TRAINING IN ENGLISH FOR PROFESSIONAL PURPOSES (FOR STUDENTS-GEOLOGISTS)

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

Т.Ю. Якич

ПРОФЕССИОНАЛЬНАЯ ПОДГОТОВКА НА АНГЛИЙСКОМ ЯЗЫКЕ (ДЛЯ СТУДЕНТОВ-ГЕОЛОГОВ)

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Пособие знакомит читателя с основными понятиями о минерале, его кристаллическим строением, физическими свойствами, типами окраски средствами английского языка. Представлены общие сведения о породообразующих, вторичных и акцессорных минералах. Отдельные главы посвящены изучению минералогических музеев и драгоценных камней. Также приводятся ряд тренировочных упражнений для успешной сдачи письменного промежуточного и итогового контроля.

Пособие предназначено для студентов-геологов, обучающихся по специальности 21.05.02 «Прикладная геология».

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Content

Introduction

Since minerals are the basic building blocks of earth materials, this course is designed to give the student a fundamental background in minerals, necessary to understand processes. The student will learn the basic principles behind the arrangement of atoms to form crystal structures, how these atoms are coordinated and bonded, and how this is reflected in the external form, chemical composition, and physical properties of the crystals.

The manual covers the basic concepts, definitions, essential words, phrases, and vocabulary tasks about metals, gemstones, rock-forming minerals, and rocks.

The student will learn how to identify the most common minerals in hand specimens and, by using optical techniques. This book includes theory, laboratory, and self-study assignments in mineralogy. Minerals are the basic building blocks of Earth materials, and a fundamental understanding of their properties is important for many fields within the Earth sciences. This course aims to provide knowledge on the structural, chemical, and physical characteristics of minerals. This course covers the fundamentals of mineralogy, including a discussion of the chemical elements that make up minerals, chemical bonds and crystal structures, crystallography, and crystal growth. In addition, the physical properties of minerals are explained.

This publication also contains materials including the history of the mineralogical museums of the world.

The manual includes laboratory and self-study assignments in mineralogy and petrography, homework tasks, cards, two examining tests, requirements for writing final project.

Resource materials for the laboratory and self-study assignments include mineral and rock samples, lens, 5%-HCl solution, Moh's Hardness Scales.

Chapter 1. Concept of a mineral

A Mineral is a *naturally occurring*, *homogeneous solid* with a definite, but generally not fixed, chemical composition and an *ordered atomic arrangement*. It is usually formed by *inorganic processes*.

"*Naturally occurring*" means that synthetic compounds not known to occur in nature cannot have a mineral name. However, it may occur anywhere, on other planets, deep in the earth, as long as there exists a natural sample to describe.

"*Homogeneous solid*" means that it must be chemically and physically homogeneous down to the basic repeat unit of the atoms. It will then have predictable physical properties (density, compressibility, index of refraction, etc.). This means that rocks such as granite or basalt are not minerals because they contain more than one compound.

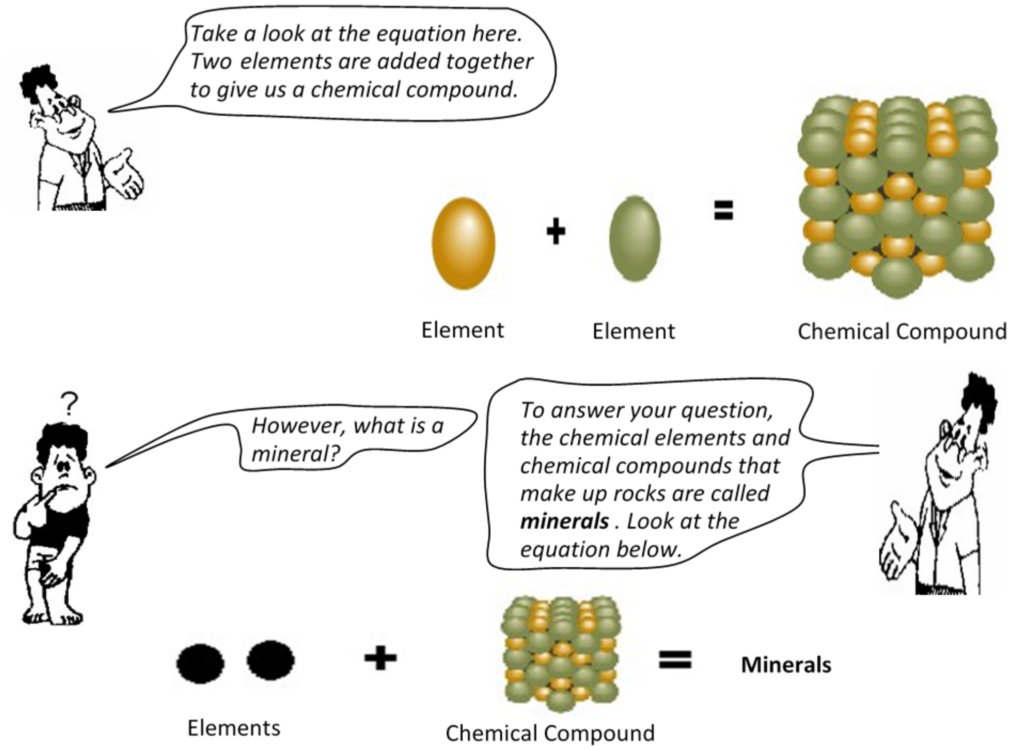
"*Ordered atomic arrangement*" means crystalline. Crystalline materials are three-dimensional periodic arrays of precise geometric arrangement of atoms. Glasses such as obsidian, which are disordered solids, liquids (e.g., water, mercury), and gases (e.g., air) are not minerals.

"*Inorganic processes*" means that crystalline organic compounds formed by organisms are generally not considered minerals. However, carbonate shells are minerals because they are identical to compounds formed by purely inorganic processes.

Mineral is a natural, smooth, inorganic, substance's chemical composition defined (within certain limits). These inorganic substances have an orderly arrangement of atoms of the elements that are composed, and the result is the development of flat surfaces known as faces.

Minerals are made up of chemical elements and compounds. Furthermore, how the elements are arranged will indicate what type of mineral and color it is.

A mineral is a naturally occurring substance characterized by solid, stable at certain temperatures, in addition to having an orderly atomic structure. It is different from a rock by the fact that these can be an aggregate of both minerals such as non-mineral, that they do not have a specific chemical composition. The specialized study of minerals is called mineralogy, which is in turn a branch of geology [1]. Mineral identification is needed in petrological studies, structural geology, mineral exploration, etc.



There are about 4,900 minerals known on planet Earth, and of those, about 4,660 have been approved by the international mineralogical Association, which brings together several agencies around the world to promote the study of minerals and regulate the naming of all of them. Minerals are described according to a series of specific hardness, color, or specific gravity physical characteristics or properties. All rocks are made of minerals. A rock's appearance and properties depend on the minerals that make up the rock [2, 3]. Most rocks are a mixture of a few minerals. For example, the igneous rock called granite contains minerals quartz, feldspar, and mica.

Mineral Facts

- Minerals are not rocks;
- Silicon and oxygen are the most abundant elements in the crust and minerals;
- Oxygen is the most abundant element in minerals.

Exercise 1. ***Choose and underline the correct words.***

- A mineral is a homogeneous/heterogeneous substance
- A mineral is of definite physical/chemical composition
- A mineral is a body produced by the process of inorganic/organic nature

- Minerals formed in the laboratory are called native/artificial minerals
- Mineral substances produced through biogenic agents are includ-ed/not included among minerals

Exercise 2. ***Answer the following questions.***

1. What is a mineral?
2. What are chemical elements?

Exercise 3. ***When elements combine, what is formed?***

A. Solution
B. Mixture
C. Minerals
D. Compound

Exercise 4. ***When elements and compounds are combined, what is formed?***

A. Gold
B. Mixture
C. Solution
D. Minerals

Exercise 5. ***Minerals that make up the rock, give the rocks their _____ and _____.***

A. name, origin
B. origin, time
C. name, identity
D. appearance, property

Exercise 6. ***A rock that contains the minerals quartz, feldspar, and mica is called:***

A. slate
B. gabbro
C. marble
D. granite

Chapter 1.1. Crystal habit (Unit 1)

Crystals reflect the way of the ordered regular arrangement of elementary particles (atoms, ions, molecules) of the substance of which they are composed, which determines their correct geometric external shape.

The following are different types of minerals *crystal habits*:

1. *Acicular*: Needle-like or slender (rutile, etc.).
2. *Bladed*: Blade-like, slender and flattened. More elongated than platy and thinner than tabular (actinolite, kyanite, etc.).
3. *Columnar*: long, slender prisms often with parallel growth (selenite).
4. *Equant* and *stout*: Length, width, and breadth roughly equal. Any three perpendicular axes through the crystal are more or less equal (fluorite, olivine, garnet).
5. *Fibrous*: Extremely slender prisms. Fibrous crystals thinner than acicular in either individual crystals or a tight compact almost cloth-like mass (tremolite, i.e. asbestos).
6. *Platy*: Flattened and thin crystals (like plates) but wider than bladed and thinner than tabular (mica).
7. *Tabular*: Book-like (tablets) that are thicker than platy but not as elongated as bladed (molybdenite, barite).
8. *Prismatic*: Pencil-like, elongated crystals that are thicker than needles (acicular) (tourmaline, etc.).
9. *Blocky*: Rectangular and box-like, but not necessarily with flat sides. More elongated than equant but less elongated than prismatic and thicker than tabular (feldspars).
10. *Stubby*: Slightly more elongated than equant but not as elongated as prismatic and possibly more rounded than blocky (topaz).
11. *Cubic*: Cube shape (pyrite, galena, halite, fluorite).
12. *Sceptered*: Crystals occur when a crystal stops growing and then for some reason continues growth on the upper portion of the crystal but not the lower portion. The result of prismatic crystals is a shape that appears like a jeweled royal scepter of kings and queens. (Smoky quartz, a variety of quartz) [1–4].

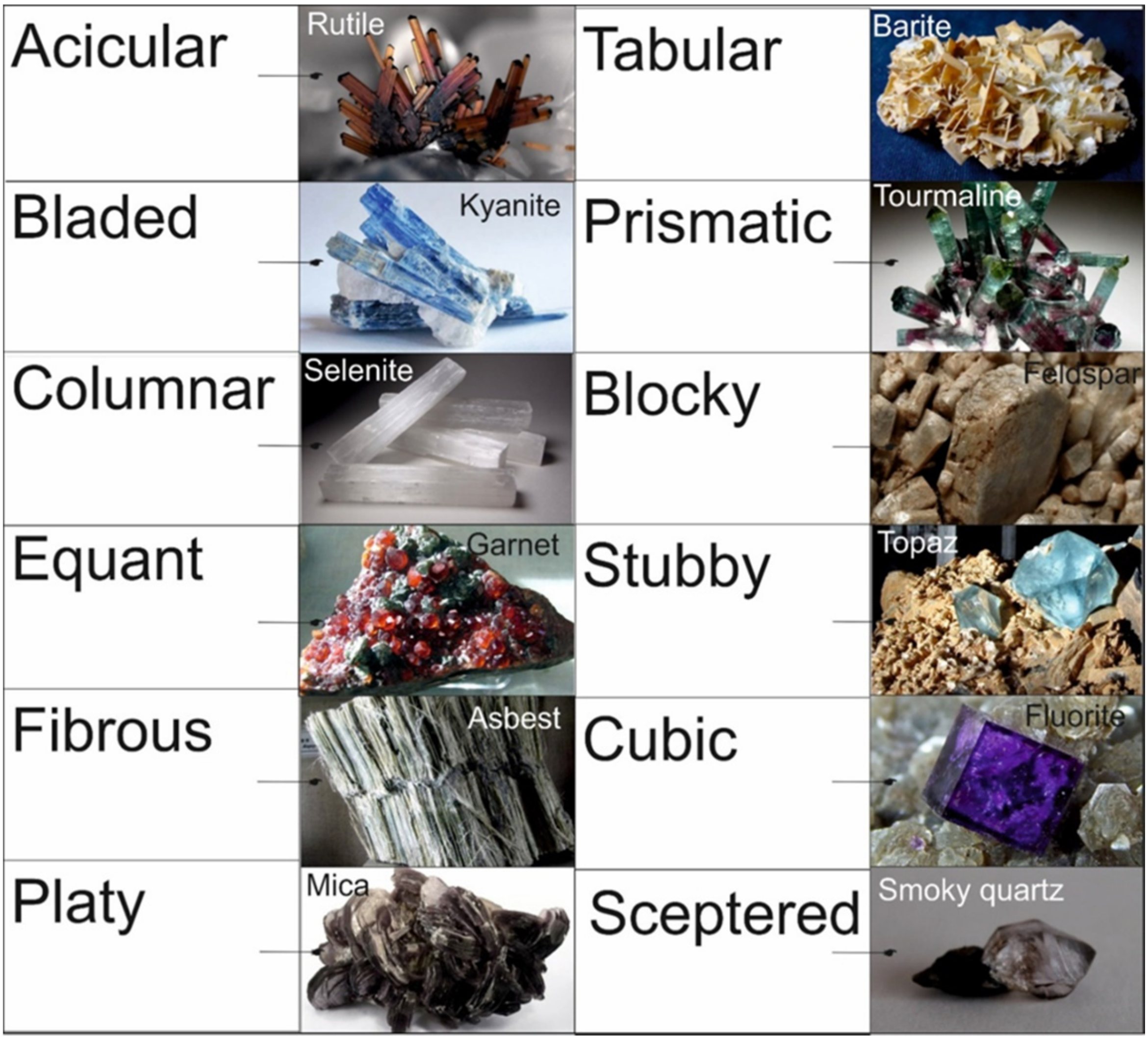


Fig. 1.1. Varieties of crystal habit

Exercise 6. ***Match the English terms in column "A" with their Russian equivalents in column "B".***

"A"	"B"
Stubby	A. Ромбоэдрический
Platy	B. Короткостолбчатый
Columnar	C. Таблитчатый
Acicular	D. Изометричный
Bladed	E. Уплощенный (пластинчатый)
Equant	F. Пластинчатый
Tabular	G. Игольчатый
Octahedral	H. Призматический
Rhombohedral	I. Додекаэдрический
Dodecahedral	J. Октаэдрический

Exercise 7. ***Name the mineral by the picture.***

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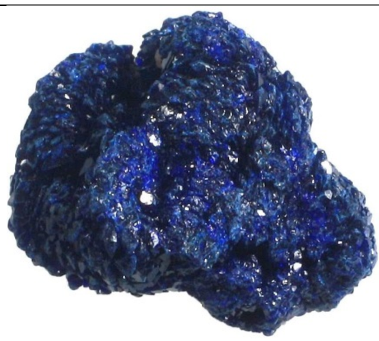
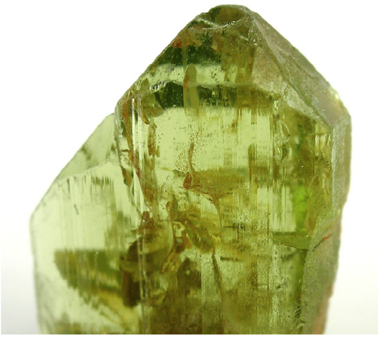
2		7	
3		8	
4		9	
5		10	

LEARNING OUTCOMES STATEMENTS

Students will be able to recall vocabulary.
Students will be able to explain terms and definitions.

Laboratory tasks.
Task description:
1. Study the main types of crystal habit.
2. Determine different crystal habit types of minerals in practice. These terms are used to describe individual crystals.

Vocabulary

spatial	пространственный	*platy*	пластинчатый
arrangement	расположение	*flattened*	уплощенный
acicular	игольчатый	*tabular*	таблитчатый
slender	тонкий	*flat*	ровный, плоский, прямой
bladed	пластинчатый		
hemispherical	полусферический	side	сторона
columnar	столбчатый	*stubby*	короткостолбчатый
fibrous	волокнистые	rectangular	прямоугольный

Chapter 1.2. Aggregate morphology (Unit 2)

There are following different types of minerals aggregate morphology:

1. *Botryoidal* or *globular*: Grape-like, hemispherical masses (hematite, malachite, etc.).
2. *Dendritic, Arborescent*: Tree-like, branching in one or more directions from central pointe. A branching growth of crystals usually on a surface or as an inclusion that forms plant-like patterns similar to "Jack Frost" on windows (black oxide of manganese, native gold, copper, silver).
3. *Druse*: Outwardly oriented crystals usually lining the inside of a geode, but is also applied to other outwardly oriented crystal coatings (variety of quartz).
4. *Geode*: A hollow stone embedded in a layer of rock mineralogically different from the mineral composing the outer shell of the geode (amethyst, quartz).
5. *Granular*: Crystals of small size, less than 1 cm across, that exhibit no discernable crystal form. Usually applied to many tiny crystals separated and disseminated throughout a host rock (spinel, garnet, quartz).
6. *Massive*: Indiscernible masses of crystals usually too fine to see (chalcopyrite, bornite, magnetite).
7. *Oolitic*: Rounded pebble to sand-sized nodules in a compact mass formed in sedimentary environs (goethite, hematite).
8. *Radiating*: Distinct crystals arranged in an orientation outward from a common point (tourmaline, celestite).
9. *Rosette*: Petal-like crystals arranged in a flattened radial habit around a central point (barite, gypsum).
10. *Stalactitic*: A concretionary growth sometimes around a hollow tube, producing long, slowly tapering, rounded masses. Cross-sections usually have circular rings like the rings of a tree. Usually formed in caves or other voids in rocks from the precipitation of a mineral from an evaporating fluid (calcite, aragonite) [2, 4].

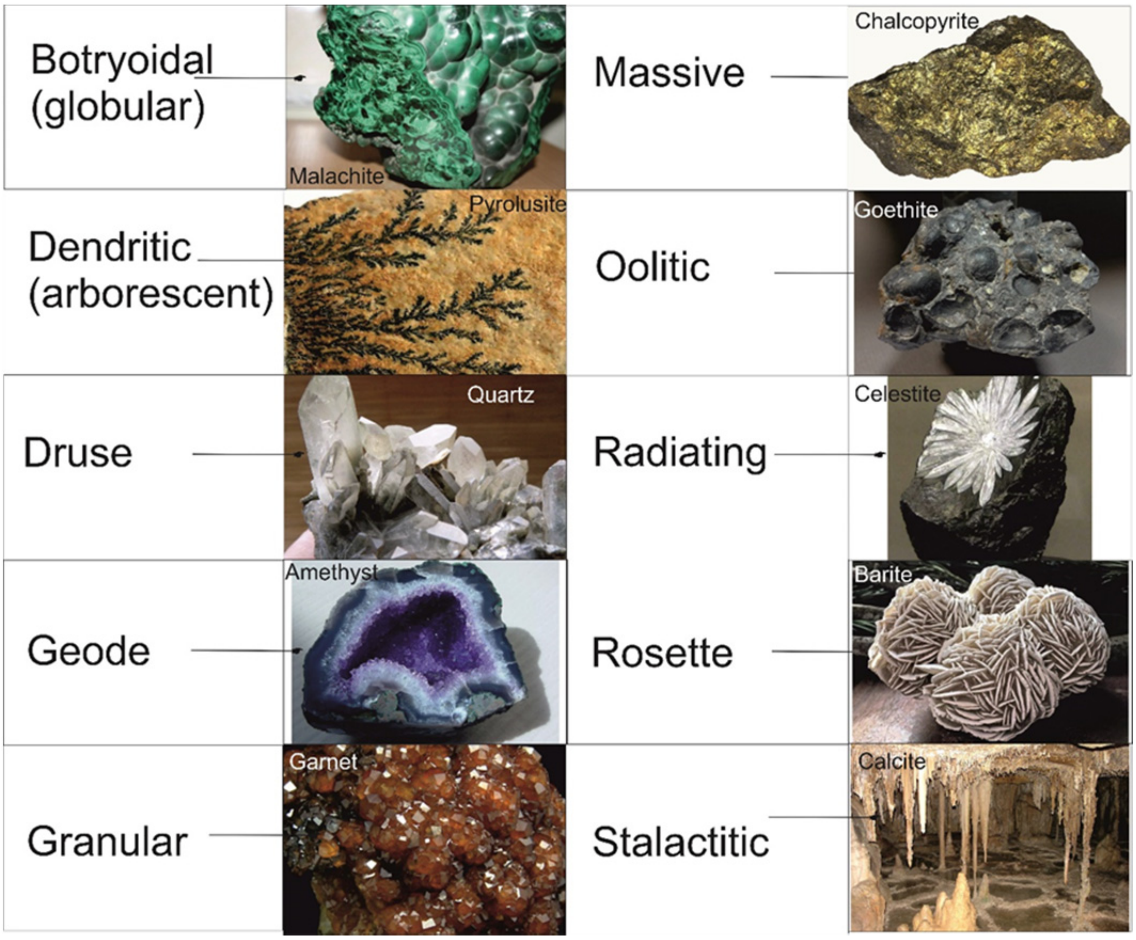


Fig. 1.2. Different types of aggregate morphology

Exercise 7. ***Match the English terms in column «A» with their Russian definition equivalents in column «B».***

«A»	«B»
Granular	группа кристаллов, имеющая на общую подложку
Globular	хемогенные отложения в карстовых пещерах
Arborescent	скопления неправильно сросшихся зерен
Druse	хемогенные образования с блестящей поверхностью
Stalactitic	расщепленнные скелетные кристаллы

LEARNING OUTCOMES STATEMENTS

Students will be able to recall vocabulary.
Students will be able to explain terms and definitions.

Laboratory tasks.
Task description:
1. Study the main types of aggregate morphology.

2. Determine different types of minerals aggregate morphology in practice. These terms are used to describe accrete crystals.

Vocabulary

botryoidal	роздеобразный, натечный	indiscernible	неразличимый
arborescent	древовидный	pebble	галька
outwardly	внешне (наглядно, наружно)	environs	среда
hollow	полый	petal	лепесток
embedded	расположенный внутри, вкрапленный	tapering	конусообразный, сужающийся
outer shell	внешняя оконтовка (корочка, оболочка)	*evaporating fluid*	испаряющаяся жидкость
granular	зернистый	cave	пещера
discernable	различимый	precipitation	осаждение
tiny	крохотный, маленький	ring	кольцо

Test № 1 (Homework 1. **Unit 1, 2**)

1. Shape of the crystalline form reflects the internal_____________?
2. The general shape of a crystal (cubic, octahedral, prismatic…) is called its crystal__________?
3. Describe the following crystal habit in English and translate these terms in Russian:
   - Acicular –
   - Equant –
   - Fibrous –
   - Tabular –
4. Give examples (minerals) of the stubby and bladed crystal habit.
5. What kinds of minerals aggregate morphology do you know?

Chapter 2. Physical properties of minerals (Unit 3, 4)

Topic: Physical properties of minerals

The physical properties of minerals are the direct result of their chemical and structural characteristics. Because they are readily determined (i.e., by examination or simple tests), they are important to the rapid identification of minerals. Other methods for studying minerals involve more elaborate tests (e.g., optical, X-ray, or SEM), and although they provide important information, can be time-consuming.

1. Optical properties of minerals:
color, streak, transparency, and *luster*.

Color: Generally speaking, color results from the interaction between light and minerals. The color of a mineral is a result of the interaction of electromagnetic radiation (visible light) with the surface of a mineral (primarily the electrons). Keep in mind that this interaction includes: transmission, refraction, reflection, scattering, or absorption. Visible light wave length = 350–750 nm. Not always a diagnostic property. Most minerals with a metallic luster have diagnostic colors that vary little, whereas many minerals whose luster is nonmetallic have variable colors.

Origin of color:

- Crystal Field Transitions: Occur when the mineral contains a transition element (chromophore) in which the orbital energies have been affected by crystallization (known as the crystal field effector crystal field splitting) (the green color of emerald, the red colors of ruby, etc.).
- Color centers and radiation damage: Color centers are defects in the crystal structure, where a "hole" results. For example, in the case of fluorite, an F-ion can go missing leaving behind a hole to be occupied by an electron. This electron, not being bound to a central nucleus, can have several energy "states". The movement of this electron between a ground state and an excited one releases energy which may result in color. "Holes" or crystal defects can be produced by irradiating a mineral (e.g. smoky quartz and amethyst??).
- Impurities/mechanical mixtures: a mechanical mixture of two minerals with different colors. For example, quartz its red color to disseminated hematite in the very fine-grained quartz.

Optical radiation:

- *Luminescence*: Ambient emission of light by a mineral due to the presence of activators (impurities; almost always transition elements).
- *Fluorescence*: Luminescence due to exposure to UV radiation, X-rays, or cathode rays.
- *Phosphorescence*: A type of fluorescence that persists even after the "energy" or radiation source is removed.

Streak is the color of a mineral in its powdered form. Streak is obtained by rubbing a mineral across a streak plate. The streak's color never varies between different colors of a mineral. Can also see the differences between minerals with metallic lusters and minerals with nonmetallic (no streak is produced).

Luster is the appearance of light reflected from the surface mineral. It describes how the mineral surface appears in "scattered" light. In reality, scattered light is a combination of reflected and refracted light rays. Types: Any mineral will have either a *metallic* or a *non-metallic* luster. *Metallic* luster looks like a piece of broken or polished metal. If the mineral reflects light very well, the luster is considered metallic (e.g. Galena, PbS). *Submetallic* has a high luster that is transitional between that of broken metal and that of broken glass. Non-metallic lusters result when some of the light rays pass through (or are absorbed by) the mineral.

Several kinds of nonmetallic luster are:

- *Adamantine* has extreme brilliance like a faceted diamond (e.g. diamond, sphalerite, wolframite, garnet).
- *Vitreous (glassy)* has a high luster like the surface of the glass (e.g. quartz).
- *Resinous* has a lustrous dark, yellow or brown appearance like resin or tree pitch (sulfur, amber).
- *Greasy or Waxy* has a faint gloss like a coating of oil (nepheline, sulfur).
- *Dull or Earthy* lacks glossiness and appears like soil or clay: (e.g. kaolinite).
- *Silky* has the sheen of an aggregate of fibrous grains that have a parallel arrangement (asbestos).

A single mineral may have different harnesses in different orientations (e.g. disthene (kyanite)). This is hardness is a reflection of the strength of the different bonds in a mineral. The weakest bond is the one that controls the "overall" hardness of the mineral if such a property exists.

Specific gravity: This property is defined as the density of a mineral relative to the density of water at 4 °C. In practice, it is measured by weighing the mineral in air, then dividing that value by the difference between the weight of the mineral in air and that in water. The specific gravity or density of the mineral depends on its chemical composition, and internal structure (how closely packed it is). Minerals can be classified according to their specific gravities into 4 groups: *very heavy*: > 5, e.g. galena, *heavy*: 3.2–5, e.g. chromite, *intermediate*: 2.4–3.2, e.g. quartz, *light*: < 2.4, e.g. halite.

The specific gravity (SG or G) of a crystalline substance is a fundamental property and thus characteristic of the substance. As such, it is a valuable diagnostic property. Specific gravity is a dimensionless number that can be defined as the ratio of the density of a material to the density of water (at 40 C). The specific gravity of a substance is primarily dependent on its chemical composition and crystal structure – i.e., by the kind of atoms/ions present and the way they are packed and bonded. In general, the heavier the atoms/ions, the closer the packing, and the stronger the bonding, the higher the specific gravity becomes. For example, diamond, which has a stronger bonding and a denser packing structure compared to graphite, – has an SG of 3.5. Graphite, though having a similar chemical composition to diamond, but with a weaker bonding and loose packing structure, has an SG of 2.3. When a substance of variable composition crystallizes in a specific structure, the variation in specific gravity will depend almost completely on the mass of the individual atoms. For example, the specific gravity of olivine $(Mg,Fe)_2SiO_4$ increases with increasing replacement of the lighter magnesium atoms by the heavier iron atoms from 3.22 for Mg_2SiO_4 (forsterite) to 4.41 for pure Fe_2SiO_4 (fayalite). Similarly, in a group of isostructural compounds (i.e., minerals with the same structure but different chemical composition), the specific gravity will show a direct relationship to the mass of the atoms present, as exemplified by the group of aragonite minerals presented in Table 2.1.

In other words, the specific gravity of a substance can be said to correlate to its chemistry and its crystallography and, thus, reflects, the nature of the atoms in the structure and how they are packed. Specific gravity is also known to vary somewhat with varying temperature and pressure because changes in these conditions generally cause mineral expansion or contraction. Hence the SG of a pure substance with fixed chemical composition and crystallizing with a specific structure should be constant at any stated temperature and pressure. In general, conditions of high pressure favor the formation of polymorphic forms with high densities, whereas conditions of high temperature favor looser packing and the formation of polymorphic forms with relatively low densities.

2. Mechanical properties of minerals:
hardness, cleavage, fracture

Hardness is a measure of the resistance of a mineral to abrasion. It is a measure of how easily a mineral can be scratched. The numerical value of hardness can be found by using the Moh's Hardness Scale (Fig. 2.1).

Moh's Hardness Scale – a scale ranking the minerals from softest to hardest; used in testing the hardness of minerals.

Cleavage is the way a mineral breaks. Many minerals break along flat planes, or cleavages – some in only one direction (mica), others in two directions (pyroxene and amphibole families), and some in three directions (feldspars) or more. Some minerals, like apatite, have no cleavage. Cleavage is an important property that results from a mineral's molecular structure, and cleavage is present even when the mineral doesn't form good crystals. Cleavage can also be described as perfect (mica), excellent (calcite), good (pyroxene family), or poor (olivine). Minerals that do not exhibit cleavage are said to *fracture*.

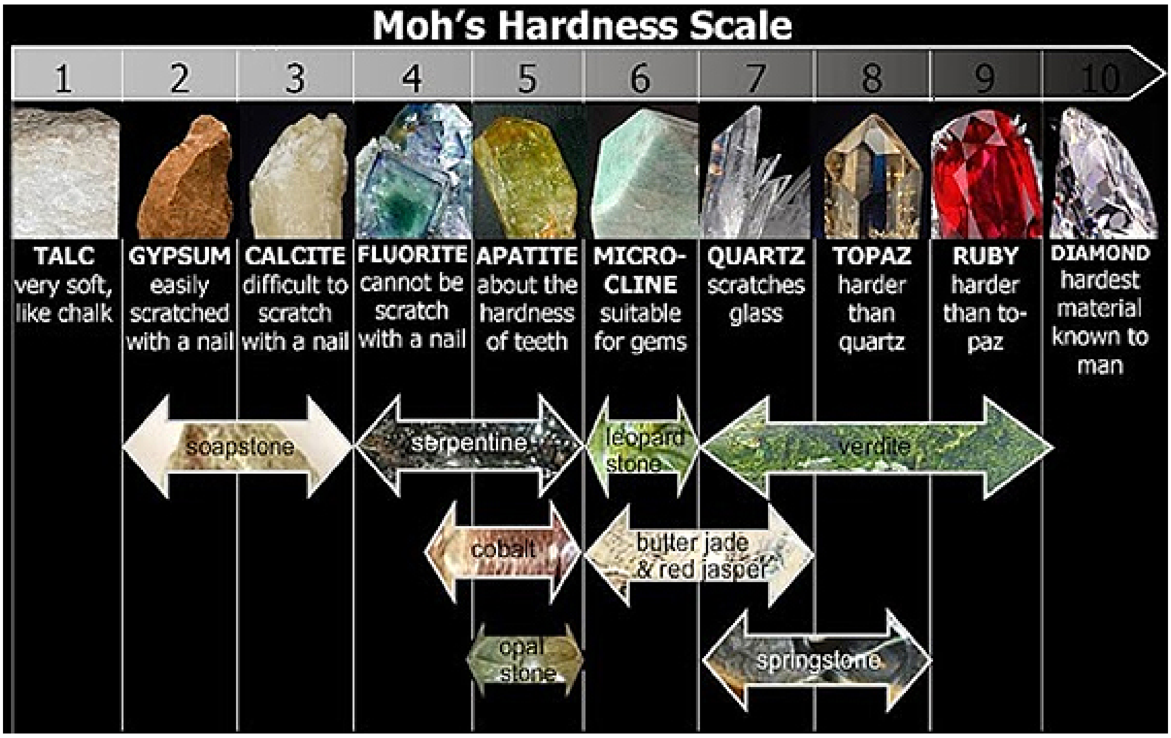


Fig. 2.1. Moh's Hardness Scale

Fracture is breakage that is not flat. Metallic minerals may have a hackly (jagged) fracture. A mineral may have good cleavage in one or two directions but a fracture in another direction.

Fracture describes the appearance of all surfaces of breakage of a mineral other than planes of cleavage or parting.

Types:

- *conchoidal*: characterized by smooth curved surfaces (quartz);
- *splintery*: when the mineral breaks into small, thin, slightly elongated pieces (actinolite);
- *hackly*: a very irregular, sharp-edged surface;
- *uneven or earthy*: an uneven surface with many small irregularities.

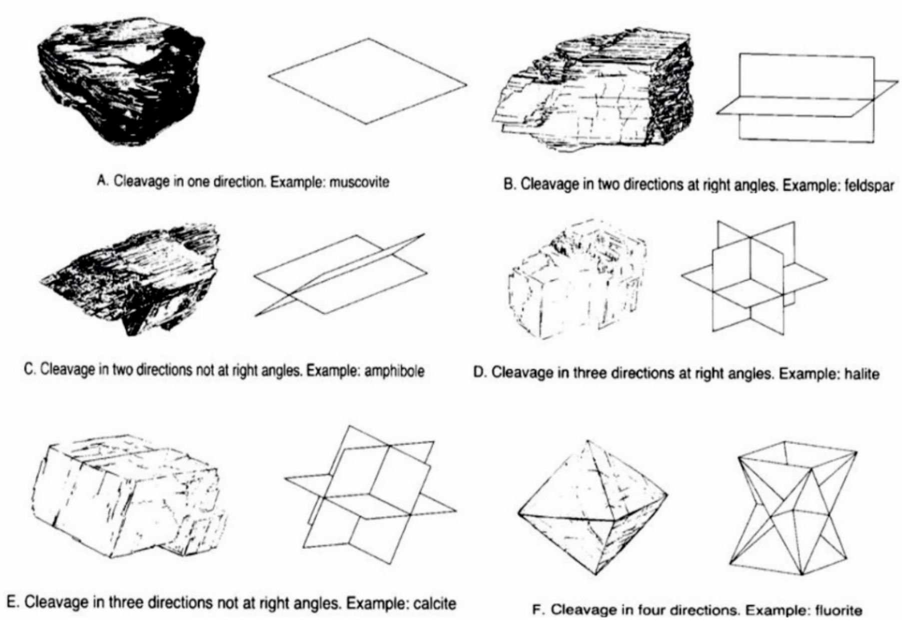


Fig. 2.2. Types of cleavage

Parting is used to describe the breakage planes in minerals that occur along structurally weak planes, but that are not cleavages, which are shown by all specimens of a mineral.

Other physical properties:

Tenacity: A function of the average or overall strengths or types of all bonds in the mineral. Tenacity – resistance to breaking, crushing, bending, and tearing.

Terms used to describe tenacity:

- *Brittle* – breaks or powders easily;
- *Ductile* – bends easily and does not return to its original shape;
- *Sectile* – can be cut into thin shavings with a knife;
- *Malleabl*e – can be hammered into thin sheets;
- *Flexible* – bends somewhat and does not return to its original shape;
- *Elastic* – bends but does return to its original shape.

***Odor*:** Some minerals with weak van der Waals bonds have a characteristic smell when rubbed. For example, realgar (AsS) has the smell of garlic.

Magnetic properties:

A mineral's magnetism can be another identifying characteristic in some instances. Magnetite, for example, has a strong pull that will attract even weak magnets. But other minerals have only a weak attraction, notably chromite (a black oxide) and pyrrhotite (a bronze sulfide). You'll want to use a strong magnet. Another way to test magnetism is to see if your specimen attracts a compass needle.

Exercise 1. ***Choose and explain why true or false the following statements.***

1. Some minerals tarnish or oxidize but this DOES NOT affect their color.
2. Most minerals occur in more than one color.
3. All minerals have the same streak color.

Exercise 2. ***Answer the following questions.***

1. What is a mineral’s hardness?
2. What tools are used to test a mineral’s hardness?
3. This property is the least useful in identifying a mineral.
4. This property describes a mineral’s resistance to scratching.
5. This property describes the way a mineral reflects light.
6. The property of a mineral that describes the way it breaks into flat surfaces.
7. What is a streak test?
8. This property is measured on a scale of 1 to 10.
9. When measuring hardness on a scale of 1 to 10, _____ is the softest.
10. Shiny, dull, earthy, metallic, glassy, and waxy all describe this property of mineral?
11. These two properties of a mineral must be tested to be observed. One uses a nail and another uses a special plate.
12. To test this property of a mineral, you need to shine a light on the rock.

Exercise 3. ***Translate some sentences from Russian into English.***

1. Минералы различают с помощью различных физических и химических свойств.

2. Твердость определяется путем царапания одного минерала другим или каким-либо веществом.
3. Упругость – это сопротивление минерала к разрушению, дроблению или изгибу.
4. Цвет минерала является результатом взаимодействия видимого света и минералов.
5. Акцессорные минералы включают топаз, циркон, корунд, флюорит, гранат, магнетит, ильменит и турмалин.

Exercise 4. ***Match the questions from 1 to 11 with the right answers from a to i. You can use the same answer several times.***

1. What state of matter are all minerals?
2. What is a mineral's hardness?
3. What tools are used to test a mineral's hardness?
4. This property is the least useful in identifying a mineral
5. This property describes the way a mineral reflects light
6. The property of a mineral that describes the way it breaks into flat surfaces
7. What is a streak test?
8. This property is measured on a scale of 1 to 10.
9. Shiny, dull, earthy, metallic, glassy, and waxy all describe this property of a mineral.
10. These two properties of a mineral must be tested to be observed. One uses a nail and another uses a special plate.
11. To test this property of a mineral, you need to shine a light on the rock.

a – Luster
b – A test that shows a mineral's true color
c – Solid
d – Hardness and Streak
e – It's the mineral's resistance to scratching.
f – Hardness can be tested using your finger, fingernail, glass, Mohs scale
g – Color
h – Cleavage
i – Hardness

Vocabulary

resistance	сопротивление	persists	сохранятся
abrasion	истирание, внешнее механическое воздействие	*streak plate (unglazed porcelain)*	(неглазированный бисквит)
exhibit	проявлять, показывать	weakest	слабая
powder	превращать в порошок	*tenacity*	прочность
rubbing	натирание	brittle	хрупкий
earthy	земляной, землистый	ductile	пластичный
refracted	преломленный	*sectile*	мягкий
resinous	смолистый, смоляной	*malleable*	поддатливый
amber	янтарь	*flexible*	гибкий
greasy or waxy	жирный	*elastic*	эластичный, упругий
faint	тусклый	*conchoidal*	раковистый
gloss	внешний блеск	*splintery*	занозистый
dull	матовый	*hackly*	шероховатый
ambient emission	излучение от внешнего воздействия	uneven or earthy	неправильный, землистый
lacks	не хватает	bond	связь
sheen	сияние	*botryoidal*	гроздеобразный

Task (Pre-reading)

Write sentences and try to understand what is about this text?

- External symmetry of form, crystallization produces also regularity of internal structure
- Regularity of fracture, or tendency to break along certain planes
- It may be obtained parallel to all like planes
- It may be obtained parallel to one plane of a kind

Text

Besides external symmetry of form, crystallization produces also regularity of internal structure, and often of fracture. This regularity of fracture, or tendency to break or cleave along certain planes, is called *cleavage*. The surface afforded by cleavage is often smooth and brilliant.

The directions of cleavage are those of least cohesive force in a crystal; it is not to be understood that the cleavage lamella are made to appear by fracture. In regard to cleavage, two principles may be here stated:

(a) In any species, the direction in which cleavage are those of least cohesive force in a crystal; it is not to be understood that the cleavage lamella are in any sense present before they are made to appear by fracture.

(b) In any species, the direction in which cleavage takes place is always parallel to some plane which either actually occurs in the crystals or may exist there in accordance with the general crystallographic laws.

Cleavage is uniform as to ease parallel to all like planes; that is, if it may be obtained parallel to all like planes, that is, if it may be obtained parallel to one plane of a kind, it may be obtained with equal facility parallel to on plane of a kind, and will afford planes of like luster. This is in accordance with the symmetry of crystallization. It will be evident from this that the angles between planes of like cleavage will be constant: thus, a mass of calcite under the blow of a hammer will separate into countless rhombohedrons.

Vocabulary

cohesive	связующий	hammer	молоток
lamella	тонкая пластинка	accordance	соответствие
countless	бесчисленный, множественный	afford	позволять, придавать, быть в состоянии
uniform	придавать однообразие	hammer	молоток

Test № 2 (Homework 2. **Unit 3**)

1. Define the word "mineral"
2. Dennis cannot scratch a mineral sample with his fingernail, but he observes that he can scratch the mineral sample with a piece of metal. What physical property of the mineral sample is Dennis investigating?
3. What is the second most abundant element in the earth's crust?
4. Cleavage is________
5. What are the mechanical properties that can be used to identify a mineral?

Test № 3 (Homework 3. **Unit 4**)

1. How can you determine the actual color of a mineral, especially if it is tarnished or oxidized?
2. Dull, silky, waxy, and pearly are descriptive terms that best describe what property of minerals?
3. What factors control the density (specific gravity) of a mineral?

4. Color is one of the best ways to identify a mineral. True or False and Why?
5. Sapphires and rubies are both forms of the mineral corundum, but they have different colors. Why?

Test № 4 (Homework 4. **Unit 4**)

1. What state of matter are all minerals?
2. What tools are used to test a mineral's hardness?
3. These two properties of a mineral must be tested to be observed. One uses a nail and another uses a special plate.
4. What other special physical properties do you know?
5. What group of minerals have an effervescent reaction?

For their first activity, students will work in teams and use their observation skills to examine and describe 5 different minerals, just like in the group brainstorm.

Templet of a written account of mineral

The mineral is ___________ (color).

Crystal habit is ___________ (prismatic (призматический); columnar (столбчатый); tabular (таблитчатый); equnt (stout) (изометричный), cubic (кубический); bladed (уплощенный); platy (пластинчатый); stubby (короткостолбчатый), blocky (блочный).

Crystal structure is (cubic, tetragonal, rhombic, hexagonal, monoclinic, triclinic, trigonal).

Morphology of aggregates is __________ grainy/granular/discrete (зернистые); compact/solid/massive/continuous (сплошные); lamellar/ laminal/fissil/foliated (листоватые); botryoidal/globular(натечные); scaly (чешуйчатые); dendritic/arborescent (древовидные, дендриты); rosette (роза); radiating (радиально-лучистые).

Cleavage in one or more direction (yes or now), (eminent/perfect/medium/imperfect/most imperfect cleavage (cohesion) – весьма совершенная, совершенная, средняя, весьма несовершенная спайность.

Hardness is_______.

Specific gravity is about _________(light/medium/heavy, weighty – легкие (< 3 g/cm^3), средние (3–5 g/cm^3), тяжелые (> 5g/cm^3).

Fracture or **parting** is____conchoidal/splintery/flat/uneven (irregular)/hackly (скорлуповатый (раковистый)/расщепленный/плоский, неровный, зазубренный излом).

Streak is _________.

Luster is _________ metallic (металлический); submetallic (полуметаллический); adamantine (алмазный); glassy (vitreous) (стеклянный); resinous (смолистый, смоляной); waxy (Greasy) (восковый, жирный); pearly (перламутровый); dull (earthy) (матовый, землистый).

Diagnostic (unique) properties are_________.

Paragenesis (coexisting) with ________.

Genesis/origin is (magmatic, metamorphic, hydrothermal, sedimentary, metasomatic).

During this lab activity, students will use their knowledge of the physical properties of minerals to investigate and describe the minerals:

- determine the relative hardness of a mineral;
- identify the color of a mineral is a physical property;
- identify the luster of a mineral as metallic or nonmetallic;
- identify the streak color of a mineral.

Before students begin lab activity, they should be able to:

- Define the word "mineral."
- Explain the physical properties used to identify minerals such as hardness, color, luster, cleavage, and streak color.
- Explain that hardness is how easily a mineral can be scratched.
- Explain that luster describes how the surface of the mineral reflects light.
- Define streak color as the color of a mineral's powder.
- Define cleavage as how a mineral breaks along flat planes.
- Explain that the color of the mineral is the color they see.

Main definitions

1. *Mineral* – is a naturally occurring, inorganic solid that has a crystal structure and definite chemical composition.
2. *Inorganic* – not formed from living things or the remains of living things.
3. *Crystal* – a solid in which the atoms are arranged in a pattern that repeats again and again.
4. *Streak* – the color of a minerals' powder.
5. *Luster* – the way a mineral reflects light from its surface.
6. *Mohs Hardness Scale* – a scale ranking the minerals from softest to hardest; used in testing the hardness of minerals.
7. *Cleavage* – a minerals ability to split easily along flat surfaces.
8. *Fracture* – the way a mineral looks when it breaks apart irregularly.

9. *Specific Gravity*: Ratio of the mass of a mineral to the mass of an equal volume of water.
10. *Crystallization* – the process by which atoms are arranged to form a material with a crystal structure.
11. *Color*: Is used to identify certain minerals (sulfur: bright yellow) but does not always help with other minerals.
12. *Other Properties*: Magnetism: magnetite. Odor: Sulfur. Taste: Salt. Bending light: clear sample of calcite.

Card 1

crystal habit	облик кристалла	rosette	роза
prismatic	призматический	glassy (vitreous)	стеклянный
columnar	столбчатый	cleavage/cohesion	спайность
tabular	таблитчатый	hardness	твердость
equant (stout)	изометричный	fracture	излом
bladed	уплощенный	streak	черта
platy	пластинчатый	luster	блеск
stubby	коротколстолбчатый	metallic	металлический
blocky	блочный	adamantine	алмазный
crystal/crystalline structure	кристаллическая структура	submetallic	полуметалличе-ский
grainy/granular/ discrete	зернистые	radiating	радиально-лучистые
botryoidal/ globular	натечные	resinous	смолистый, смоляной
lamellar/laminal/ fissil/foliated	листоватые	dull (earthy)	матовый, землистый
cubic	кубический	pearly	перламутровый
scaly	чешуйчатые	waxy (greasy)	восковый, жирный
compact/ solid/massive/ continuous	сплошные	conchoidal/ splintery/ flat/uneven (irregular)/ hackly	скорлуповатый (раковистый)/ расщепленный/ плоский, неровный, зазубренный
dendritic/ arborescent	древовидные, дендриты		

Chapter 3. Common rock-forming minerals (Unit 5)

Scientists have identified over 4,000 different minerals. A small group of these minerals makes up almost 90 % of the rocks of Earth's crust. These minerals are known as the common rock-forming minerals.

To be considered a common rock-forming mineral, a mineral must: a) be one of the most abundant minerals in Earth's crust; b) be one of the original minerals present at the time of a crustal rock's formation; and, c) be an important mineral in determining a rock's classification.

Minerals that easily meet these criteria include: olivine, pyroxenes, amphiboles, micas, plagioclase, feldspars, alkali feldspars, quartz, clays, calcite, and dolomite (Fig. 3.1).

1. Minerals of the Oceanic Crust

As an example of the influence of just a few minerals, let's consider the rocks of the oceanic crust. The oceanic crust is mainly composed of basalt and gabbro. These two rock types are made up mainly of plagioclase feldspar and pyroxenes, with smaller amounts of olivine, micas, and amphiboles. This small group of minerals makes up most of the rocks of the oceanic crust.

2. Minerals of the Continental Crust

As a second example, let's consider the rocks of the continental crust. The continental crust is made up mainly of rocks with a granitic to andesitic composition. These rocks are composed mainly of alkali feldspar, quartz, and plagioclase feldspar, with smaller amounts of amphiboles and micas. This small number of minerals makes up most of the continental crust.

3. Minerals in Sedimentary cover

Both the oceanic and continental crusts are partly covered with a thin layer of sedimentary rocks and sediments. These consist mainly of clastic rocks such as sandstone, siltstone, and shale, along with carbonate rocks such as dolomite stone and limestone. These clastic rocks are composed of mainly quartz, clay minerals, and a small number of micas and feldspar minerals. The carbonate rocks consist primarily of calcite and dolomite. A small number of materials, composed of a small number of minerals, make up most of the sediment and sedimentary rocks that cover the continents and ocean basins.

So, the minerals that form rock are feldspar, quartz, amphiboles, micas, olivine, calcite, pyroxenes. Minerals that occur in tiny amounts within a rock are called "accessory minerals". Although accessory minerals are only present in tiny quantities, they can provide useful insight into a rock's geological history and are often used to determine a rock's age. Common minerals for accessories are zircon, monazite, apatite, titanite, tourmaline, pyrite, and other opaque minerals.

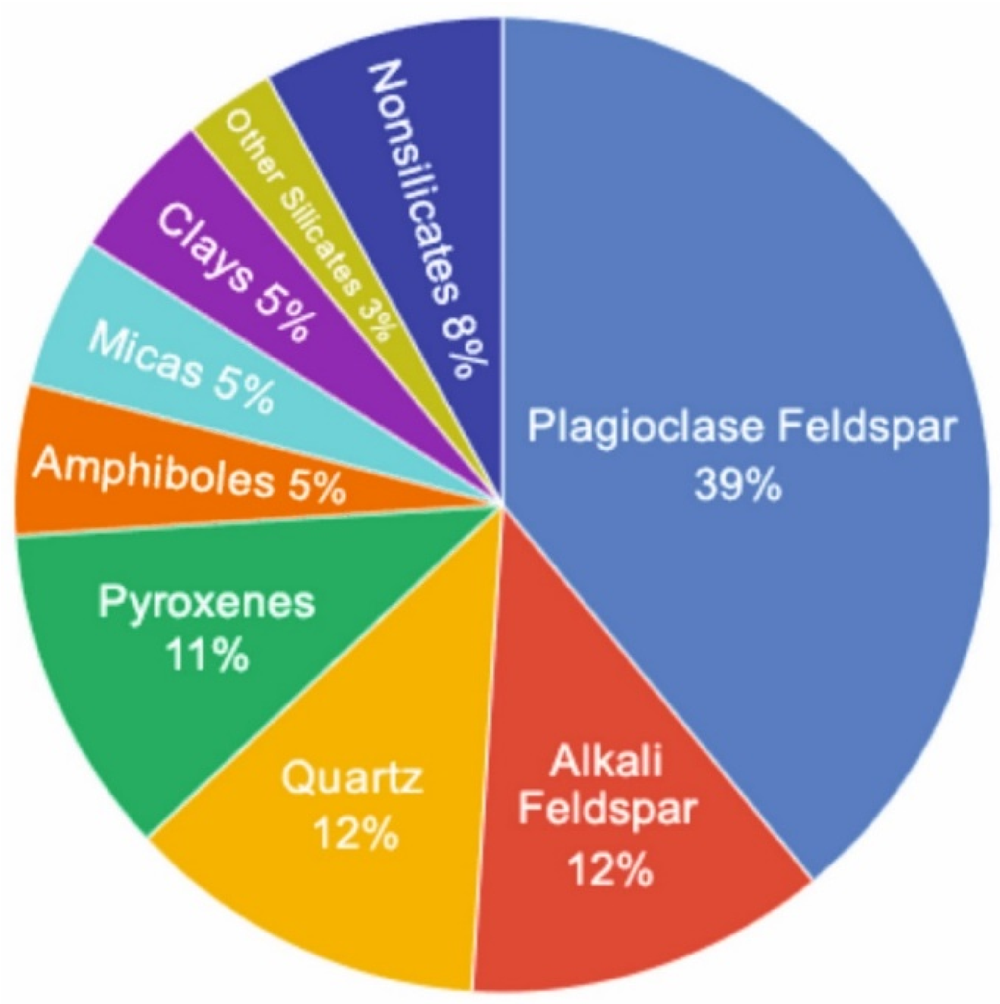


Fig. 3.1. Most abundant minerals in Earth's Crust

Feldspars ($KAlSi_3O_8$–$NaAlSi_3O_8$–$CaAl_2Si_2O_8$) are a collection of rock-forming tectosilicate minerals that make up by weight about 41 % of the mainland surface of the Earth. In both intrusive and extrusive igneous rocks, feldspars crystallize from magma as veins and are also present in many kinds of metamorphic rock. It is regarded as anorthosite rock made almost completely of calcium plagioclase feldspar. In many kinds of sedimentary rocks, feldspars are also discovered.

Quartz is Earth's second most common mineral, behind feldspar, in the continental crust. There are two forms of quartz, the normal α-quartz, and the β-quartz high-temperature, both chiral. There is an abrupt transformation from α-quartz to β-quartz at 573 °C (846 K). Since the transition is followed by a substantial quantity shift, ceramics or rocks that pass through this temperature limit can readily be induced to fracture.

Amphibole is a significant cluster of inosilicate minerals that form prisms or needle-like crystals, consisting of SiO_4 tetrahedra double chain, connected at the vertices and usually carrying ions of iron and/or magnesium in their constructions. Amphiboles may be green, black, white, yellow, blue, or brown. Amphiboles are presently classified by the International Mineralogical Association as a mineral supergroup, within which there are two categories and several subgroups.

Mica group of sheet silicate (phyllosilicate) minerals involves several near-perfect basal cleavage associated products. They are all monoclinic, with a tendency towards pseudohexagonal crystals, and in chemical composition are comparable. The almost ideal cleavage is clarified by the hexagonal sheet-like structure of its atoms, which is the most prominent feature of mica.

Olivine is characterized by the formula $(Mg^{2+},Fe^{2+})_2SiO_4$. It is therefore a kind of nesosilicate or orthosilicate. The earth's upper mantle's main element, is a prevalent mineral in the subsurface of Earth, but it weathers rapidly on the ground. Olivine contains only small quantities of non-oxygen, silicon, magnesium, and iron components. The extra components frequently found in the greatest levels are manganese and nickel. Olivine provides its name to the set of associated minerals (the olivine group) – including tephroite (Mn_2SiO_4), monticellite ($CaMgSiO_4$), and kirschsteinite ($CaFeSiO_4$).

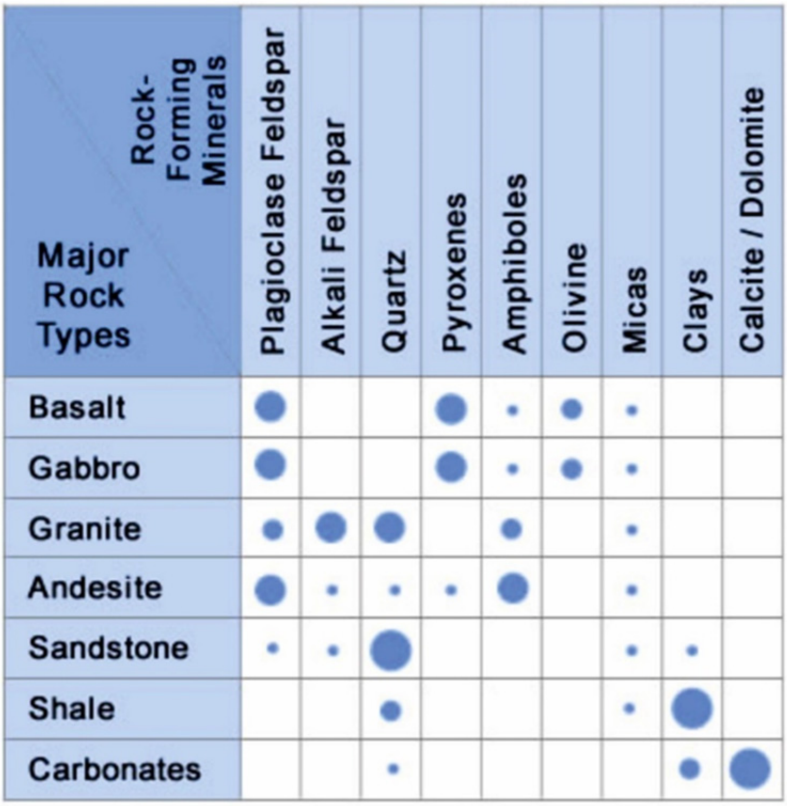
Calcite is a mineral carbonate and the most stable calcium oil polymorph ($CaCO_3$). The mineral hardness scale of Mohs, based on the contrast of scratch hardness, describes value 3 as "calcite".

Other calcium carbonate polymorphs are aragonite and vaterite minerals. Over time scales of days or less, aragonite will change to calcite at temperatures above 300 °C, and vaterite is even less stable.

Pyroxenes (frequently shortened to Px) are a set of significant minerals discovered in many igneous and metamorphic rocks that form rock inosilicates. Pyroxenes have the overall formula $XY(Si,Al)_2O_6$ where X depicts calcium, sodium, iron (II) or potassium and more commonly zinc, manganese, or lithium, and Y includes ions of lower magnitude such as chromium, aluminum, iron (III), magnesium, cobalt, manganese, scandium, titanium, vanadium or even metal (II).

Table 3.1

Relative abundance of common rock-forming minerals in major rock types



Exercise 1. ***Match the rock-forming minerals with their occurrence in the geological environment.***

1. Olivine, Pyroxenes — A. Sedimentary rocks
2. Alkali Feldspar, Amphiboles — B. Igneous rocks from Oceanic crust
3. Clay minerals, Dolomite — C. Igneous rocks from Continental crust

Exercise 2. ***Match the rock-forming minerals with their classification units.***

1. Feldspar	A. Carbonate
2. Quartz	B. Oxide
3. Amphibole	C. Phyllosilicate
4. Mica	D. Inosilicate with tetrahedra double chains
5. Olivine	E. Orthosilicate
6. Calcite	F. Tectosilicate
7. Pyroxene	G. Inosilicate

Fig. 3.2. Rock-forming minerals

Exercise 3. ***Match the relative abundance of rock-forming minerals in major rock types.***

1. Olivine	A. Carbonate
2. Quartz	B. Gabbro
3. Clay	C. Shale
4. Calcite	D. Sandstone
5. Amphibole	E. Andesite

Chapter 4. Accessory and secondary minerals (Unit 6)

Accessory (auxiliary) minerals include all the many detrital minerals that are found in clastic terrigenous rocks that do not contribute directly to rock classification (thus, primarily minerals other than quartz and feldspar). Although thousands of minerals could potentially fall under that definition; practically, a limited number are found with any great frequency. *Accessory (auxiliary)* minerals as a whole typically make up less than 1 % (rarely more than 2 %) of most terrigenous sedimentary rocks. For example, granites contain such accessory minerals as *titanite*, *rutile*, *apatite*, *magnetite*, *ilmenite*, *zircon*, etc.; therefore peridotites are characterized by *chromium spinels, sulfides of copper*, *nickel*, *iron*, etc. The same minerals, being accessories for some rocks, occur in large quantities in others (over 5 %) and form ores (copper-nickel and platinum are characteristic of basic and ultrabasic rocks, apatite – for alkaline, etc.).

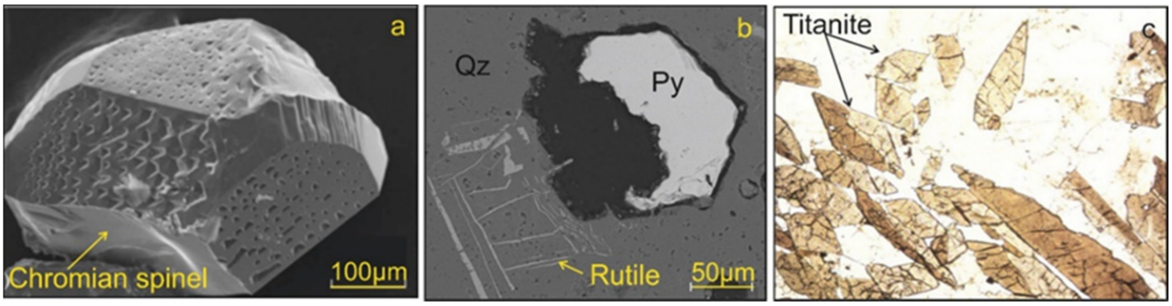


Fig. 4.1. Accessory minerals:
a – scattered electron image of the chromian spinel from the dunite core of the mafic-ultramafic Konder massif [5]; b – needles of rutile in vuggy silica in association with pyrite (Py) and quartz (Qz) within the epithermal gold deposit (Okhotsk-Chukotka volcanic belt); c – transmitted-light microphotographs of the titanite grains

Secondary minerals may be formed as products of weathering at the Earth's surface. Usually, the formation of secondary minerals begins near the site where primary minerals are being attacked, perhaps even originating as coatings on the crystal surfaces [6, 7]. Secondary minerals are often dominated by layered silicate or "clay" minerals and formed by the subsolidus alteration of a pre-existing primary mineral in an igneous rock. Most secondary minerals are hydrated silicates. A typical example is the alteration of primary olivine to secondary chlorite and serpentine.

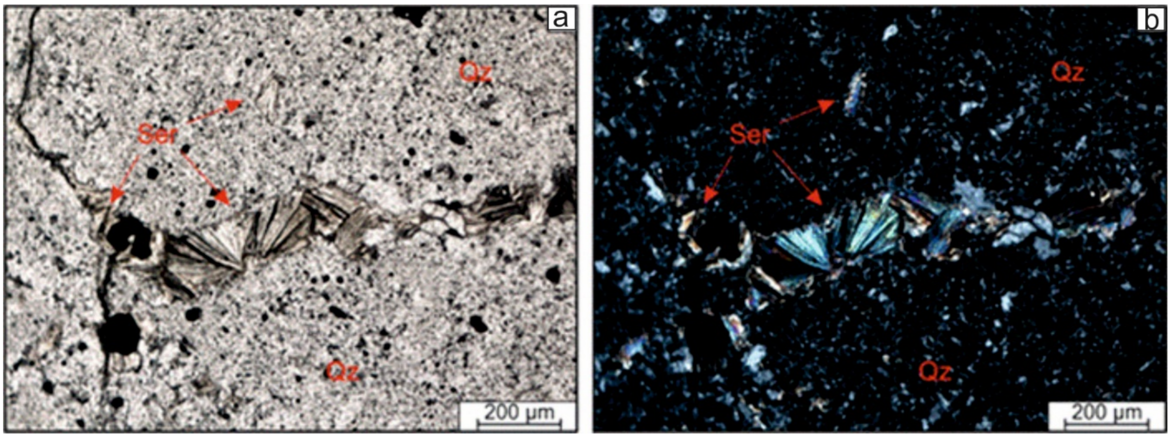


Fig. 4.2. Transmitted light microphotographs of the sericite aggregates (secondary mineral) in vuggy silica (quartz-Qz) in the plane (a) and cross-polarized (b) light

Exercise 1

Compose 1 sentence with 1 term

accessory mineral (акцессорный минерал)	**secondary** **epigenetic mineral** (вторичный минерал)
gangue mineral (жильный минерал)	**acicular** **needle mineral** (игольчатый минерал)
altered mineral (измененный минерал)	**primary mineral** **rock-forming** (первичный, породообразующий минерал)
fragile mineral (хрупкий минерал)	**durable mineral** (прочный минерал)
ore mineral (рудный минерал)	**micaceous mineral** (слюдистый минерал)
rod-like mineral (столбчатый минерал)	**finely-dispersed mineral** (тонкодисперсный минерал)
platy mineral (пластинчатый минерал)	**host mineral** (минерал хозяин, минерал, включающий другой минерал)

Chapter 5. Gemstones (Unit 7)

A gemstone (also called a gem, fine gem, jewel, precious stone, or semi-precious stone) is a piece of mineral crystal that, in cut and polished form, is used to make jewelry or other adornments. However, certain rocks (such as lapis lazuli, opal, and jade) or organic materials that are not minerals (such as amber, jet, and pearl) are also used for jewelry and are therefore often considered to be gemstones as well. Most gemstones are hard, but some soft minerals are used in jewelry because of their luster or other physical properties that have aesthetic value. Rarity is another characteristic that lends value to a gemstone.

Apart from jewelry, from the earliest antiquity engraved gems and hardstone carvings, such as cups, were major luxury art forms. A gem maker is called a lapidary or gemcutter; a diamond worker is a diamantaire. The carvings of Carl Fabergé are significant works in this tradition.

What is a Precious Stone?

What is the difference between precious stones and semi-precious stones? These terms are based on old traditions from the west. These days, all gemstones are considered precious since they are all rare and there is a limited supply of them.

The traditional list of gemstones that are considered precious stones are:

1) ***Diamond;***
2) ***Ruby;***
3) ***Sapphire;***
4) ***Emerald*** (Fig. 5.1).

Fig. 5.1. Photo of diamond (a); ruby (b); sapphire (c); emerald (d, e)

All other gemstones are considered as being semi-precious stones. These are old terms and not necessarily true these days.

1. Diamond

The gift of diamond jewelry is the most cherished way to celebrate many of life's important moments. From new engagements and important anniversaries to milestone birthdays, a diamond ring truly says it all.

Diamonds are the most popular and well-known gemstone on the market today. It is an exceptional, naturally occurring stone, which consists of pure carbon. Every carbon atom of a diamond is bounded by another four different carbon atoms and associated with well-built covalent bonds. This plain, standardized, tightly-bonded series of atoms yields the hardest and most durable mineral.

Diamonds are captivating gemstones. They are extremely hard, making diamonds an appropriate cutting tool and for other purposes where hardness is necessary. However, diamonds also contain some special visual properties such as an extremely high index of refraction, high dispersion, and stunning white color. All these properties and great marketing make the diamond the earth's most famous gemstone.

Part of the explanation for diamond fame is an outcome of its visual properties or how it reflects with light. Several factors include fashion; tradition and marketing. Diamonds compose a high-luster. This high luster is the effect of a diamond that reflects an elevated percentage of the light that strikes its surface, which provides the diamonds an enjoyable "sparkle". Moreover, diamond also consists of a high diffusion. As white light outdoes through a diamond, this dispersion makes that light disconnect into its colors. Diffusion is what makes a prism divide white light into certain colors. This property of diffusion is what provides the diamonds a colorful fire.

There is a wide market for diamonds and supply is mostly controlled by DeBeers. Artificial diamonds have been formed to keep up with industrial demand. They can be created at a lower cost than naturally mined stones however larger stones are still not possible.

Most diamonds vary from colorless to yellow. The most highly sought-after Diamonds are those that are colorless. However, another kind of diamond gemstone is raising in popularity. These are the "fancy" groups of diamonds, which appear in series of colors such as yellow, blue, green, pink, and red. The worth of these stones is based upon their shade, strength, scarcity, and popularity. In recent times the rise of niche Diamonds such as the Chocolate Diamond has given new excitement to colors that were previously considered worthless.

The Four C's Of Diamonds

Diamonds are distinguished based on the four Cs which are the Color of the diamond, the Carat of the diamond, the Cut of the diamond, and the Clarity of the diamond. These four Cs determine the quality of the diamond. Generally, the rough shape of the diamond will determine the type of cut it undergoes. A diamond enthusiast is visually allured by the different diamond shapes.

The C which means the Cut is determined by the shape of the Diamond in the rough. The color, the clarity, and the carat weight all depend on how the diamond cutter interpenetrates the rough. The diamond cutter has to take into consideration the weight of the final stone and also if there are any fractures or flaws in the original diamond. The ultimate goal is to minimize the loss of weight during the cutting process. Diamond cutting is a difficult job that is helped by the use of advanced technology. The professional diamond cutter follows a plan on how to attain maximum weight with color and clarity to allure the admirers.

Diamond Cuts

The ***round*** *shape* is supposed to be the most common and famous among diamond admirers. The cut which has evolved over the years now includes 57 facets.

The ***princess*** cut diamond is very sophisticated as the name itself indicates. It comes in square and rectangular shapes. The princess cut diamonds give out different colors at each corner in the princess cut diamond.

The ***cushion***-cut diamonds are also available in square and rectangular shapes. They have maximum clarity and brightness and many of the old famous Diamonds are cut this way. The most well-known would be the Cullinan II Diamond.

The ***marquise*** cut diamond has a maximum carat weight. The marquise cut diamond depicts the actual shape of the diamond rough. Special care should be taken with this cut to not damage the points.

The ***emerald-***cut diamond is rectangular and gives a larger clarity to enthusiasts because of its wide width.

The ***radiant*** cut diamond: As the name indicates it has a maximum radiance because of its craftsmanship. The corners are trimmed and it is eight-cornered.

The ***pear*** shape diamond gives a sleek and savvy look.

The ***oval*** cut diamond is as popular as the round cut diamond. It enhances the jewelry with its sleek design.

The ***asscher*** cut is popular and it enhances the color due to its cut. It is a more modern cut that has become very popular among the younger generation.

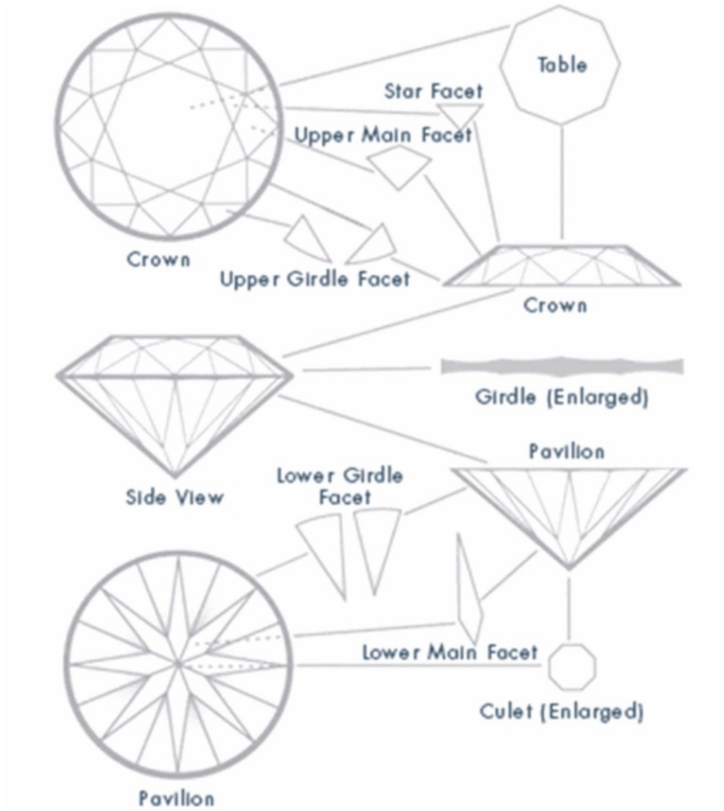


Fig. 5.2. Photo of diamond cuts

Diamond Shapes

When it comes to diamond shapes it is important to note that the shape only refers to the overall shape of the stone. It does not take into account the cutting style of the Diamond. For example, a round-shaped Diamond can be cut with the modern brilliant cut (57 facets) or any number of different cutting styles. The old European cutting style of round Diamonds had fatter, larger facets as opposed to the modern way of cutting round Diamonds. The image below from the GIA shows how the evolution of the round brilliant Diamond with all of the different cutting styles evolution of the round brilliant cut diamond. The standard diamond shapes are round, oval, square, marquise, pear, cushion, rectangular, heart.

Carat Weight

This is the feature that most people care about the most. The overall weight of the Diamond is often the talking point of the stone, not the color or the clarity. While carat size is important it can be deceiving. In terms of a quality Diamond, imagine a 2ct stone that is cut very deep, so the diameter is not very big. Even though it is a 2ct diamond, it might not look much bigger than a 1ct Diamond from the face-up. Since it is cut deep, the color could also be a shade darker. The weight of a Diamond should be the last consideration when judging Diamond quality.

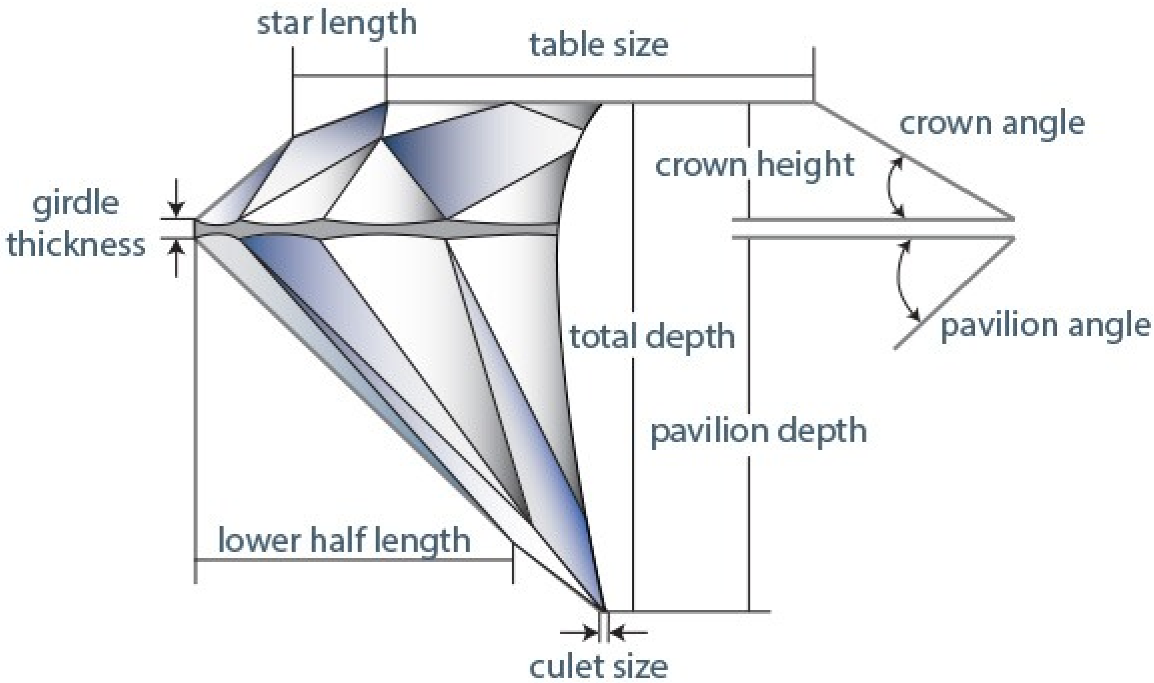


Fig. 5.3. Diamond anatomy of round brilliant shape with 57 facets

Fig. 5.4. Photo of matching the size and weight of the diamond

Treated Diamonds

Color treatment technological developments now allow the creation of diamonds of almost any color, either completely artificially or from natural diamonds whose color is unattractive (not clearly defined, yellowish, brownish, etc). Such stones can be manufactured at will, resulting in the production of goods that are the exact contrary of what they are substituting for: They may be cheaper to buy, however, their resale value is almost zero. The most common treatments in white Diamonds are HPHT treatment and laser drilling.

The ***clarity*** of a diamond is the most obvious factor when looking at a Diamond with the naked eye (Fig. 5.5). Clarity refers to the size and location of any inclusions (also known as floors) present in the Diamond. Inclusions can interfere with the light bouncing around inside the gem. They can also be seen as black “pepper” marks inside the stone.

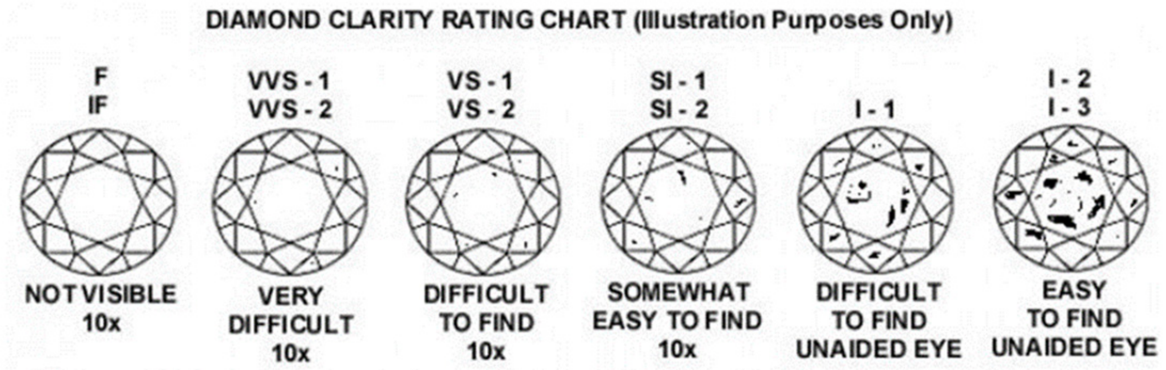


Fig. 5.5. Different types of diamond clarity

The GIA has developed a scale that represents how these inclusions can be seen with the naked eye or with a 10x magnification. The clarity scale is:

Internally Flawless (IF) – No internal flaws. Very rare and beautiful diamonds which are quite expensive.

VVS1, VVS2 – Very, Very Slightly Included: Very difficult to see inclusions under 10x magnification. An excellent quality diamond.

VS1, VS2 – Very Slightly Included: Inclusions are not visible to the unaided eye. Less expensive than the VVS1 or VVS2 grades.

SI1, SI2 – Slightly Included: Inclusions are visible under 10x magnification, SI clarity diamonds are usually of the best value since inclusions are not visible to the naked eye and prices are reasonable when compared to prices of the VS2 clarity and upgrades.

SI3 – Slightly Included-EGL: SI3 is an EGL grade and is not recognized by GIA or other gemological institutions. It may be graded by GIA as either

SI2 or I1. SI3 diamonds never have any black inclusions or cracks visible to the naked eye, but may have some very minor white inclusions which can be seen with the naked eye.

I1 – Included: an I1 clarity diamond will have a visible flaw that can be seen with the naked eye, but there should only be one major flaw that is not too obvious. If your budget only allows for an SI3 or I1 clarity diamond, be sure to examine it thoroughly before purchasing and make sure you can not see any inclusions.

I3 – Included: These diamonds will have inclusions visible to the naked eye, and will have many black spots from the black inclusions and appear cloudy from the white inclusions, feathers, and cracks.

Cut

This is one of the most complex and misunderstood characteristics of Diamond quality. While most people think this refers to the shape that the diamond is cut into, in reality, it is a lot more complex. To cut a Diamond, the *lapidaries* must try to get the biggest possible stone out of a piece of rough. To do that, the proportions of the Diamond might not allow the cuter to cut a stone deep enough or wide enough. What this does is allow light to leak out the sides of the Diamond instead of being directed back towards the top of the stone. If the diamond is cut too shallow, the light will leak straight through the Diamond and create what is called a «fish-eye» or a window (Fig. 5.6). If the diamond is cut too deep, it can create large areas of extinction (pure blackness) instead of beautiful white light.

Fig. 5.6. Different types of diamond cut

Video about diamonds produced by Discovery Channel
https://www.youtube.com/watch?v=KB9FtcNvS6o

Exercise 1. ***Listening.***

You will see the video and then and fill the gaps and answer the following questions.

1. Diamonds begin ________________________________ under-ground.
2. The last diamond spitting eruption happened __________________ years ago.
3. When did geologists discover one of the richest kimberlite pipes in Africa?
4. How many tons of rock are blasted crushed?
5. At the Finch mine in South Africa miners have been digging __________________.
6. ________________of the diamonds unearthed make the grade as gems.

Vocabulary

adornments	украшения	naked	невооруженный
jet	гагат	misunderstood	недопонимать
emphasis	особое внимание, акцент	lapidary	огранщик драгоцен-ных камней
apart	кроме	***video***	
cherished	заветный	stuff	материал
engagements	обязательства	guise	вид
anniversaries	годовщины, юбилеи	creatures	существа
milestone	веха	blown	взорван
admirer	почитатель, поклон-ник, обожатель	allotrope	аллотроп, аллотропи-ческая модификация
exceptional	исключительный	spew	изливаться, извергаться
captivating	очаровательный	spitting	извергающийся
stunning	ошеломляющий	plumbing	водопроводная система
sparkle	искриться, сверкать	hidden	скрытый
artificial	искусственный	odd	странный
supply	поставка	comrade	компаньон
undergo	подвергаться	mounds	курганы, насыпь

enthusiast	энтузиаст	excavate	копать, рыть
allured	увлеченный	feet	фут (30,48 см)
craftsmanship	степень мастерства, тонкая искусная работа	split	разлагаться, делиться на несколько, раскалываться
rarity	редкость	rainbow	радуга
sophisticated	утонченный	insignificant	незначительный
depict	изображать, описывать	handful	горсть, небольшое количество
rough	грубый	tight	плотный
sleek	лоск	unearthed	извлечено из Земли
excitement	возбуждение, волнение	disintegrate	распадаться, разрушаться
strength	прочность	savvy look	продвинутый вид
shade	оттенок	scarcity	редкость

Exercise 2. ***Reading practice.***

Multiple Matching choice

You have several short statements followed by some short paragraphs. You have to read the text and 15 short statements followed by a text divided into paragraphs from A to P. They have to scan the text and decide which of the statements matches with paragraphs of the text.

Ruby and Sapphire

A Most people don't realize that ruby and sapphire are both gems of the mineral corundum. Both of these gemstones have the same chemical composition and the same mineral structure. Trace amounts of impurities determine if gem corundum will be a brilliant red ruby or a beautiful blue sapphire. It is surprising that "impurities" can produce such wonderful results! Red corundums are known as "rubies," blue corundums are known as "sapphires," and corundums of any other color are known as "fancy sapphires." Impurities cause corundum to occur in a spectrum of colors, and when it is completely free of color-causing impurities, it is a colorless gem known as "white sapphire."

B Very few specimens of corundum have a natural color within the range required for a ruby. Very few also have the clarity required to produce a nice faceted stone. Long ago, people who prepare gem materials for cutting began experimenting with ways to improve their color and clarity.

C Corundum crystals under controlled conditions can improve or intensify their color. Heating can also remove inclusions by causing them to dissolve, making them less visible, and improving the clarity of a gem. Most rubies in the market today have been heated to improve their color and clarity. This heat treatment is normal and expected in the gem trade, but a seller should disclose the treatment to a buyer in advance of a sale.

D One of the early treatments was to fill surface-reaching fractures with oils, waxes, or resins. These treatments filled pits and fractures on the surface of the gem and improved their appearance. However, these treatments are not permanent because the oils can be washed out, and the waxes and resins can crack and fall out with age – even with special care. They produce a temporary improvement in the appearance of the stone and are mainly done to produce a quick and profitable sale.

E A more permanent type of fracture treatment is to fill the fractures with minor amounts of flux, glass, or another durable material. These enter the fractures during the heat treatment process. When the stone cools, a permanent filling of the fracture was accomplished. These treatments reduce the visibility of the fractures and improve the clarity of the gems. They also might improve the durability of some stones. This type of treatment is generally acceptable but should be disclosed to the buyer.

F A much more aggressive treatment is to heat the gem to a very high temperature and inject glass or flux into the fractures. The temperature of this treatment can be high enough that some of the rubies melt and mixes with the fracture-filling materials. The result of this treatment is an altered stone with an improved appearance. But the stone now contains an unknown and possibly significant amount of non-ruby material. If these gems are sold "by the carat", the buyer might pay a significant portion of the price for non-ruby material. Many people believe that these treatments produce man-made composite materials that should not be called "ruby".

G Trace amounts of iron and titanium can produce a blue color in corundum. Blue corundum are known as "sapphires." The name "sapphire" is used for corundums that range from a very light blue to a very dark blue color. The blue can range from a greenish-blue to violetish blue. Gems with a rich blue to violetish blue color are the most desirable.

H Gem-quality corundum occurs in a wide range of other colors, including pink, purple, orange, yellow, and green. These gems are known as "fancy sapphires." Surprisingly, a single mineral can produce gemstones of so many different colors. When the color of a sapphire is any color other than blue, the color should be used as a preceding adjective to describe the stone. For example, pink sapphire, yellow sapphire, or green sapphire. Used alone, the word "sapphire" refers only to blue corundum.

I Some rough materials that have no trace of blue color can be heated to produce a spectacular blue. Some milky to yellowish, cloudy to translucent corundum can be heated to yield stones that are transparent and bright blue. If such treatments have been used, sellers should disclose the types of treatments to potential buyers when the stone is presented for sale.

J Some sapphires are treated by a process known as "lattice diffusion." In lattice diffusion, the sapphire is heated in the presence of a material that will release tiny metal ions. When the corundum is heated, its lattice expands enough that these tiny ions can diffuse into the gem and become trapped within the lattice when the corundum is allowed to cool. The trapped ions prevent the corundum from contracting to its normal dimensions, producing a defect that alters the color of light passing through the gem.

K Beryllium diffusion can produce orange, yellow, and pink colors. Titanium diffusion can produce blue. Lattice diffusion treatment is considered to be a severe treatment that is sometimes hard to detect. Some people believe that corundum that has its color produced by lattice diffusion should not be called "sapphire."

L Ruby and sapphire are extremely popular gemstones. Virtually every jewelry store that features colored gemstones in jewelry will have a generous portion of their display dedicated to ruby and sapphire items. Ruby is the most popular red gemstone, and sapphire is the most popular blue gemstone.

M The pie chart on this page shows the share of colored stone imports on a dollar-value basis that went to the categories of sapphire, ruby, emerald, and all other gemstone varieties during the 2015 calendar year. It shows that sapphire and ruby were the second and third most imported colored stones during that year. A total of $464 million worth of sapphire was imported, and a total of $149 million worth of ruby was imported.

N Although the pie chart does not include domestic colored stone production, it can be considered as nearly complete. The United States Geological Survey estimates that the value of the total domestic production of colored stones of all kinds in the United States during the calendar year 2015 was only $8.5 million.

O Most gem-grade corundum forms in metamorphic rocks, such as schist or gneiss; or in igneous rocks such as basalt or syenite. However, gem corundums are rarely mined from the rocks in which they form. Mining small gems from hard rock are possible, but it is very expensive, and many of the gems are broken during the mining process. Fortunately, corundum is very hard and resistant to weathering. In many areas, natural weathering and erosion have liberated the stones from their host rock and carried them into streams over long periods of geologic time.

Diffusion treatment	1	
Domestic production	2	
High-temperature treatment	3	
Mining of corundum	4	
Visual characteristics improvement	5	
Ruby and sapphire are preferable gemstones	6	
Classic sapphire	7	
Provisional improvement of gems	8	
Colorful corundum	9	
One mineral gives two gems	10	
A more widespread type of treatment of ruby	11	
Some specimens have a good natural clarity	12	
A worth of gemstones import	13	
Different types of lattice diffusion	14	
Quality transformation	15	

Vocabulary

to dissolve	разлагать	to estimate	оценивать
a seller	продавец	spectacular	эффектный
intensify	активизировать	tiny	мелкий, крошечный
a pit	ямка	trapped	пойманный в ловушку
permanent	постоянный	expand	раскрываться
temporary	временный	dimensions	размеры
profitable	прибыльный	to alter	изменять
accomplish	достигать	a store	магазин, лавка
acceptable	приемлимый	dedicated	преданный
flux	флюс	a worth	стоимость
desirable	желанный	domestic	внутренний
rough	необработанный, черновой	disclose	обозначать, раскрывать, указывать
yield	доходный, прибыльный	a stream	поток

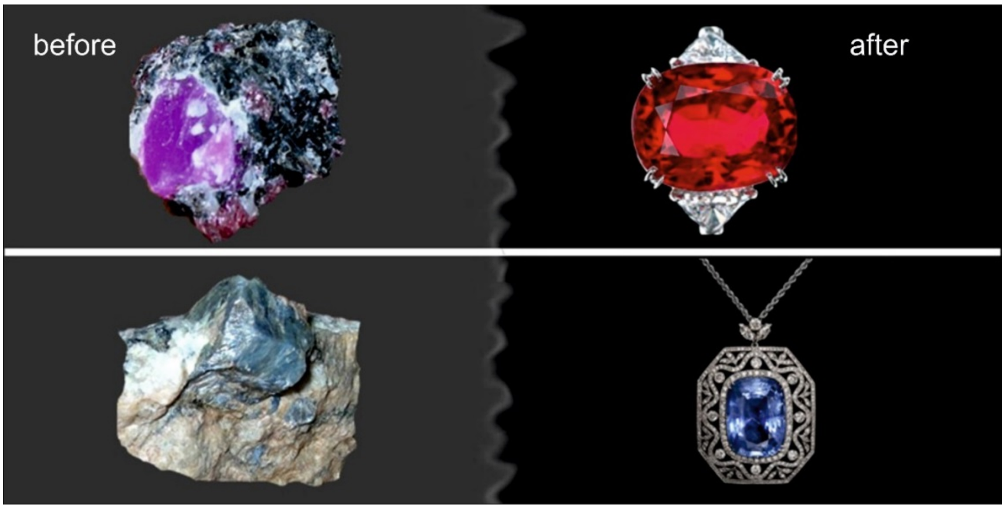


Fig. 5.7. Photo of ruby and sapphire from raw corundum

Test № 5 (Homework 5. **Unit 7**)

1. What are gemstones do you know?
2. List Four C's of Diamond quality
3. What diamond cuts (shapes) do you know?
4. How do you spell out the GIA?
5. What is Diamond's quality characteristic describes with use such abbreviations as IF, VVS1, SI, I1-I3, etc?

Chapter 6. Metals (ferrous and nonferrous metals) (Unit 8)

Listening

https://www.youtube.com/watch?v=Q4SUIjwPmCk

You will hear women talking about native metals and fill the gaps and answer the questions.

1. The gold group consists of gold________lead, aluminium__________ and ____________.
2. The platinum group consists of platinum,___________, osmium,__________, rhodium, and___________________.
3. What do metals occur in nature in large amounts?
4. What is the natural weathering process can erode metals?
5. Non-metallic elements occurring in the native state include ________________ and _________________.
6. So while _________ and _________ were known well before the copper age and Iron Age.

Nonferrous metals

By definition, all metallic materials that do not have iron (Fe) as their major ingredient are called nonferrous metals.

The arbitrary classification of non-ferrous metals:

1. **Light metals**: Aluminum, Magnesium, Titanium, Beryllium.
2. **Heavy metals**: Copper, Zinc, Lead, Tin.
3. **Refractory metals**: Molybdenum, Tungsten, Chromium, Nickel.
4. **Precious metals**: Gold, Platinum, Silver.

The light weight of certain nonferrous materials is of special importance in the aircraft and space industry. Zinc, tin, and lead (with low melting points) are used in special applications. Tungsten, molybdenum, and chromium are used in products that must resist high temp. Nickel and cobalt are also suitable as heat-resistant alloys. Precious metals (with high cost) are not only used in jewelry, but also many applications requiring high electrical conductivity and corrosion resistance.

Aluminum is the highest-ranking material in use next to steel. Copper and its alloys (brass and bronze) rank second while Zinc ranks third in consumption.

Light metals

Aluminum (Al): It is probably the most important non-ferrous metal. It has outstanding physical properties (e.g. light weight, high thermal and electrical conductivity, and corrosion resistance). It is suitable for all machining, casting, and forming operations.

Titanium (Ti): It is used in corrosive environments or applications of light weight, high strength, and nonmagnetic properties. It has good high-temperature strength has compared with other light metals.

Beryllium (Be): Beryllium is a recently emergent material having several unique properties of low density (one-third lighter than aluminum), high modulus-to-density ratio (six times greater than ultra-high-strength steels), high melting point, dimensional stability, excellent thermal conductivity, and transparency to X-rays.

However, it has serious deficiencies of high cost, poor ductility, and toxicity. It is not especially receptive to alloying. It is typically used in military aircraft brake systems, missile guidance systems, satellite structures, and X-ray windows.

Magnesium (Mg): This is the lightest engineering material available. The combination of low density and good mechanical strength has made it one of the most specified materials in aircraft, space, portable power tools, luggage, and similar applications as competing with the aluminum alloys.

Heavy metals

Copper (Cu): It is probably the first engineering metal to be used. Unlike other metals, it can occur in nature in the metallic form as well as an ore. It has very good heat and electrical conductivity and resists corrosion when alloyed with other metals. However, due to lower density, aluminum has higher conductivity per unit weight.

Copper alloys consist of the following general categories:

1. Coppers (minimum 99.3 % Cu)
2. High coppers (99.3–96 % Cu)
3. Brasses (Cu-Zn alloys with 5–40 % Zn)
4. Bronzes (mainly Cu-Sn alloy, and also alloys of Cu-P, Cu-Al, Cu-Si)
5. Copper Nickels (Cu-Ni alloys, also known as cupro-nickels)
6. Nickel Silvers (Cu-Ni-Zn alloys which do not contain silver)

Zinc (Zn): Zinc is an inexpensive material with moderate strength. It is chemically similar to magnesium. Mechanically, however, zinc is more ductile but not as strong. Although it's metal and alloy forms are important, zinc is most commonly used to extend the life of other materials such as steel (galvanizing), rubber and plastic (as an aging inhibitor), and wood (in paint coatings). The zinc-based alloys have an important place as a die-casting metal as it has a low melting point (419.5 ºC) which does not affect steel dies adversely, and hence it can be made into alloys with good strength properties and dimensional stability.

Tin (Sn): As with many metals, pure tin is too weak to be used alone for most mechanical applications. It is often alloyed with elements such as copper, antimony, lead, aluminum, and zinc to improve mechanical or physical properties. It is commonly used as a coating for other metals such as tin cans, copper cooking utensils. Other applications include die-casting alloys, pewter chemicals, bronze, bearing alloys, and solder.

Lead (Pb): Lead is a versatile material due to special properties of high atomic weight and density, softness, ductility, low strength, low melting point, corrosion resistance, and ability to lubricate. On the downside, toxicity is one of the chief disadvantages.

There are two principal grades: chemical lead and common lead. Typical uses include chemical apparatus, batteries, and cable sheathing. For corrosion resistance and X-ray and Gamma-rays shielding, pure lead gives the best performance.

Lead is alloyed with tin and antimony to form a series of useful alloys employed for their low melting points. Solder is the alloy of lead and tin-containing small amounts of antimony and silver. The solders are mainly used in soldering electronic circuits due to their lower melting points.

Refractory metals

Tungsten, molybdenum, tantalum, and niobium (with melting points above 1900 °C) are characterized by high-temperature strength and corrosion resistance.

In addition, chromium and nickel also have major importance as high-temp. materials. Although nickel has a lower melting point (1455 °C), it is also categorized in this group due to its specific corrosion resistance and high-temp. strength.

Niobium (Nb) – formerly known as "Columbium" (Nb) & ***Tantalum (Ta)***: These elements are distinguished by excellent ductility even at low temperatures. Both metals occur together in ores and they must be separated for nuclear use since tantalum has a higher neutron absorption than columbium.

They can be fabricated by most conventional processes, usually worked at room temperature. They are usually considered together since most of their working operations are identical. They are used as anode and grid elements in medium to high-power tubes as well as in capacitors and foil rectifiers.

Tungsten (W) – also known as "Wolfram" (W) & *Molybdenum* (Mo): Tungsten is the only refractory metal with good electrical & thermal conductivity, excellent erosion resistance, low coefficient of expansion, and high strength at a high temp. Although having low ductility and malleability, it can be fabricated into many forms with proper procedures. Thomas Edison's trials with tungsten during the invention of the incandescent lamp were the most important application. Other uses are electrodes for inert-gas welding, electron tube filaments, anodes for X-ray and electron tubes.

Molybdenum (Mo) is a special metal having some resistance to hydrofluoric acid. It is very similar to tungsten but more ductile, easier to fabricate, and cheaper. Its typical applications are electron tube anodes, grids for high-power electron tubes dies with standing "thermal cycling", and supports for tungsten filaments in light bulbs. Both metals have brittleness at room temp. and oxidation at relatively low temp.

Chromium (Cr): Most refractory metals oxidize and lose their strength at a high temp. whereas chromium (less subjected to oxidation) loses strength above 1090 ºC. It is used in chrome-plating and steel alloys to improve hardness, strength at high temp. and corrosion resistance. Its brittleness may limit its application areas.

Nickel (Ni): Nickel alloys have desirable properties like ultra-high strength, high proportional limit, and high modulus of elasticity. Commercial pure nickel has good electrical, magnetic, and magnetostrictive properties. Nickel alloys are still strong, tough, and ductile at cryogenic (very low) temperatures. Most nickel alloys can be hot and cold worked, machined, and welded successfully. They can be joined by shielded metal-arc, gas tungsten arc, gas metal-arc, plasma arc, electron beam, oxy-acetylene, resistance welding, brazing, and soft soldering.

Precious metals

They are divided into three subgroups: gold and gold alloys, silver and silver alloys, platinum group metals (consists of six metals extracted from nickel ores: platinum, palladium, rhodium, iridium, ruthenium, osmium). These metals are nearly completely corrosion resistant. Platinum metals withstand upto1760°C without any evidence of erosion and corrosion.

Gold (Au): Extremely soft, ductile material that undergoes very little work hardening. It is often alloyed with other metals (such as copper) for greater strength. It has occasional uses as a reflecting surface, attachments to transistors, and jewelry.

Silver (Ag): The least costly metal of this group. Very corrosion resistant. Plated onto low-voltage electrical contacts to prevent oxidation of surfaces when arcing occurs. Used in photographic emulsions due to photosensitivity of silver salts.

Platinum (Pt): A silver-white metal. Extremely malleable, ductile, and corrosion-resistant. When heated to redness, it softens and easily worked. Since it is inert, nearly non-oxidizable, and stable even at a high temp. Used for high-temp. handling of high purity of chemicals and laboratory materials. Also used in thermocouples, spinning and wire-drawing die, components of high power vacuum tubes glass-working environment, and electrical contacts.

Vocabulary

arbitrary	произвольный	solder	припой
refractory	тугоплавкие	sheathing	обшивка
aircraft	авиация	shielding	экранирование, защита
space industry	космическая промышленность	performance	эксплуатационные качества
conductivity	проводимость	circuits	схемы
consumption	сфера потребления	refractory	тугоплавкий
thermocouples	термопар	nuclear	ядерный, атомный
dimensional	измеряемый	conventional	обычный, традиционный
transparency	прозрачность	grid	решетка, сетка
deficiencies	недостатки	capacitors	конденсаторы
receptive	восприимчивый	rectifiers	детекторы
brake	тормоз	malleability	тягучесть, ковкость
missile	ракета, ракетный	trials	испытания

guidance	управление	relatively	относительно
satellite	спутник	welding	сварка
strength	прочность	hydrofluoric	плавиковой
due to	из-за, благодаря	bulb	колба
brass	латунь	brittleness	хрупкость
ductile	пластичный, ковкий	incandescent	накаленный, раскаленный
rubber	резина	chrome-plating	хромирование
die-casting	литье под давлением	ductile	пластичный, ковкий
pure	чистый	brazing	пайка твердым припоем
weak	слабый	redness	покраснение
utensils	принадлежности	emergent	внезапно, неожиданно появляющийся
pewter	оловянный		

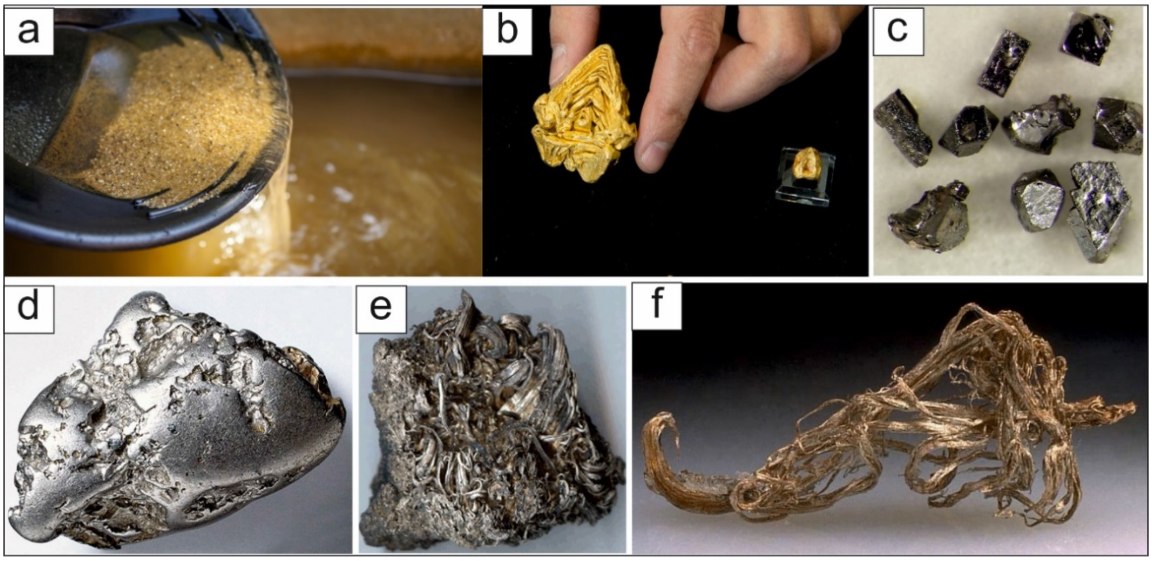


Fig. 6.1. Photo of gold (a, b); platinum (c, d), and silver (e, f)

Test № 6 (Homework 6. **Unit 8**)

1. What light metals do you know?
2. What do metals occur in nature in large amounts?
3. What is the natural weathering process that can erode metals?
4. Non-metallic elements occurring in the native state include __________________ and ___________________.
5. List metals that can be found as native deposits singly or in alloys.

Card 2

Light metals

Magnesium (Mg)	магний
Aluminum (Al)	алюминий
Beryllium (Be)	бериллий
Titanium (Ti)	титан

Heavy metals

Zinc (Zn)	цинк
Tin (Sn)	олово
Copper (Cu)	медь
Lead (Pb)	свинец

Refractory metals

Tantalum (Ta)	тантал
Niobium (Nb)	ниобий
Tungsten (W)	вольфрам
Molybdenum (Mo)	молибден
Nickel (Ni)	никель
Chromium (Cr)	хром

Precious metals

Gold (Au)	золото
Platinum (Pt)	платина
Silver (Ag)	серебро

Other native metals

Arsenic (As)	мышьяк
Antimony (Sb)	сурьма
Cadmium (Cd)	кадмий
Bismuth (Bi)	висмут
Indium (In)	индий
Cobalt (Co)	кобальт
Iron (Fe)	железо
Rhenium (Re)	рений
Selenium (Se)	селен
Tellurium (Te)	теллур
Vanadium (V)	ванадий
Mercury (Hg)	ртуть
Iridium (Ir)	иридий
Osmium (Os)	осмий
Palladium (Pd)	палладий
Rhodium (Ro)	родий
Ruthenium (Ru)	рутений

Chapter 7. Mineralogical museums of the world (Unit 9)

https://www.youtube.com/watch?v=ctfjB6uc6ts

Hello and Welcome to the Mineralogical Museum of the University of Hamburg!

This is a space, dedicated to all kinds of _______________ that Mother Nature created, and in particular to the beauty of crystals. A large number of ____________________ are categorized and stored here. _____________________ of the collection are on display for everyone to see.

Unfortunately, we cannot invite you all personally, to come to Hamburg, to visit this museum. Instead, we will take you on a short flight through the museum. Keep your eyes open for all the different shapes of the crystals. They will range from perfect ________ to long _________ or _______________.

When people come to this place they often ask: "Are these crystals cut and polished like ____________?" And they are surprised when they learn, that they are not. All the crystals, we will show you, grew into that particular shape they have now. Apart from cleaning they _______________________ further.

So, what forces the crystals into these shapes?

That's the question we want to answer in this chapter. But for now, sit back and enjoy the view of the crystalline world.

* Flight through the Museum *

You may recognize this crystal from the trailer of our course. These are pyrite crystals. And what is remarkable, is of course their shininess. And what is also remarkable is their macroscopic form: Perfect cubes with ____________________________

In the last chapter you learned all about ____________. The unit cell of pyrite is cubic. And the overall shape of these crystals can be explained perfectly well, if we realize, that crystals are nothing more than tightly packed unit cells. Thus, it is not very surprising that an arrangement of small cubes results in a large cube.

But here we have another pyrite crystal. As you can see, this is no longer a perfect cube but ______________________.

How is this possible? In the next units we want to answer this question: How do crystals get ________________________ and how can we describe them?

Listening

You will see the video about visiting the Mineralogical Museum and then fill the gaps.

1. This is a space, dedicated to all kinds of _______________ that Mother Nature created, and in particular to the beauty of crystals.
2. A large number of ____________________ are categorized and stored here.
3. _____________________ of the collection are on display for everyone to see.
4. They will range from perfect ________ to long _________ or ________________.
5. When people come to this place they often ask: "Are these crystals cut and polished like ____________?"
6. Apart from cleaning they _____________________________ further.

After video

7. Perfect cubes with ____________________________.
8. In the last chapter you learned all about ____________.
9. As you can see, this is no longer a perfect cube but _______________________.
10. How do crystals get ________________________ and how can we describe them?

Card 3

Solid-state matter	твердое вещество
a specimen	образец
faceted polyhedra	ограненный многогранник
extreme sharp edges	экстремально-ровные грани
outer shape	внешняя форма
unit cell	ячейка

Test I

1. Shape of the crystalline form reflects the internal _____________?
2. Translate these terms from English into Russian:

- Acicular –
- Equant –
- Fibrous –
- Tabular –

3. Give examples (minerals) that have the columnar/or botryoidal crystal habit (in English):_____________________________________.
4. Match the English terms in column "A" with their Russian equivalents in column "B":

"A"		"B"
Stubby	( )	A. Ромбоэдрический
Platy	( )	B. Короткостолбчатый
Columnar	( )	C. Таблитчатый
Acicular	( )	D. Изометричный
Bladed	( )	E. Уплощенный (пластинчатый)
Equant	( )	F. Пластинчатый
Tabular	( )	G. Игольчатый
Octahedral	( )	H. Призматический
Rhombohedral	( )	I. Додекаэдрический
Dodecahedral	( )	J. Октаэдрический

5. Define the term "mineral"_____________.
6. What is the first most abundant element in the Earth's crust?
7. What 2 elements are most common in the Earth's crust?
8. Define the term "cleavage"____________.
9. What factors control the density (specific gravity) of a mineral?
10. How can you determine the hardness of a mineral?
11. What is the natural weathering process that can erode metals?
12. Do all minerals break the same way?
13. Luster is__________.
14. Streak is__________.
15. Some examples of gem stones are__________.
16. List Four C's of Diamond quality____________.
17. Sapphires and rubies are both forms of the mineral corundum, but they have different colors. Why?
18. Compose 1 sentence with 1 term (accessory mineral, altered mineral, rock-forming mineral, durable mineral, finely-dispersed mineral).

Test II

1. What state of matter are all minerals?
2. Translate these terms in Russian:

- Excavate –
- Open-pit –
- Steam-driven pump –
- Underground method –
- Flint –
- Ore –
- Surface –

3. This property is the least useful in identifying a mineral –
4. Match the English terms in column "A" with their Russian equivalents in column "B":

"A"			"B"
Competitive	( )	A.	Жила
Discover	( )	B.	Шахта
Prospecting	( )	C.	Извлечение
Shaft	( )	D.	Конкурентоспособный
Specimen	( )	E.	Пласт
Determine	( )	F.	Определять, устанавливать
Extracting	( )	G.	Изобретение
Invention	( )	H.	Образец
Vein	( )	I.	Разведочные работы
Seam	( )	J.	Открывать

5. Define the term "hard rock"
6. What is the first mineral that was found?
7. What refractory metals do you know?
8. What do metals occur in nature in large amounts?
9. List other physical properties:
10. Translate these names of metals from Russian into English:

- Висмут –
- Хром –
- Теллур –
- Сурьма –
- Свинец –
- Родий –

11. Crystallization is__________.
12. Inorganic is__________.
13. Compose 1 sentence with 1 verb (to extract, to increase, to require, to provide, to resemble).
14. Choose and underline the correct form:

- An earthquake usually folds the (strata/straight) of the rocks.
- Marble consists of small crystals (have/having/had) a definite chemical composition.
- Due (to/by/of) its high degree of activity oxygen occurs in the magma only in combination with other elements.
- There is (little/few) hope that geologic hazards can be eliminated.
- Similar (phenomena/phenomenon) are found in many parts of the world.

Conclusions

Acquaintance with the information in the tutorial contains the basic concepts of the mineral, its physical properties, individual precise stones. Knowledge and understanding of the terms and definitions described in the presented manual are sufficient for successful passing of the set-off in the subject in the discipline "English for professional purposes".

The student should learn identify the most common minerals in hand specimens. This tutorial aims to provide knowledge on the structural, chemical, and physical characteristics of minerals. This course covers the fundamentals of mineralogy with describing the symmetry of crystals and outlines the key concepts of crystallography and mineralogy. The tutorial is accompanied by pictures to facilitate understanding and assimilation of the material.

Vocabulary (Professional terms)

Mineralogy is a subject of geology specializing in the scientific study of chemistry, crystal structure, and the physical properties of minerals.

Petrography is a branch of petrology that focuses on detailed descriptions of rocks. The mineral content and the textural relationships within the rock are described in detail. The classification of rocks is based on the information acquired during the petrographic analysis. Petrographic descriptions start with the field notes at the outcrop and include a macroscopic description of hand specimens. However, the most important tool for petrography is the petrographic microscope. The detailed analysis of minerals by optical mineralogy in thin sections and the micro-texture and structure is critical to understanding the origin of the rock.

The ***mantle*** is a layer inside a terrestrial planet and some other rocky planetary bodies. For a mantle to form, the planetary body must be large enough to have undergone the process of planetary differentiation by density. The mantle lies between the core below and the crust above.

Lava is the molten rock expelled by a volcano during an eruption. The resulting rock after solidification and cooling is also called lava. The molten rock is formed in the interior of some planets, including Earth, and some of their satellites. The source of the heat that melts the rock within the earth is geothermal energy. When first erupted from a volcanic vent, lava is a liquid at temperatures from 700 to 1,200 °C (1,292 to 2,192 F).

Igneous rock is one of the three main rock types, the others being sedimentary and metamorphic. Igneous rock is formed through the cooling and solidification of magma or lava. Igneous rock may form with or without crystallization, either below the surface as intrusive (plutonic) rocks or on the surface as extrusive (volcanic) rocks. This magma can be derived from partial melts of pre-existing rocks in either a planet's mantle or crust. Typically, the melting is caused by one or more of three processes: an increase in temperature, a decrease in pressure, or a change in composition. Over 700 types of igneous rocks have been described, most of them having formed beneath the surface of Earth's crust.

An ***intrusion*** is an igneous rock body that forms from crystallized magma under Earth's surface. Magma slowly pushes up from deep within the earth into any cracks or spaces it can find, sometimes pushing existing country rock out of the way, a process that can take millions of years. As the rock slowly cools into a solid, the different parts of the magma crystallize into minerals. Many mountain ranges, such as the Sierra Nevada in California, are formed mostly by intrusive rock, large granite (or related rock) formations.

Extrusive refers to the mode of igneous volcanic rock formation in which hot magma from inside the Earth flows out (extrudes) onto the surface as lava or explodes violently into the atmosphere to fall back as pyroclastics or tuff. This is as opposed to an intrusive rock formation, in which magma does not reach the surface. The main effect of extrusion is that the magma can cool much more quickly in the open air or under seawater, and there is little time for the growth of crystals. Often, a residual portion of the matrix fails to crystallize at all, instead of becoming a natural glass or obsidian.

If the magma contains abundant volatile components which are released as free gas, then it may cool with large or small vesicles (bubble-shaped cavities) such as in pumice, scoria, or vesicular basalt.

Metamorphic rocks arise from the transformation of existing rock types, in a process called metamorphism, which means "change in form". The original rock (protolith) is subjected to heat (temperatures greater than 150 to 200 °C) and pressure (1500 bars), causing profound physical and/or chemical change. The protolith may be sedimentary rock, igneous rock, or another older metamorphic rock.

Crystal habit is the characteristic external shape of an individual crystal or crystal group. A crystal structure is a unique arrangement of atoms, ions, or molecules in a crystalline liquid or solid.

Crystal twinning occurs when two separate crystals share some of the same crystal lattice points symmetrically. The result is an intergrowth of two separate crystals in a variety of specific configurations. A twin boundary or composition surface separates the two crystals.

A ***crystal or crystalline solid*** is a solid material whose constituents, such as atoms, molecules, or ions, are arranged in a highly ordered microscopic structure, forming a crystal lattice that extends in all directions. In addition, macroscopic single crystals are usually identifiable by their geometrical shape, consisting of flat faces with specific, characteristic orientations.

Crystallization is the (natural or artificial) process of formation of solid crystals precipitating from a solution, melt, or more rarely deposited directly from a gas.

Crystal growth is a major stage of a crystallization process and consists of the addition of new atoms, ions, or polymer strings into the characteristic arrangement of a crystalline Bravais lattice.

Fluid is a substance that continually deforms (flows) under applied shear stress. Fluids are a subset of the phases of matter and include liquids, gases, plasmas, and to some extent, plastic solids. Fluids can be defined as substances that have zero shear modulus or in simpler terms, a fluid is a substance that cannot resist any shear force applied to it.

Polymorphism is the ability of a solid material to exist in more than one form or crystal structure. Polymorphism can potentially be found in any crystalline material including polymers, minerals, and metals, and is related to allotropy, which refers to chemical elements.

Pleochroism is an optical phenomenon in which a substance appears to be of different colors when observed at different angles, especially with polarized light. Anisotropic crystals will have optical properties that vary with the direction of light. The polarization of light determines the direction of the electric field, and crystals will respond in different ways if this angle is changed. These kinds of crystals have one or two optical axes. If absorption of light varies with the angle relative to the optical axis in a crystal then pleochroism results.

Asterism (from Ancient Greek: ἀστήρ star), or star stone, is a name applied to the phenomenon of gemstones exhibiting a luminous star-like shape when cut en cabochon. The typical asteria are the star sapphire, generally bluish-grey corundum, milky or opalescent, with a star of six rays. In red corundum, the stellate reflection is less common, and hence the star-ruby occasionally found with the star-sapphire in Sri Lanka is among the most valued of "fancy stones".

Fluorescence is the emission of light by a substance that has absorbed light or other electromagnetic radiation. It is a form of luminescence. In most cases, the emitted light has a longer wavelength, and therefore lower energy, than the absorbed radiation. The most striking example of fluorescence occurs when the absorbed radiation is in the ultraviolet region of the spectrum, and thus invisible to the human eye, while the emitted light is in the visible region, which gives the fluorescent substance a distinct color that can only be seen when exposed to UV light. However, unlike phosphorescence, where the substance would continue to glow and emit light for some time after the radiation source has been turned off, fluorescent materials would cease to glow immediately upon the removal of the excitation source. Hence, it is not a persistent phenomenon.

Radioactive decay, also known as nuclear decay or radioactivity, is the process by which a nucleus of an unstable atom loses energy by emitting radiation. A material that spontaneously emits such radiation – which includes alpha particles, beta particles, gamma rays, and conversion electrons – is considered radioactive.

A ***chemical element*** or element is a chemical substance consisting of atoms having the same number of protons in their atomic nuclei. 118 elements have been identified, of which the first 94 occur naturally on Earth with the remaining 24 being synthetic elements.

Chemical composition (or simply composition) is a concept in chemistry that has different (but similar) meanings if referred to a single pure substance or a mixture.

An ***alloy*** is a mixture of metals or a mixture of a metal and another element. Alloys are defined by metallic bonding character. An alloy may be a solid solution of metal elements (a single phase) or a mixture of metallic phases (two or more solutions). Intermetallic compounds are alloys with a defined stoichiometry and crystal structure.

Ductility is a solid material's ability to deform under tensile stress; this is often characterized by the material's ability to be stretched into a wire.

A ***chemical formula*** is a way of expressing information about the proportions of atoms that constitute a particular chemical compound, using a single line of chemical element symbols, numbers, and sometimes also other symbols, such as parentheses, dashes, brackets, commas, and (+) and minus (−) signs. These are limited to a single typographic line of symbols, which may include subscripts and superscripts. A chemical formula is not a chemical name, and it contains no words. Although a chemical formula may imply certain simple chemical structures, it is not the same as a full chemical structural formula. Chemical formulas can fully specify the structure of only the simplest of molecules and chemical substances and are generally more limited in power than are chemical names and structural formulas.

An ***amorphous*** (from the Greek a, without, morphé, shape, form) or non-crystalline solid is a solid that lacks the long-range order characteristic of a crystal. In some older books, the term has been used synonymously with glass. Nowadays, "amorphous solid" is considered to be the overarching concept, and glass the more special case: A glass is an amorphous solid that exhibits a glass transition.

A ***dislocation*** is a crystallographic defect, or irregularity, within a crystal structure. The presence of dislocations strongly influences many of the properties of materials.

A ***vein*** is a distinct sheet-like body of crystallized minerals within a rock. Veins form when mineral constituents carried by an aqueous solution within the rock mass are deposited through precipitation. The hydraulic flow involved is usually due to hydrothermal circulation

Euhedral crystals are those that are well-formed with sharp, easily recognized faces.

The ***Mohs scale*** of mineral hardness is a qualitative ordinal scale that characterizes the scratch resistance of various minerals through the ability of a harder material to scratch a softer material. It was created in 1812 by the German geologist and mineralogist Friedrich Mohs and is one of several definitions of hardness in materials science, some of which are more quantitative.

luster is the way light interacts with the surface of a crystal, rock, or mineral. A range of terms is used to describe luster, such as earthy, metallic, greasy, and silky. Similarly, the term vitreous (derived from the Latin for glass, vitreum) refers to a glassy luster.

The ***streak*** (also called "powder color") of a mineral is the color of the powder produced when it is dragged across an un-weathered surface.

Cleavage is the tendency of crystalline materials to split along definite crystallographic structural planes. These planes of relative weakness are a result of the regular locations of atoms and ions in the crystal, which create smooth repeating surfaces that are visible both in the microscope and to the naked eye.

Fracture is the shape and texture of the surface formed when a mineral is fractured. Minerals often have a highly distinctive fracture, making it a principal feature used in their identification. Fracture differs from cleavage in that the latter involves clean splitting along the cleavage planes of the mineral's crystal structure, as opposed to more general breakage. All minerals exhibit fracture, but when very strong cleavage is present, it can be difficult to see.

Specific gravity is the ratio of the density of a substance to the density of a reference substance; equivalently, it is the ratio of the mass of a substance to the mass of a reference substance for the same given volume.

Vugs (also spelled vugh) are small to medium-sized cavities inside a rock that may be formed through a variety of processes. Most commonly cracks and fissures opened by tectonic activity (folding and faulting) are partially filled by quartz, calcite, and other secondary minerals.

Native element minerals are those elements that occur in nature in uncombined form with a distinct mineral structure. The elemental class includes metals and intermetallic elements, naturally occurring alloys, semi-metals, and non-metals.

The ***sulfide minerals*** are a class of minerals containing sulfide (S^{2-}) as the major anion. Some sulfide minerals are economically important as metal ores. The sulfide class also includes the selenides, the tellurides, the arsenides, the antimonides, the bismuthinides, the sulfarsenides, and the sulfosalts.

The ***oxide mineral class*** includes those minerals in which the oxide anion (O^{2-}) is bonded to one or more metal ions. The hydroxide bearing minerals are typically included in the oxide class.

The ***halide mineral class*** includes those minerals with a dominant halide anion (F^-, Cl^-, Br^- and I^-). Complex halide minerals may also have polyatomic anions in addition to or those that include halides.

Carbonate minerals are those minerals containing the carbonate ion: CO_3^{2-}.

The ***silicate minerals*** are rock-forming, constituting approximately 90 percent of the crust of the Earth. They are classified based on the structure of their silicate group which contains different ratios of silicon and oxygen. They make up the largest and most important class of rock-forming minerals.

The ***pyroxenes*** (commonly abbreviated to Px) are a group of important rock-forming inosilicate minerals found in many igneous and metamorphic rocks. They share a common structure consisting of single chains of silica tetrahedra and they crystallize in the monoclinic and orthorhombic systems.

Amphibole /ˈæmfɨboʊl/ is the name of an important group of generally dark-colored, inosilicate minerals, forming a prism or needlelike crystals, composed of double chain SiO_4 tetrahedra, linked at the vertices and generally containing ions of iron and/or magnesium in their structures. Amphiboles can be green, black, colorless, white, yellow, blue, or brown.

The ***mica group*** of sheet silicate (phyllosilicate) minerals includes several closely related materials having nearly perfect basal cleavage. All are monoclinic, with a tendency towards pseudohexagonal crystals, and are similar in chemical composition. The nearly perfect cleavage, which is the most prominent characteristic of mica, is explained by the hexagonal sheet-like arrangement of its atoms.

Minerals

Silver (native metal) is a chemical element with the symbol **Ag** and atomic number 47. A soft, white, lustrous transition metal, it possesses the highest electrical conductivity, thermal conductivity, and reflectivity of any metal.

Gold (native metal) is a chemical element with the symbol **Au** (from Latin: aurum) and atomic number 79. In its purest form, it is a bright, slightly reddish yellow, dense, soft, malleable, and ductile metal.

Copper (native metal) is a chemical element with the symbol **Cu** (from Latin: cuprum) and atomic number 29. It is a soft, malleable, and ductile metal with very high thermal and electrical conductivity. A freshly exposed surface of pure copper has a reddish-orange color.

Diamond is a chemical element with symbol **C** (/ˈdaɪəmənd/ or /ˈdaɪmənd/; from the ancient Greek ἀδάμας – adámas "unbreakable") is a metastable allotrope of carbon, where the carbon atoms are arranged in a variation of the face-centered cubic crystal structure called a diamond lattice.

Graphite is a chemical element with symbol **C** /ˈɡræfaɪt/, archaically referred to as Plumbago, is a crystalline form of carbon, a semimetal, a native element mineral, and one of the allotropes of carbon. Graphite is the most stable form of carbon under standard conditions. Therefore, it is used in thermochemistry as the standard state for defining the heat of formation of carbon compounds. Graphite may be considered the highest grade of coal, just above anthracite and alternatively called meta-anthracite, although it is not normally used as fuel because it is difficult to ignite.

Chalcocite, copper (I) sulfide (**Cu_2S**), is an important copper ore mineral. It is opaque and dark gray to black with a metallic luster. It has a hardness of 2½ – 3 on the Mohs scale. It is a sulfide with an orthorhombic crystal system.

The term chalcocite comes from the alteration of the obsolete name-chalcosine, from the Greek khalkos, meaning copper. It is also known as redruthite, vitreous copper, and copper-glance.

Galena **(PbS)**, also called lead glance, is the natural mineral form of lead(II) sulfide. It is the most important ore of lead and an important source of silver.

Galena is one of the most abundant and widely distributed sulfide minerals. It crystallizes in the cubic crystal system often showing octahedral forms. It is often associated with the minerals sphalerite, calcite, and fluorite.

Stibnite, sometimes called ***antimonite***, is a sulfide mineral with the formula $\mathbf{Sb_2S_3}$. This soft grey material crystallizes in an orthorhombic space group. It is the most important source of metalloid antimony. The name is from the Greek στίβι stibi through the Latin stibium as the old name for the mineral and the element antimony.

Molybdenite is a mineral of molybdenum disulfide, $\mathbf{MoS_2}$. Similar in appearance and feel to graphite, molybdenite has a lubricating effect that is a consequence of its layered structure. The atomic structure consists of a sheet of molybdenum atoms sandwiched between sheets of sulfur atoms. The Mo-S bonds are strong, but the interaction between the sulfur atoms at the top and bottom of separate sandwich-like tri-layers is weak, resulting in easy slippage as well as cleavage planes. Molybdenite crystallizes in the hexagonal crystal system as the common polytype 2H and also in the trigonal system as the 3R polytype.

Sphalerite (**(Zn, Fe)S**) is a mineral that is the chief ore of zinc. It consists largely of zinc sulfide in crystalline form but almost always contains variable iron. When iron content is high it is an opaque black variety, marmatite. It is usually found in association with galena, pyrite, and other sulfides along with calcite, dolomite, and fluorite. Miners have also been known to refer to sphalerite as zinc blende, black-jack, and ruby jack.

Cinnabar and ***cinnabarine*** (**HgS**) (pronounced /ˈsɪnəbɑr/ and /sɪnəˈbɑraɪt/), likely deriving from the Greek κινναβαρι (kinnabari), refer to the common bright scarlet to the brick-red form of mercury(II) sulfide, formula HgS, that is the most common source ore for refining elemental mercury, and is the historic source for the brilliant red or scarlet pigment termed vermilion and associated red mercury pigments.

Cinnabar generally occurs as a vein-filling mineral associated with recent volcanic activity and alkaline hot springs. The mineral resembles the quartz in symmetry and its exhibiting birefringence

Realgar, α-$\mathbf{As_4S_4}$, is an arsenic sulfide mineral, also known as "ruby sulfur" or "ruby of arsenic". It is a soft, sectile mineral occurring in monoclinic crystals, or in granular, compact, or powdery form, often in association with the related mineral, orpiment (As_2S_3). It is orange-red, melts at 320 °C, and burns with a bluish flame releasing fumes of arsenic and sulfur. Realgar is soft with a Mohs hardness of 1.5 to 2 and has a specific gravity of 3.5. Its streak is orange-colored.

The mineral ***pyrite***, or iron pyrite, also known as fool's gold, is an iron sulfide with the chemical formula **FeS_2**. This mineral's metallic luster and pale brass-yellow hue give it a superficial resemblance to gold, hence the well-known nickname of fool's gold.

Chalcopyrite is a copper iron sulfide mineral that crystallizes in the tetragonal system. It has the chemical formula **$CuFeS_2$**. It has a brassy to golden yellow color and a hardness of 3.5 to 4 on the Mohs scale. Its streak is diagnostic as green-tinged black. On exposure to air, chalcopyrite oxidizes to a variety of oxides, hydroxides, and sulfates. Associated copper minerals include the sulfides: bornite (Cu_5FeS_4), chalcocite (Cu_2S), covellite (CuS); carbonates such as malachite, and azurite, and rarely oxides such as cuprite (Cu_2O). Chalcopyrite is rarely found in association with native copper (Cu).

Pyrrhotite is an iron sulfide mineral with the formula **$Fe_{(1-x)}S$** (x = 0 to 0.2). It is a nonstoichiometric variant of this, the mineral known as troilite. Pyrrhotite is also called magnetic pyrite because the color is similar to pyrite and it is weakly magnetic. The magnetism decreases as the iron content increases, and troilite is non-magnetic.

Cuprite is an oxide mineral composed of copper (I) oxide **Cu_2O** and is a minor ore of copper. Its dark crystals with red internal reflections are in the isometric system hexoctahedral class, appearing as cubic, octahedral, or dodecahedral forms, or in combinations. Penetration twins frequently occur.

Corundum is a crystalline form of aluminum oxide (**Al_2O_3**) typically containing traces of iron, titanium, vanadium, and chromium. It is a rock-forming mineral. It is one of the naturally transparent materials but can have different colors when impurities are present. Transparent specimens are used as gems, called ruby if red and padparadscha if pink-orange. All other colors are called sapphire, e.g., "green sapphire" for a green specimen. Because of corundum's hardness (pure corundum is defined to have 9.0 Mohs), it can scratch almost every other mineral. It is commonly used as an abrasive on everything from sandpaper to large machines used in machining metals, plastics, and wood. Corundum occurs as a mineral in mica schist, gneiss, and some marbles in metamorphic terranes. It also occurs in low silica igneous syenite and nepheline syenite intrusives.

Hematite, is the mineral form of iron(III) oxide (**Fe_2O_3**), one of several iron oxides. Hematite crystallizes in the rhombohedral lattice system, and it has the same crystal structure as ilmenite and corundum. Hematite and ilmenite form a complete solid solution at temperatures above 950 °C (1,740 °F). Hematite is a mineral, colored black to steel or silver-gray, brown to reddish-brown, or red. It is mined as the main ore of iron. Varieties include kidney ore, martite (pseudomorphs after magnetite), iron rose, and specularite (specular hematite). While the forms of hematite vary, they all have a rust-red streak.

Rutile is a mineral composed primarily of titanium dioxide, $\mathbf{TiO_2}$.

Rutile is the most common natural form of TiO_2. Rutile is a common accessory mineral in high-temperature and high-pressure metamorphic rocks and igneous rocks.

Thermodynamically, rutile is the most stable polymorph of TiO_2 at all temperatures.

Chromite is an iron chromium oxide: $\mathbf{FeCr_2O_4}$. It is an oxide mineral belonging to the spinel group. Magnesium can substitute for iron in variable amounts as it forms a solid solution with magnesiochromite ($MgCr_2O_4$); substitution of aluminum occurs leading to hercynite ($FeAl_2O_4$). It is an industrially important mineral for the production of metallic chromium, used as an alloying ingredient in stainless and tool steels.

Quartz is the second most abundant mineral in the Earth's continental crust, after feldspar. Its crystal structure is a continuous framework of SiO_4 silicon-oxygen tetrahedra, with each oxygen being shared between two tetrahedra, giving an overall chemical formula of $\mathbf{SiO_2}$.

Opal is a hydrated amorphous form of silica ($\mathbf{SiO_2 \cdot nH_2O}$); its water content may range from 3 to 21 % by weight but is usually between 6 and 10 %. Because of its amorphous character, it is classed as a mineraloid, unlike crystalline forms of silica, which are classed as minerals. It is deposited at a relatively low temperature and may occur in the fissures of almost any kind of rock, being most commonly found with limonite, sandstone, rhyolite, marl, and basalt. Opal is the national gemstone of Australia.

Halite /ˈhælaɪt/, commonly known as rock salt, is a type of salt, the mineral form of sodium chloride (**NaCl**). Halite forms isometric crystals. The mineral is typically colorless or white, but may also be light blue, dark blue, purple, pink, red, orange, yellow, or gray depending on the amount and type of impurities. It commonly occurs with other evaporite deposit minerals such as several sulfates, halides, and borates.

Fluorite (also called fluorspar) is the mineral form of calcium fluoride, $\mathbf{CaF_2}$. It belongs to the halide minerals. It crystallizes in isometric cubic habit, although octahedral and more complex isometric forms are not uncommon. Fluorite is a colorful mineral, both in visible and ultraviolet light, and the stone has ornamental and lapidary uses. Industrially, fluorite is used as a flux for smelting, and in the production of certain glasses and enamels. The purest grades of fluorite are a source of fluoride for hydrofluoric acid manufacture, which is the intermediate source of most fluorine-containing fine chemicals.

Calcite is a carbonate mineral and the most stable polymorph of calcium carbonate ($\mathbf{CaCO_3}$). The other polymorphs are the minerals aragonite and vaterite. Aragonite will change to calcite at 380–470 °C and vaterite is even less stable.

Magnesite is a mineral with the chemical formula $\mathbf{MgCO_3}$ (magnesium carbonate). Mixed crystals of iron (II) carbonate and magnesite (mixed crystals known as ankerite) possess a layered structure: monolayers of carbonate groups alternate with magnesium monolayers as well as iron(II) carbonate monolayers. Magnesite occurs as veins in and an alteration product of ultramafic rocks, serpentinite, and other magnesium-rich rock types in both contact and regional metamorphic terrains. These magnesites often are cryptocrystalline and contain silica in the form of opal.

Siderite is a mineral composed of iron (II) carbonate ($\mathbf{FeCO_3}$). It takes its name from the Greek word σίδηρος sideros, "iron". It is a valuable iron mineral since it is 48 % iron and contains no sulfur or phosphorus. It crystallizes in the trigonal crystal system and is rhombohedral in shape, typically with curved and striated faces. It also occurs in masses. Color ranges from yellow to dark brown or black, the latter being due to the presence of manganese. Siderite is commonly found in hydrothermal veins and is associated with barite, fluorite, galena, and others. It is also a common diagenetic mineral in shales and sandstones, where it sometimes forms concretions, which can encase three-dimensional preserved fossils. In sedimentary rocks, siderite commonly forms at shallow burial depths and its elemental composition is often related to the depositional environment of the enclosing sediments. In addition, some recent studies have used the oxygen isotopic composition of sphaerosiderite (a type associated with soils) as a proxy for the isotopic composition of meteoric water shortly after deposition.

Aragonite is a carbonate mineral, one of the two common, naturally occurring, crystal forms of calcium carbonate, $\mathbf{CaCO_3}$ (the other form being the mineral calcite). It is formed by biological and physical processes, including precipitation from marine and freshwater environments.

Aragonite's crystal lattice differs from that of calcite, resulting in a different crystal shape, an orthorhombic system with acicular crystals. Repeated twinning results in pseudo-hexagonal forms. Aragonite may be columnar or fibrous, occasionally in branching stalactitic forms called flos-ferri ("flowers of iron") from their association with the ores at the Carinthian iron mines.

Dolomite /ˈdɒləmaɪt/ is an anhydrous carbonate mineral composed of calcium magnesium carbonate, ideally **$CaMg[CO3]_2$**. The word dolomite is also used to describe the sedimentary carbonate rock, which is composed predominantly of the mineral dolomite (also known as dolostone).

Malachite is a copper carbonate hydroxide mineral, with the formula **$Cu_2[CO_3](OH)_2$**. This opaque, green-banded mineral crystallizes in the monoclinic crystal system, and most often forms botryoidal, fibrous, or stalagmitic masses, in fractures and spaces, deep underground, where the water table and hydrothermal fluids provide the means for chemical precipitation. Individual crystals are rare but do occur as slender to acicular prisms. Pseudomorphs after more tabular or blocky azurite crystals also occur.

Azurite is a soft, deep blue copper mineral produced by weathering of copper ore deposits.

Apatite (**$Ca_5[PO_4]_3(F, OH, Cl)$**) is a group of phosphate minerals, usually referring to hydroxylapatite, fluorapatite, and chlorapatite, with high concentrations of OH^-, F^- and Cl^- ions, respectively, in the crystal. Apatite is one of a few minerals produced and used by biological micro-environmental systems. Apatite is the defining mineral for 5 on the Mohs scale. The primary use of apatite is in the manufacture of fertilizer – it is a source of phosphorus. It is occasionally used as a gemstone. Green and blue varieties, in finely divided form, are pigments with excellent covering power.

The mineral ***olivine*** is a magnesium iron silicate with the formula **$(Mg, Fe^{2+})_2[SiO_4]$**. Compositions of olivine are commonly expressed as molar percentages of forsterite (Fo) and fayalite (Fa) (e.g., $Fo_{70}Fa_{30}$).

Garnets /ˈɡɑrnət/ are a group of silicate minerals that have been used since the Bronze Age as gemstones and abrasives.

All species of garnets possess similar physical properties and crystal forms but differ in chemical composition. The different species are pyrope, almandine, spessartine, grossular (varieties of which are hessonite or cinnamon-stone and tsavorite), uvarovite, and andradite. The garnets make up two solid solution series: pyrope-almandine-spessartine and uvarovite-grossular-andradite.

Zircon (/ˈzɜrkɒn/ or /ˈzɜrkən), including hyacinth or yellow zircon) is a mineral belonging to the group of nesosilicates. Its chemical name is zirconium silicate and its corresponding chemical formula is $\mathbf{Zr[SiO_4]}$.

Kyanite ($\mathbf{Al_2O[SiO_4]}$), whose name derives from the Greek word kuanos sometimes referred to as "kyanos", meaning deep blue, is a typically blue silicate mineral, commonly found in aluminum-rich metamorphic pegmatites and/or sedimentary rock. Kyanite in metamorphic rocks generally indicates pressures higher than four kilobars. Although potentially stable at lower pressure and low temperature, the activity of water is usually high enough under such conditions that it is replaced by hydrous aluminosilicates such as muscovite, pyrophyllite, or kaolinite. Kyanite is also known as disthene.

Beryl is a mineral composed of beryllium aluminum cyclosilicate with the chemical formula $\mathbf{Be_3Al_2[Si_6O_{18}]}$. The hexagonal crystals of beryl may be very small or range to several meters in size. Terminated crystals are relatively rare. Pure beryl is colorless, but it is frequently tinted by impurities; possible colors are green, blue, yellow, red, and white.

Tourmaline (/ˈtʊərməliːn/ TOOR-mə-leen) is a crystalline boron silicate mineral compounded with elements such as aluminum, iron, magnesium, sodium, lithium, or potassium. Tourmaline is classified as a semi-precious stone and the gemstone comes in a wide variety of colors.

Enstatite is a mineral; the magnesium endmember of the pyroxene silicate mineral series enstatite $\mathbf{Mg[Si_2O_6]}$ – ferrosilite $Fe[Si_2O_6]$). The magnesium-rich members of the solid solution series are common rock-forming minerals found in igneous and metamorphic rocks. The intermediate composition, (Mg, Fe) $[Si_2O_6]$, has historically been known as hypersthene, although this name has been formally abandoned and replaced by orthopyroxene. When determined petrographically or chemically the composition is given as relative proportions of enstatite (En) and ferrosilite (Fs) (e.g., $En_{80}Fs_{20}$).

Diopside is a monoclinic pyroxene mineral with the composition $\mathbf{MgCa[Si_2O_6]}$. It forms complete solid solution series with hedenbergite

$FeCa[Si_2O_6]$ and augite, and partial solid solutions with orthopyroxene and pigeonite. It forms variably colored, but typically dull green crystals in the monoclinic prismatic class. It has two distinct prismatic cleavages at 87 and 93° typical of the pyroxene series. It has a Mohs hardness of six.

Hedenbergite, **$FeCa[Si_2O_6]$** is the iron-rich end-member of the pyroxene group having a monoclinic crystal system. The mineral is extremely rarely found as a pure substance and usually has to be synthesized in a lab. Contact metamorphic rocks high in iron are the primary geologic setting for hedenbergite. This mineral is unique because it can be found in chondrites and skarns (calc-silicate metamorphic rocks). Since it is a member of the pyroxene family, there is a great deal of interest in its importance to general geologic processes.

Aegirine is a member of the clinopyroxene group of inosilicates. Aegirine is the sodium endmember of the aegirine-augite series. Aegirine has the chemical formula **$NaFe[Si_2O_6]$** in which the iron is present as Fe^{3+}. In the aegirine-augite series, the sodium is variably replaced by calcium with iron (II) and magnesium replacing the iron (III) to balance the charge. Aluminum also substitutes for iron (III). It is also known as acmite, which is a fibrous, green-colored variety. Aegirine occurs as dark green monoclinic prismatic crystals. It has a glassy luster and perfect cleavage. The Mohs hardness varies from 5 to 6 and the specific gravity is 3.2 to 3.4

Spodumene is a pyroxene mineral consisting of lithium aluminum inosilicate, **$LiAl[Si_2O_6]$**, and is a source of lithium. It occurs as colorless to yellowish, purplish, or lilac kunzite (see below), yellowish-green or emerald-green hiddenite, prismatic crystals, often of great size.

Wollastonite is a calcium inosilicate mineral **$Ca_3[Si_3O_9]$** that may contain small amounts of iron, magnesium, and manganese substituting for calcium. It is usually white. It forms when impure limestone or dolostone is subjected to high temperature and pressure sometimes in the presence of silica-bearing fluids as in skarns or contact metamorphic rocks. Associated minerals include garnets, vesuvianite, diopside, tremolite, epidote, plagioclase feldspar. It is named after the English chemist and mineralogist William Hyde Wollaston (1766–1828).

Rhodonite is a manganese inosilicate, **$CaMn_4[Si_5O_{15}]$,** and a member of the pyroxenoid group of minerals, crystallizing in the triclinic system.

It commonly occurs as cleavable to compact masses with a rose-red color (the name comes from the Greek ῥόδος Rhodos, rosy), often tending to brown because of surface oxidation. Rhodonite crystals often have a thick tabular habit but are rare. It has perfect, prismatic cleavage, almost at right angles. The hardness is 5.5–6.5, and the specific gravity 3.4–3.7; luster is vitreous, being less frequently pearly on cleavage surfaces.

Tremolite is a member of the amphibole group of silicate minerals with composition: $\mathbf{Ca_2(Mg)_5[Si_4O_{11}]_2(OH)_2}$. Tremolite forms by metamorphism of sediments rich in dolomite and quartz. Tremolite forms a series with actinolite and ferro-actinolite. Pure magnesium tremolite is creamy white, but the color grades to dark green with increasing iron content. It has a hardness on a Mohs scale of 5 to 6. Nephrite, one of the two minerals of the gemstone jade, is a green variety of tremolite.

Actinolite is an amphibole silicate mineral with the chemical formula $\mathbf{Ca_2(Mg, Fe)_5[Si_4O_{11}]_2(OH)_2}$ name actinolite is derived from the Greek word aktis (ἀκτίς), meaning "beam" or "ray", because of the mineral's fibrous nature.

Hornblende is a complex inosilicate series of minerals (ferrohornblende – magnesio-hornblende). It is not a recognized mineral in its own right, but the name is used as a general or field term, to refer to a dark amphibole.

Hornblende is an isomorphous mixture of three molecules; a calcium-iron-magnesium silicate, an aluminum-iron-magnesium silicate, and an iron-magnesium silicate.

Talc is a mineral composed of hydrated magnesium silicate with the chemical formula $\mathbf{Mg_3[Si_4O_{10}](OH)_2}$. In loose form, it is the widely used substance known as a baby powder (aka talcum). It occurs as foliated to fibrous masses, and in an exceptionally rare crystal form. It has perfect basal cleavage, and the folia are non-elastic, although slightly flexible.

The ***chlorites*** are a group of phyllosilicate minerals. Chlorites can be described by the following four endmembers based on their chemistry via substitution of the following four elements in the silicate lattice: Mg, Fe, Ni, and Mn. The range of chemical composition allows chlorite group minerals to exist over a wide range of temperature and pressure conditions. For this reason, chlorite minerals are ubiquitous minerals within low and medium-temperature metamorphic rocks, igneous rocks, hydrothermal rocks, and deeply buried sediments. The typical general formula is $\mathbf{Mg_5Al[AlSi_3O_{10}]OH_8}$.

The name chlorite is from the Greek chloros (χλωρός), meaning "green", about its color. They do not contain the element chlorine, also named from the same Greek root.

The ***serpentine*** group describes a group of common rock-forming hydrous magnesium iron phyllosilicate $\mathbf{(Mg, Fe)_6[Si_4O_{10}](OH)_8}$ minerals, resulting from the metamorphism of the minerals that are contained in ultramafic rocks. They may contain minor amounts of other elements including chromium, manganese, cobalt, or nickel. In mineralogy and gemology, serpentine may refer to any of 20 varieties belonging to the serpentine group. Owing to admixture, these varieties are not always easy to individualize, and distinctions are not usually made. There are three important mineral polymorphs of serpentine: antigorite, chrysotile, and lizardite. The serpentine group of minerals is polymorphous, meaning that they have the same chemical formulae, but the atoms are arranged into different structures or crystal lattices. Chrysotile, which has a fibrous habit, is one polymorph of serpentine and is one of the more important asbestos minerals. Other polymorphs in the serpentine group may have a platy habit. Antigorite and lizardite are polymorphs with platy habit.

Biotite is a common phyllosilicate mineral within the mica group, with the approximate chemical formula $\mathbf{K(Mg, Fe)_3[AlSi_3O_{10}](OH, F)_2}$. More generally, it refers to the dark mica series, primarily a solid-solution series between the iron-endmember annite, and the magnesium-endmember phlogopite; more aluminous end-members include siderophyllite.

Muscovite (also known as common mica, isinglass, or potash mica) is a phyllosilicate mineral of aluminum and potassium with formula $\mathbf{K(Al)_2[AlSi_3O_{10}](OH, F)_2}$. It has a highly perfect basal cleavage yielding remarkably thin laminæ (sheets) which are often highly elastic.

Lepidolite is a lilac-gray or rose-colored member of the mica group with formula $\mathbf{KLi_{1,5}Al_{1,5}[AlSi_3O_{10}](F, OH)_2}$. It is a secondary source of lithium. It is a phyllosilicate mineral and a member of the polylithionite-trilithionite series. It is associated with other lithium-bearing minerals like spodumene in pegmatite bodies. It is one of the major sources of the rare alkali metals rubidium and cesium. it occurs in granite pegmatites, in some high-temperature quartz veins, greisens, and granites. Associated minerals include quartz, feldspar, spodumene, tourmaline, columbite, cassiterite, topaz, and beryl.

Microcline **K[$AlSi_3O_8$]** is an important igneous rock-forming tectosilicate mineral. It is a potassium-rich alkali feldspar. Microcline typically contains minor amounts of sodium. It is common in granite pegmatites. Microcline forms during slow cooling of orthoclase; it is more stable at lower temperatures than orthoclase. Sanidine is a polymorph of alkali feldspar stable at a yet higher temperature. Microcline may be clear, white, pale-yellow, brick-red, or green; it is generally characterized by cross-hatch twinning that forms as a result of the transformation of monoclinic orthoclase into triclinic microcline.

Albite is a plagioclase feldspar mineral. It is the sodium endmember of the plagioclase solid solution series. As such it represents a plagioclase with less than 10 % anorthite content. The pure albite endmember has the formula **Na[$AlSi_3O_8$]**. It is a tectosilicate. Its color is usually pure white, hence its name from Latin albums. It is a common constituent in felsic rocks.

Labradorite **(Ca, Na)[Al, Si)$_3O_8$]**, a feldspar mineral is an intermediate to calcic member of the plagioclase series. It has an anorthite percentage (%An) of between 50 and 70. The specific gravity ranges from 2.68 to 2.72. The streak is white, like most silicates.

Nepheline, also called nephelite (from Greek: νεφέλη, "cloud"), is a feldspathoid: a silica-undersaturated aluminosilicate, **Na[$AlSiO_4$]**, that occurs in intrusive and volcanic rocks with low silica, and in their associated pegmatites.

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The printed length of the final project work is 10–20 pages. The text should be containing an introduction, main part, conclusions, and reference list. No more than 50 % of the printed document should consist of figures and tables. Use a normal, plain font (e.g., 14-point Times Roman) for text. Use the automatic page numbering function to number the pages. Please use no more than three levels of displayed headings.

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