthesized during metabolism or taken in from the environment

3) excretion		c) a science dealing with biological mechanisms of toxicity and host defences against toxicity
4) toxicology		d) the process for xenobiotic to enter the body
5) metabolite		e) a substance alien to an organism

9. State whether each of the following sentences are true or false, if false, explain why.

1. Toxicology has started to develop as an independent science from the moment of virus and microbe discovery.
2. Xenobiotics may be an anthropogenic environmental chemical action.
3. Principles of toxicology are applied to many branches of other sciences.
4. There are three mechanisms by which the body handles the chemicals.
5. Absorption is a terms that indicates the overall accumulation of xenobiotic in a body.
6. The most common opportunity for exposure is contaminated hands.
7. After the circulation in blood the xenobiotic is mixed in it no matter how it has entered the organism.
8. Transformations of xenobiotic in organism may activate the action of xenobiotic by converting the native agent into a metabolite.

10. Read the text again and make notes under the following headings. Find some additional information on each of the topics. Talk about the process of toxicokinetics. Use the scheme.



– The role of toxicology, its interaction with other sciences.
– The stages of handling the chemicals by the body.
– The process of xenobiotic absorption in organism.
– The process of xenobiotic distribution in organism.
– Metabolism of xenobiotic.
– Excretion of xenobiotic from organism.

11. Read the text and answer the questions.

Toxic heavy metals

The major heavy metals (metals with relatively high atomic weight) that pose health hazards to people and ecosystems include mercury, lead, cadmium, nickel, gold, platinum, silver, bismuth, arsenic, selenium, vanadium, chromium, and thallium. Each of these elements may be found in soil and water that has not been contaminated by people. However, each of these metals has uses in the modern industrial society, and each is also a by-product of the mining, refining, and use of other elements. Heavy metals often have direct physiological toxic effect. Some are stored or incorporated in living tissue, sometimes permanently. Heavy metals tend to accumulate over time in fatty body tissue. As a result, a little arsenic each day may eventually result in a fatal dose (the plot of more than one murder mystery).

Mercury, thallium, and lead are very toxic to people. They have long been mined and used, and their toxic properties are well known. Mercury, for example, is the “Mad Hatter” element. At one time, it was used in making felt hats stiff, and because mercury damages the brain, hatters were known to act peculiarly in Victorian England. Thus, the Mad Hatter in Lewis Carroll’s Alice in Wonderland had real antecedents in history.

Chemical elements released from rocks or human processes can become concentrated in humans through many pathways. These pathways may involve what is known as biomagnification – the accumulation or increase in the concentration of a substance in living tissue as it moves through a food web (also known as bioaccumulation). For example, cadmium, which influences the risk of heart disease, may enter the environment via ash from burning coal. The cadmium in coal exists in very low concentrations. After coal is burned in a power plant, the ash is collected in a solid form and disposed in a landfill (свалка). The landfill is covered with soil and revegetated. The low concentration of cadmium in the ash and soil is taken into the plants as they grow. But the concentration of cadmium in the plants is three to five times greater than the concentration in the ash. As cadmium moves through the food chain, it becomes more and more concentrated. By the time it is incorporated in the tissue of people and other carnivores, the concentration is approximately 50-60 times the original concentration in coal.

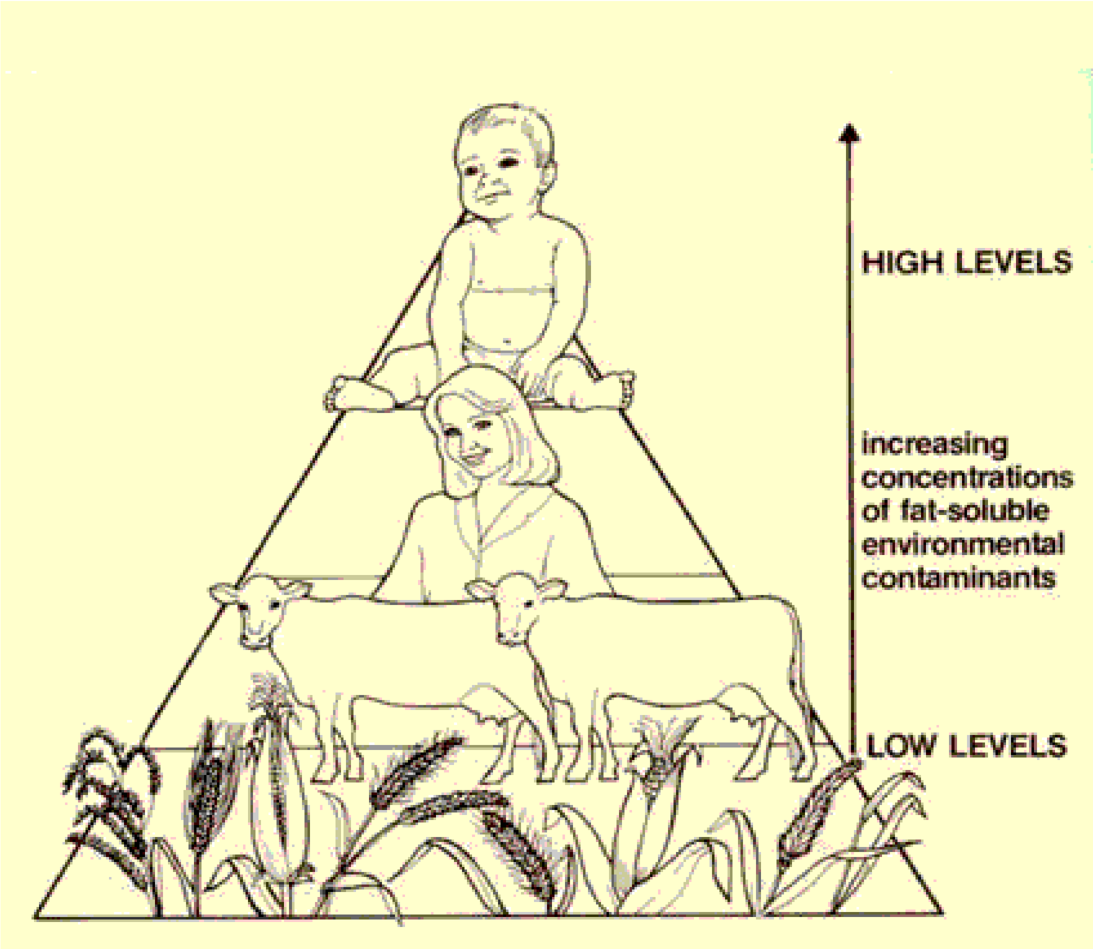
Mercury in aquatic ecosystems offers another example of biomagnification. Mercury is a potentially serious pollutant of aquatic ecosystem, such as ponds, lakes, rivers, and the ocean. Natural sources of mercury in the environment include volcanic eruption and the erosion of natural mercury deposits. However, we are most concerned with human input of mercury into the environment through burning coal in power plants, incinerating (сжигать) wastes, and processing metals, such as gold. Although we are unable to measure it precisely, it is estimated that human activities have doubled or tripled the amount of mercury in the atmosphere, and that it is increasing at about 1.5 % per year.

A major source of mercury in many aquatic ecosystems is precipitation from the atmosphere – rain and snow. Most of what is deposited is inorganic mercury, but once this mercury is in surface water, a process known as methylation may occur. Methylation changes inorganic mercury into methyl mercury through bacterial activity. Methyl mercury is much more toxic than organic mercury, and it is eliminated more slowly from animals' system.

As the methyl mercury works its way through food chain, biomagnification occurs, so that higher concentrations of methyl mercury are found farther up the food chain. Thus, big fish that eat little fish contain higher concentration of mercury than do smaller fish and the aquatic insects that the fish feed on. Large fish, such as tuna and swordfish, have elevated mercury concentrations, which is why today we are advised to limit our consumption of these fish. Indeed, pregnant women are advised not to eat them at all.

(From E.A. Keller, D.B. Botkin. Essential Environmental Science. John Wieley & Sons, Inc., 2007)

1. What is biomagnification? Describe its process looking at the picture.



Biomagnification through the Food Chain

2. Give the examples of biomagnification of some elements.

3. What are the main sources of contamination with heavy metals in the environment?

4. Find more information on the impact on human organism.

mercury;
cadmium;
thallium;
lead;
arsenic;
selenium;
vanadium;
chromium

12. Work in pairs. Write 6 questions on the text above.
Act your dialogue using the expressions of agreement and disagreement.

13. a) Name the main principles of toxicokinetics. Characterise each of them.

b) You will hear the description of the process taking place at each stage of toxicokinetics. Decide which description corresponds to what principle.

a) Absorption
b) Distribution
c) Metabolism
d) Excretion

1	2	3	4

14. a) Name the organs involved in each stage of toxicokinetics.

Example: Absorption may occur through …

b) Describe the processes of toxicokinetics using the picture.

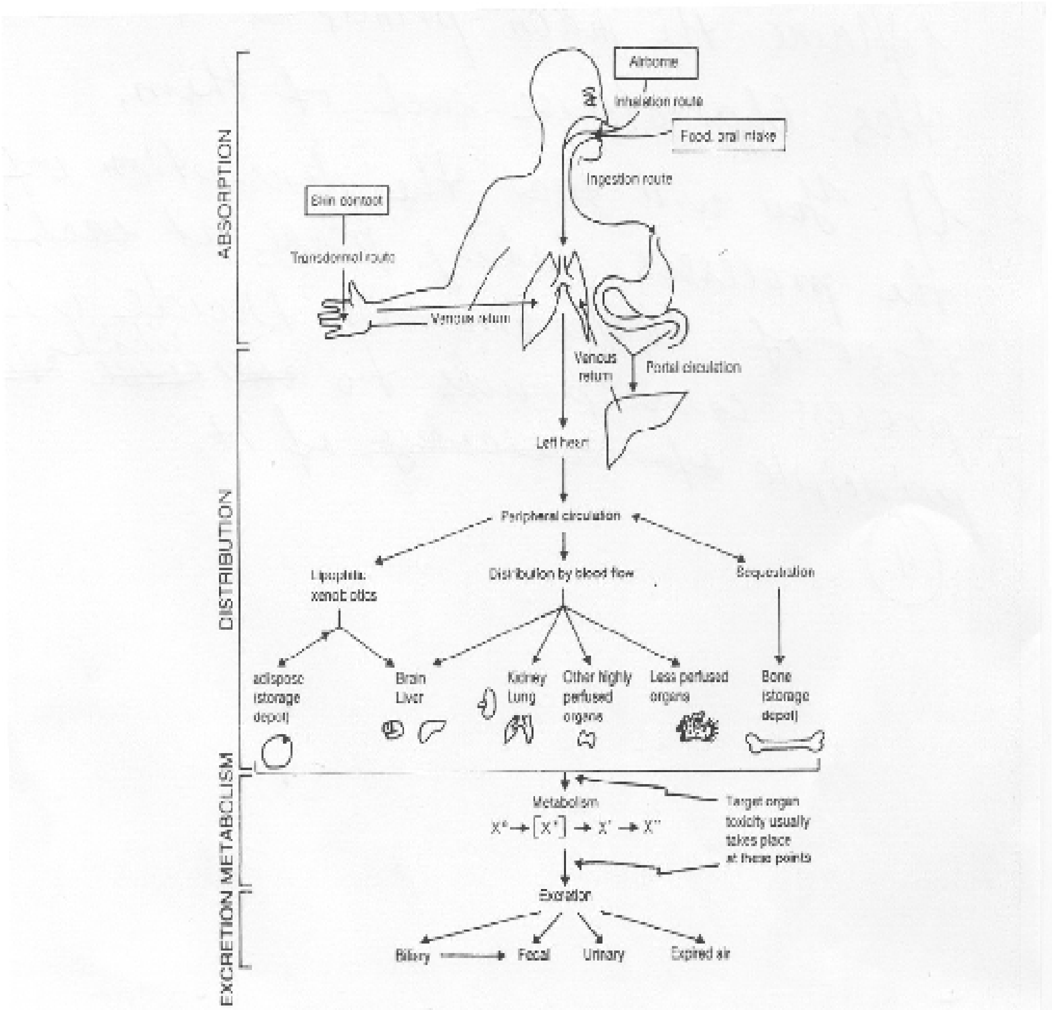


FIGURE 1 Principles of toxicokinetics: absorption, distribution, metabolism, and excretion. (Reproduced with permission from Guidotti, 1994.)

WORDLIST

Biomagnification	бионакопление, биоаккумуляция
Bolus	пищевая масса, кусок пищи
By-product	побочный продукт
Eliminate	устранять
Excretion	выведение, экскреция
Exposure	подвергание воздействию,

	экспозиция
Food web	пищевая сеть
Framework	структура, точка отсчета
Hazard	опасность, риск
Host	организм-хозяин, реципиент
Host defences	иммунная защита организма
Infusion	вливание, введение
Ingestion	прием пищи, глотание
Input	ввод, вход
Intravenous	внутривенный
Metabolite	метаболит, продукт обмена веществ
Pathway	путь, прохождение, траектория
Risk assessment	оценка рисков
Scope	рамки, границы
Sequestration	секвестрация, отторжение
Target organ	орган-мишень
Tissue	ткань
Uptake	поглощение, ввод
Xenobiotic	ксенобиотик, чужеродное вещество

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PETROLEUM ENGINEERING
COURSE **BOOK**

НЕФТЕГАЗОВОЕ ДЕЛО
КНИГА ДЛЯ СТУДЕНТОВ

Учебное пособие

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