TOMSK POLYTECHNIC UNIVERSITY

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GUIDE BOOK
GEOECOLOGICAL EDUCATIONAL TRAINING IN KHAKASIA

Tutorial

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This tutorial briefly describes main geoecological educational training conduction materials for students from Geoecological Department. Basing on natural and mining – industrial systems this tutorial reveals Geoecological problems of mineral lakes, extractive and processing ore – mining industries and also the attention was paid to the waste fields.

The tutorial was prepared by Geoecology and Geochemistry Department, Tomsk Polytechnic University and is intended for students of specialty 013600 "Geoecology" (code 020804 in OKSO-2003).

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CONTENT

INTRODUCTION

Geological educational training in Khakasia has been carried out for over 40 years on the training ground base of Geology and Oil & Gas Institute, Tomsk Polytechnic University (TPU). The location of the training base was chosen very successfully, on the lake Sobachje (Fig. 1), by G.A. Ivankin in 1959. According to the specialists' opinion, TPU educational training ground is build up in one of the best places of Russia where natural geological history is fully presented.

Three week educational geoecological training in Khakasia, on TPU's geological training ground base, with the students of specialty 013600 "Geoecology" in 1997–2003, allowed evaluating the appropriateness of geological objects and enterprises for conducting geological training and developing further cooperation with foreign partners.

Area of educational training, which is situated in the coupling zone of multiage structures of Kuzneckij Alatau, Batenjovskij mountain-ridge and Chebakovo-Balakhtenskaja cavity, represents a very interesting geological object (Ivankin, 1979; Geology, 1998). It is also unique according to its nature – climate peculiarities (Guide…, 1969). Variety of flora and fauna together with the combination of different landscape zones, starting from steppe plains which change into forest-steppe and taiga up to the mountains, allows for discovery of the features in natural formation (Fig. 2, 3, 4). The development of soil on the territory of Khakasia, both in mountain and hollow areas, conditioned on the macroprocesses of soil formation such as sod, saline, podzol gley and peat. Visual teaching methods, based on direct observation, provide a good possibility for students to consolidate their knowledge in such subjects as "Landscape science" and "Soil science" (Gradoboev, 1954; Kulikova, 1976).

Mining-resource industrial complex in Khakasia is known from the early ages (Sunchugashev, 1975 and etc.) and nowadays it is represented by different spheres of mining manufacture (coal, gold, copper, molybdenum, marble and etc.). Students are visiting main natural and mining establishments of Khakasia during three weeks. While training they film the main objects, collect rock and soil samples, ground sediments, slag-heap and tailing pit samples for studying and fulfilling the degree work.

During educational process the collected samples are analyzed and prepared for analytical research applying laser microanalyser and X-ray photography structural analysis. Also researches are carried out by nuclear geochemical laboratory of TPU's Geochemical and Geoecology Department, "Berezovgeologia" analytical base and other special laboratories. Upon the material of educational training students fulfill degree works. The most interesting are presented on the annual International Scientific Symposium for students, post – graduates and young scientists, named after academician M.A. Usov.

Fig. 1. Training ground base of Geology and Oil & Gas Institute of Tomsk Polytechnic University

Fig. 2. Multilevel Khakasian relief is emphasized by ancient planation surface

The authors of this tutorial made an attempt to reveal briefly the most interesting and significant routes of geoecological context, which would be suitable for conducting educational training (Fig. 5).

Fig. 3. At the point over 1500 meters there are snowflake even in summer

Fig. 4. Typical feature of the Khakasian forest-steppe part.
Steppe feather grass on southern slopes
of the hills and woods on the northern slopes

Special thanks for contribution in educational training conducting to the staff of Geological, Mineralogical and Mineral exploration department – B.D. Vasyljev, A.A. Potseluev, L.V. Peshekhonov, S.S. Gugimovich, I.I. Koptev, Y.S. Ananjev, V.S. Nekrasov, M.V. Sheldibin, D.S. Apenishev; to the sponsor, postgraduate of the year 1972 director FGUP "Bereg", V.K. Kondrin; manager of the municipal enterprise MPZK "Kompleks"

V.A. Areshkov, manager of the Shirinsk auto park G.A. Mukhin for providing auto transport and to the drivers J.N. Duleba and others.

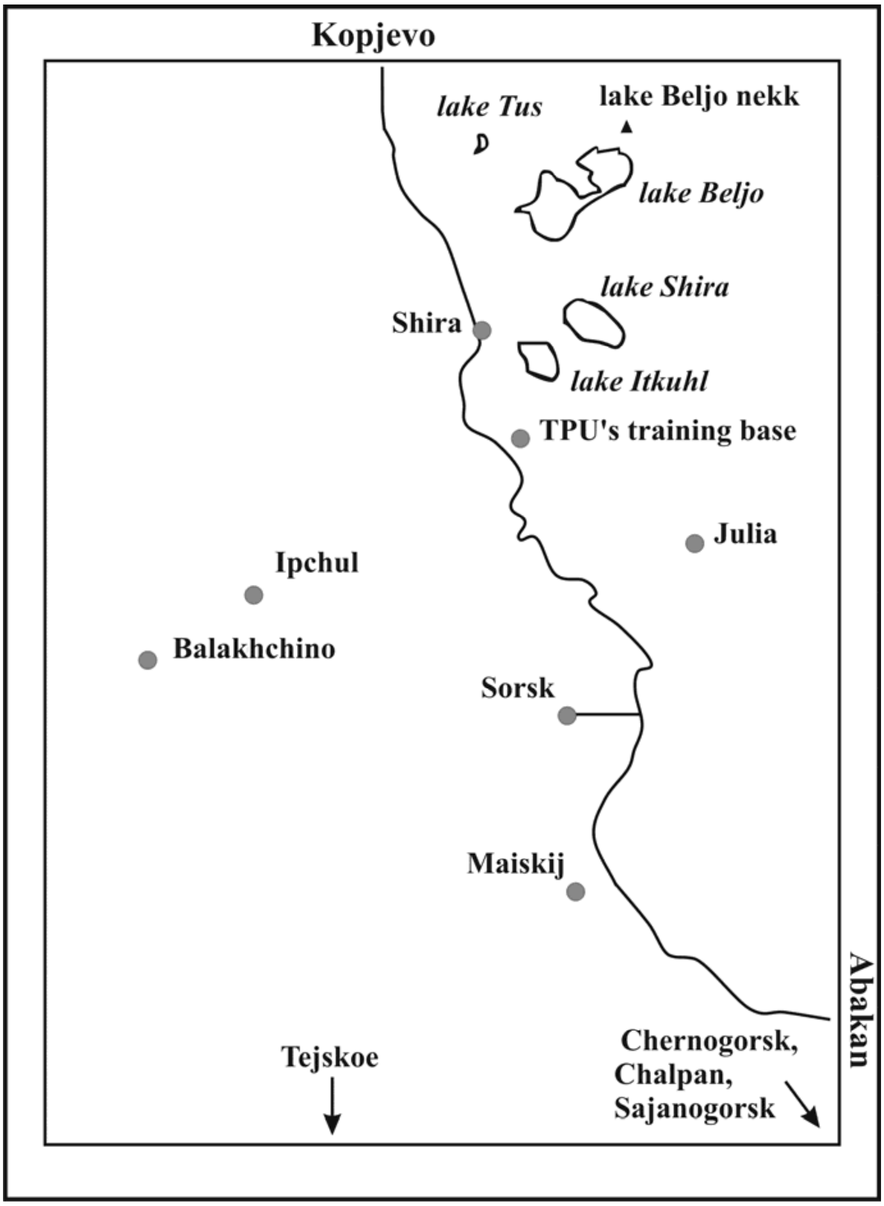


Fig. 5. Scheme of geoecological excursion round Khakasian republic

Successful conducting of geoecological educational training on different stages is provided by heads of Nature Resource and Environment authority: A.M. Adam, V.V. Goltsov, I.I. Vishnevetskij, V.V. Korjagin; heads of state forest reserves “Khakasia” and “Chazi”.

The photos presented in this guide book were made during educational training by E.G. Jazikov (1997–1999), S.I. Arbuzov (1998–2004), and also by students of “Geoecology” specialty A.A. Kumarjkov (Fig. 2, 3, 4) and E. Sergeeva (Fig. 31, 32).

CHAPTER 1. GEOECOLOGICAL REGION OF EDUCATIONAL TRAINING. GENERAL GEOGRAPHICAL AND GEOLOGICAL CHARACTERISTIC

Republic Khakasia is situated on the south of Siberia (Fig. 6). Khakasian natural boundaries are presented by high mountains and water ways. On the West the border goes through the Kuzneck Alatau watershed and Abakan mountain ridge. On the south – west the border and the Altay republic goes through the river basin Bolshoi Abakan. The southern border and the republic of Tiva lies on the axle mountain ridge of western Sajan and its branches – Kantegirskij and Sabinskij mountain ridges. Eastern border between Khakasia and Krasnoyarsk region goes through Yenisey river, Krasnoyarsk water basin and Dzhebash mountain ridge. Only the northern Khakasian border with Krasnojarsk region does not have the distinct natural boundaries – it crosses the steppe area of Chulimo – Yeniseysk basin.

The surface of the Khakasian republic is divided into two parts – mountainous (2/3 of the whole territory) and hilly – plain. Plain areas of the basins are confined to the wide valleys of Yenisey and Abakan rivers and their creeks. Khakasian highest point (2930 m) is the town of Karatash (Karatas) which is located on the mountain range of Eastern Sayan. The lowest point (243 m) – the level of Krasnojarsk water basin. The highest point of TPU's geological training ground area in Khakasia – 2178 m (mountain Verhnij Zub).

Khakasian climate is strongly continental (Fig. 7). South – east winds are prevailing. Average air moisture is 75…80 %. Average air temperature in July is +17 °C – +19 °C, maximum reaches +35 °C – +39 °C. Average air temperature in January is –21 °C, minimum is –53 °C. Annual precipitation amount 250…300 mm, at the foothills 500…700 mm, maximum amount of precipitation is observed in July.

Khakasia is rich in different water sources (Fig. 8). Numerous rivers, natural sweet and salt lakes, water basins, underground water-bearing horizon.

The republic estimetes 324 rivers, 4 large – Yenisey, Abakan, Chulym and Tom. The total rivers length is 8 000 km.

Khakasia is often called the country of lakes. The lakes are distinguished according to water mineralization – sweet, saltish and salty. The most large ones are – sweet lake Itkol (Itkul), salt lake Beljo and artificial lake Sosnovoe.

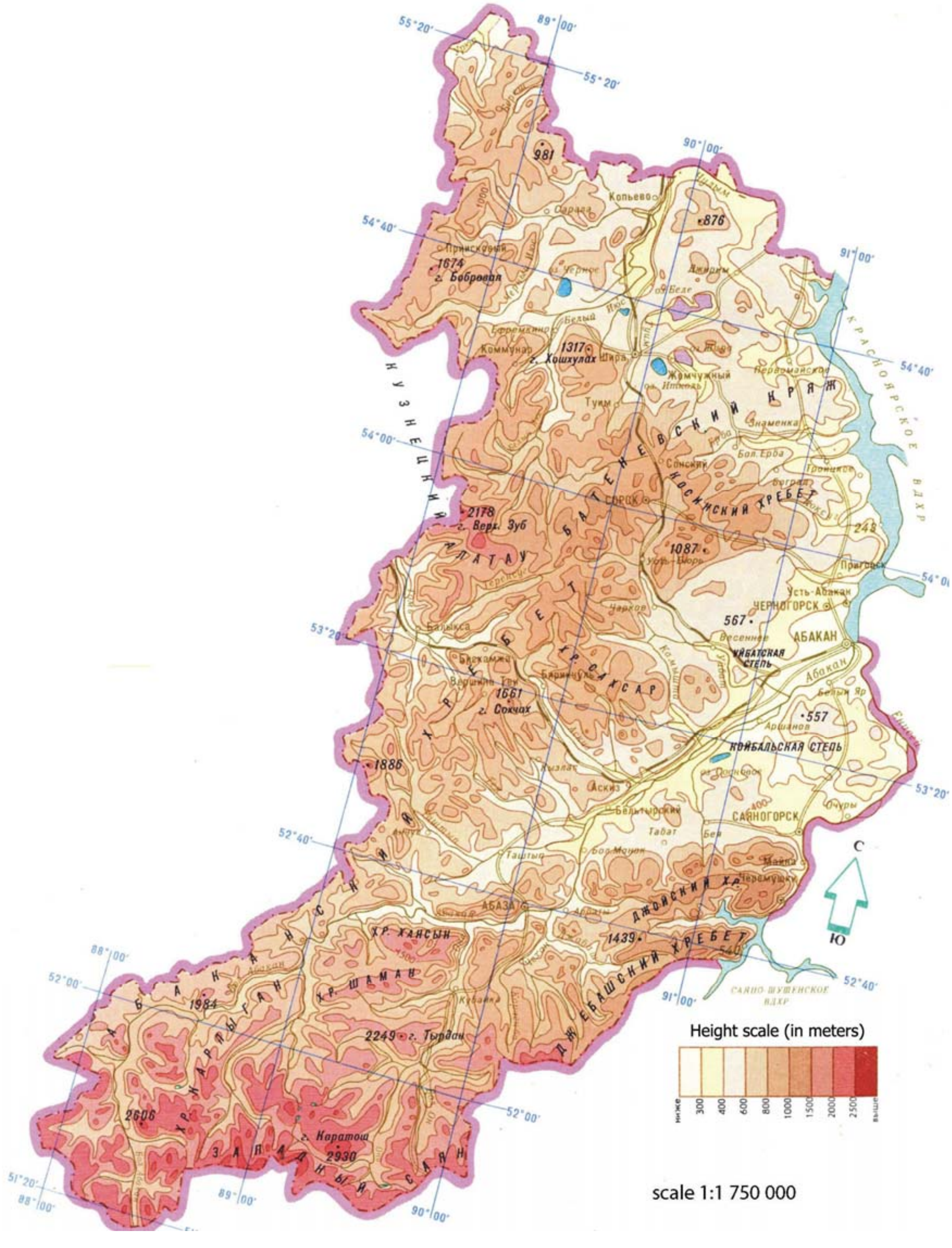


Fig. 6. Physical map of Khakasian republic
(according to atlas of Khakasian republic, 1998)

The total number of lakes is about 500, water – surface area covers over 10 hectares and includes 390 sweet and 110 salt lakes. In dry steppe areas of the republic artificial sweet water basins were made for irrigation. The total amount is about 100. Besides, there are about 50 irrigation systems. The largest ones are Abakanskaja and Kojbalskaja. Two large water basins were created on Yenisey river in eastern part of the republic: Krasnojarskoe – length 388 km, square 2 000 km^2, depth 105 m, volume 73,3 km^3; and Sajano-Shushenskoje – square 621 km^2, depth up to 220 m, volume 31,3 km^3.

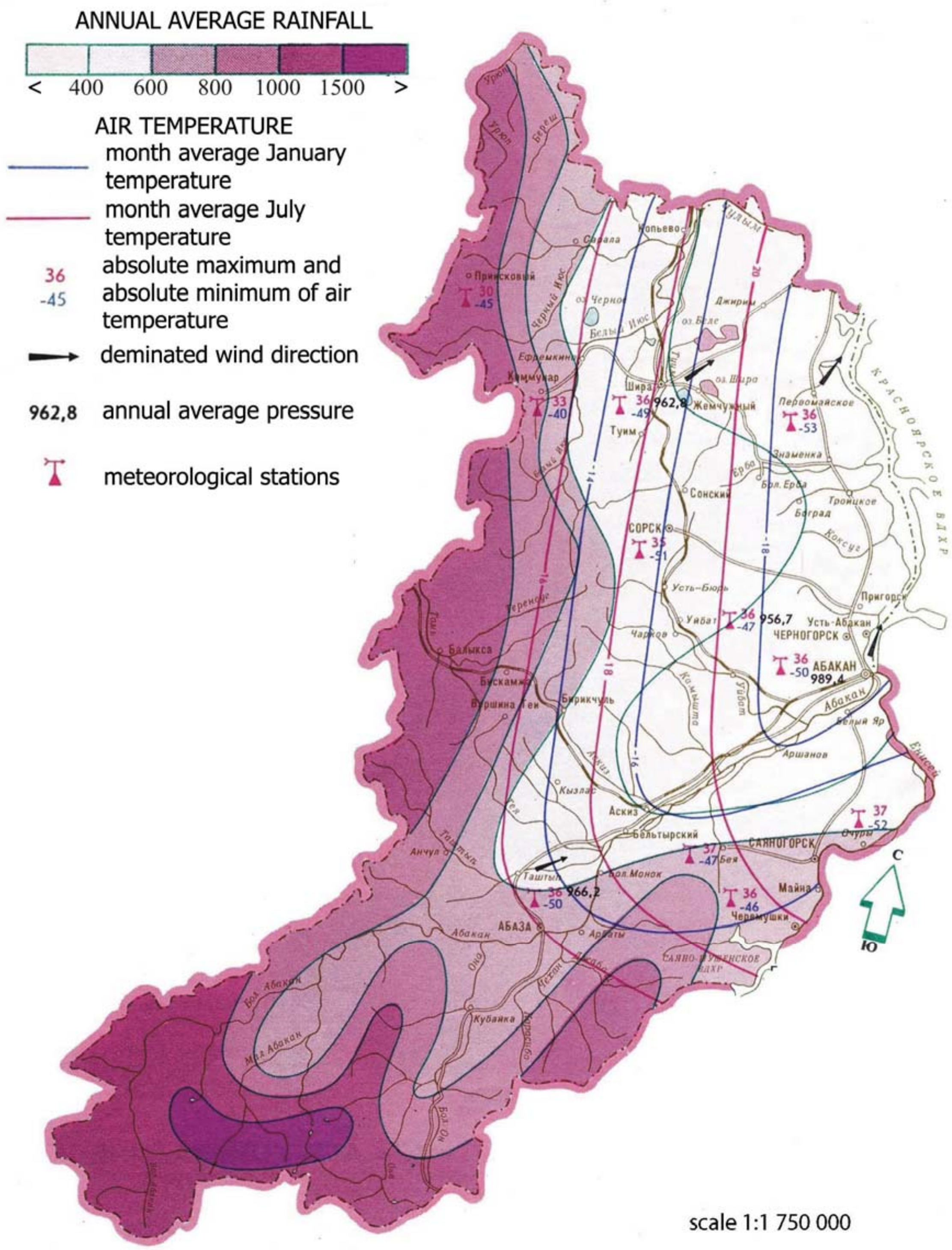


Fig. 7. Climate (according to the atlas of Khakasian republic, 1998)

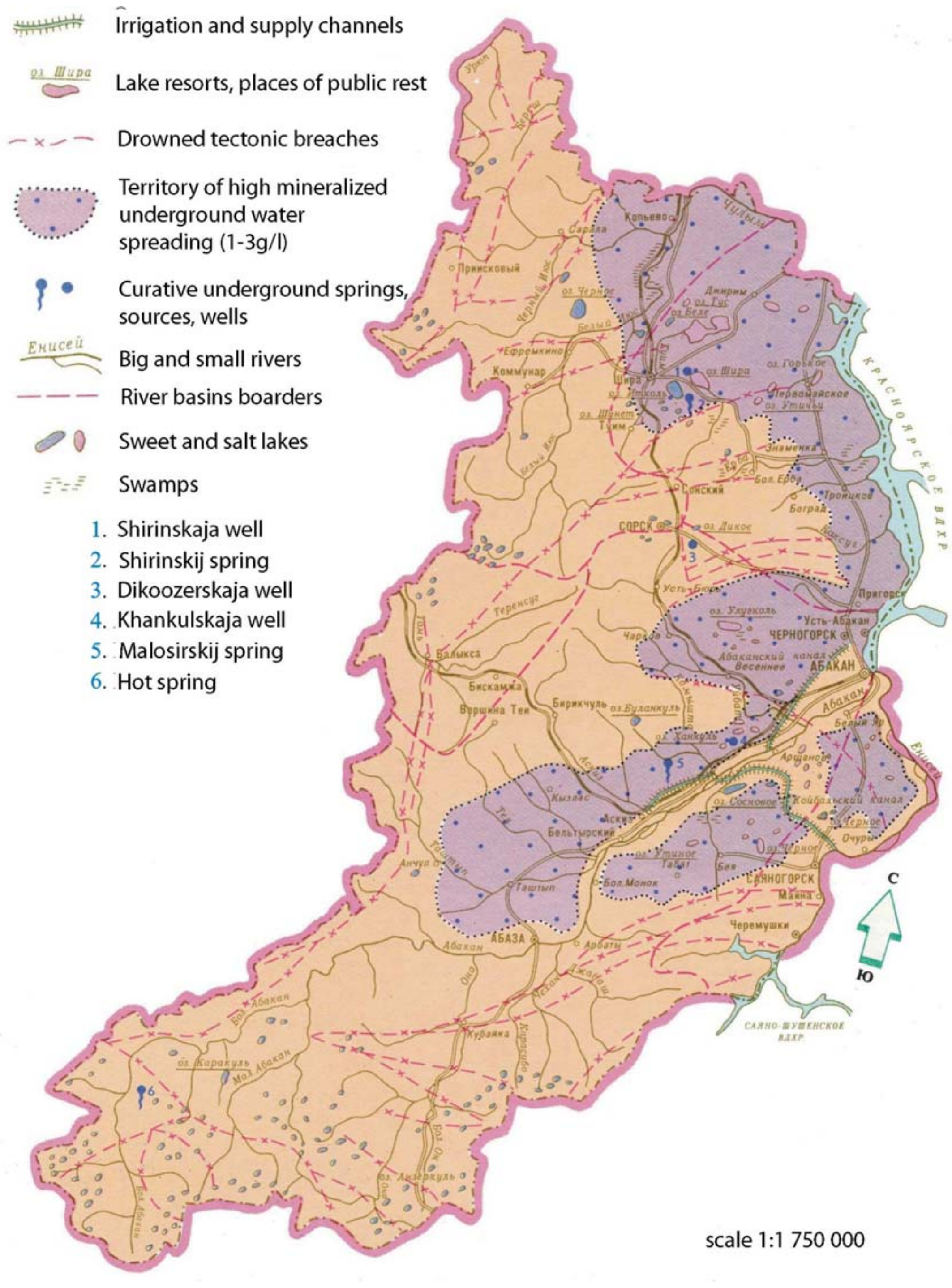


Fig. 8. Water resources (according to the atlas of Khakasian republic, 1998)

There are not so many swamps in Khakasia – they occupy at about 1 % of the whole republic square. Underground waters of Khakasia belong to the several water-bearing horizons and complexes (Fig. 8). According to the period of formation the underground waters vary in mineralization and thickness of water-bearing layer. In places of tectonic faults water comes to the surface generating springs and water sources.

Khakasian soil differs in variety and complexity (Fig. 9). Hilly-tundra soils form the upper belt in the system of vertical soil zones. In Zapadnij Sajan and Kuzneck Alatau these soils appear at the height of 1400…2000 m.

Hilly – field soils develop under the grassy vegetation of Alpine and Sub alpine meadows. Brown forest, podzol and grey forest soils with acid and subacid reactions are formed in taiga – forest zone. At the bottom of the hills and forest steppe area, hilly chernozem, grey hilly – forest and forest turf soils occur. In the steppe area, simple and south chernozem soils, formed from different soil developing stratum are prevailing. In dry steppe area, zonal soils are the dark chestnut soils. Among the steppe soils, especially in Ujbatsk steppe, solonetz and alkali soils prevail. In river and lake valleys – alluvial soils, swampy and field – swampy soils occur.

Khakasian republic include mining – ore regions of Kuzneck Alatau Eastern mountainside, North – West part of Zapadnij Sajan (37,4 thousand km^2) and south – west part of Minusinsk flexure (24,5 thousand km^2). The territory has complex geological structure and is formed by different age complexes from Proterozoic to Cainozoe eras (Fig. 10). Detailed geological description is given in a Guide Book of Educational Geological Grounds, Siberian Higher Education Institutes ("Geology and Minerals", 1998).

Republic is rich in different minerals (Fig. 11). On the territory of republic there is Minusinsk coal – basin with a large stock of high quality coals suitable for strip mining. The most significant field is iron ore mining which is delivered to East Siberian metallurgical works. The reserve iron ore fields are Anzesskoe and Volkovskoe in Zapadnij Sajan. Khakasia is the main Russian supplier of molybdenic concentrate – material for producing high quality steel. On Sorskoe copper-molybdenic field – silver, copper and molybdenic concentrates are recovered. Molybdenic field Agaskirsk and Ipchulsk are the reserves of raw material.

Republic is one of the oldest in Siberia gold – bearing regions were gold has been extracted for over 150 years. Besides gold-ore fields of vien- stockwork type, small auriferous gravels are developed in rock formations.

Unique in quality and stock is Kibik – Kordonsk marble field on the basis of which, such industrial complexes as OAO "Sajanmramor" and AOA "MKK – Sajanmramor" are operating. Besides, marble industrial complex departments treat decorative granite from Visokogornoe field.

All this gives an opportunity to show the basic types of mining industries (where extraction and processing of ore – mining material is carried out with the application of different methods and in different landscape zones) being on different stages of nature – technique system development (Fig. 12) and producing the whole range of man – caused environmental influence (Table 1).

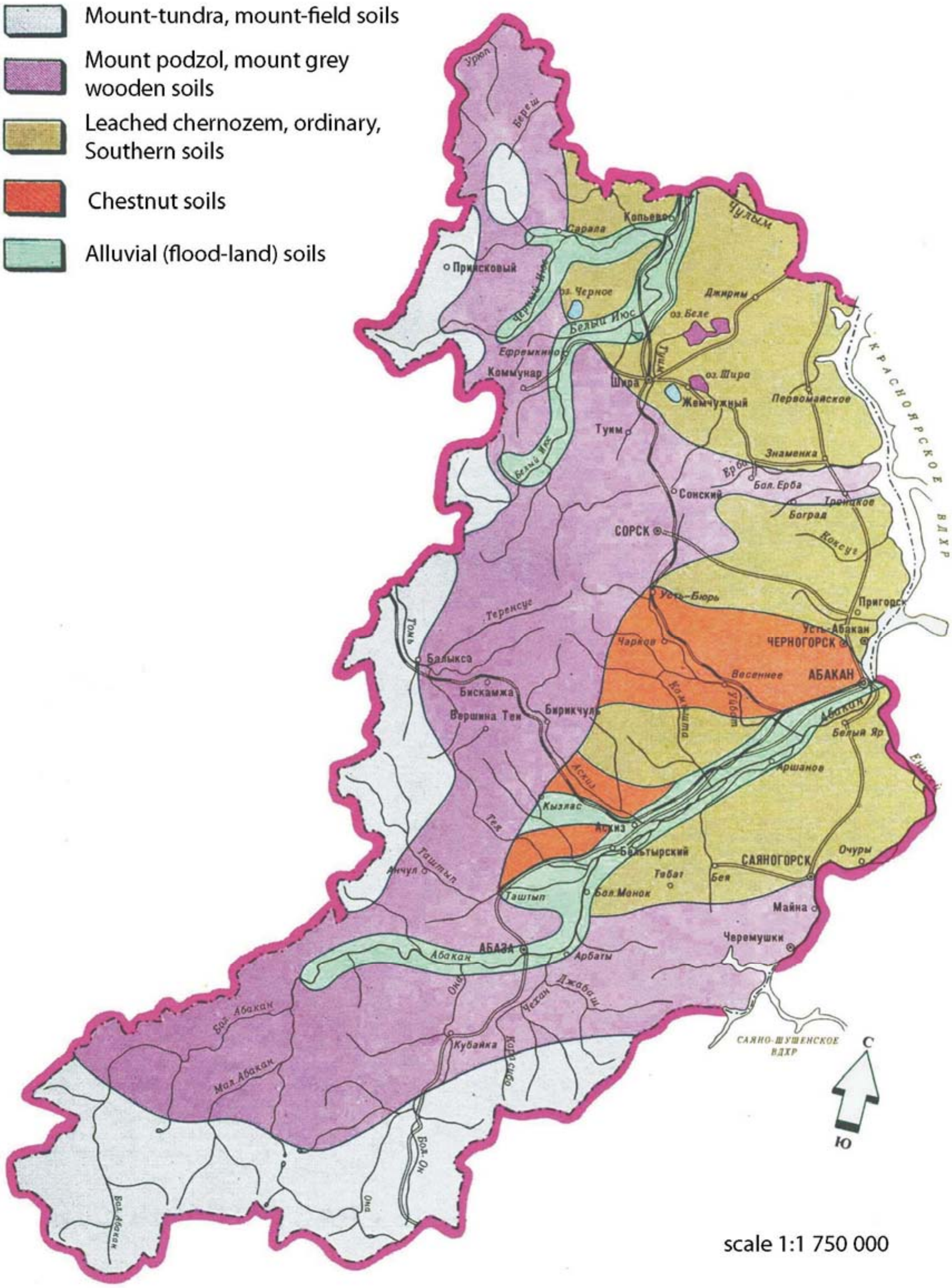


Fig. 9. Soils
(according to the atlas of Khakasian republic, 1998)

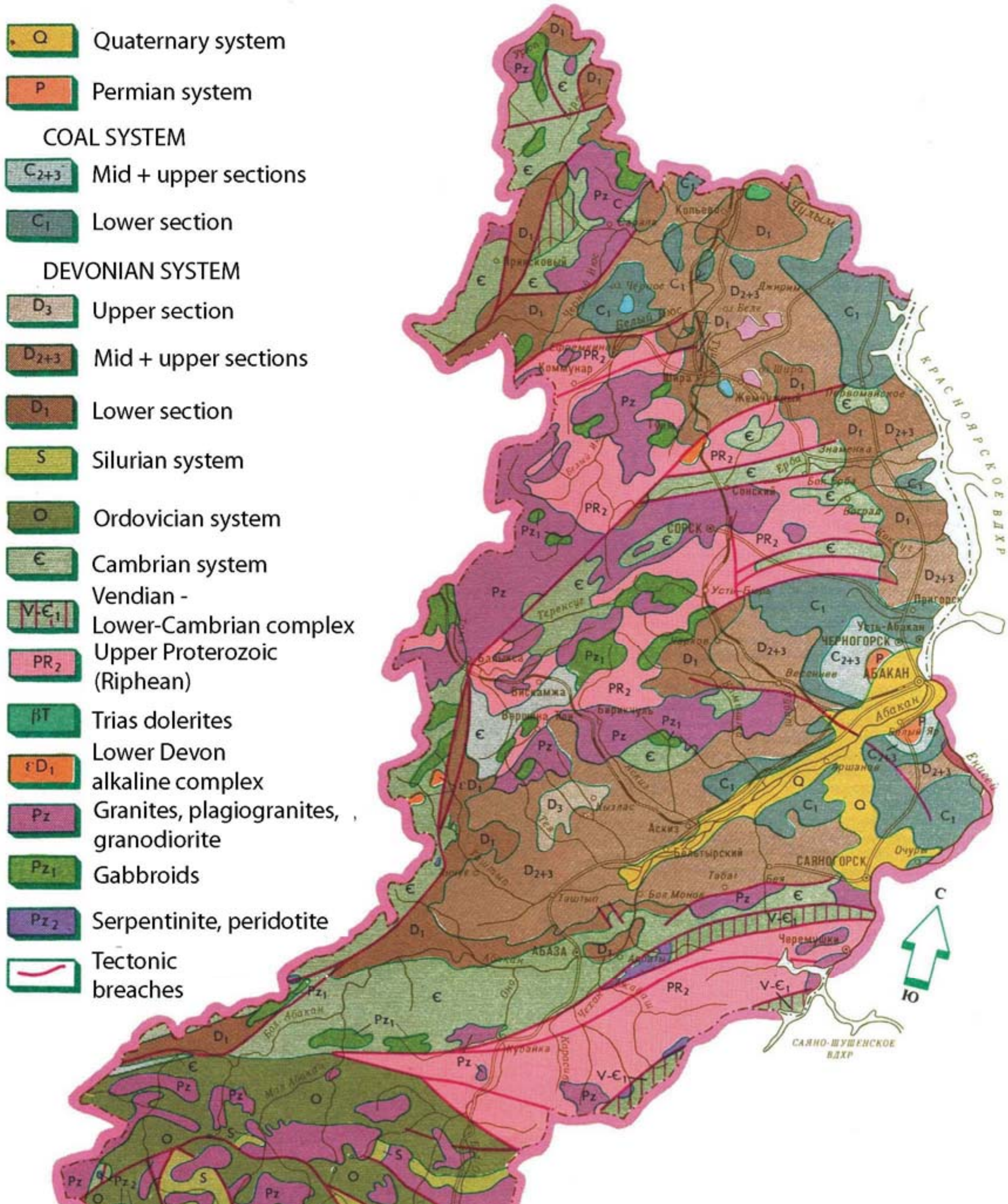


Fig. 10. Geological structure
(according to the atlas of Khakasian republic, 1998)

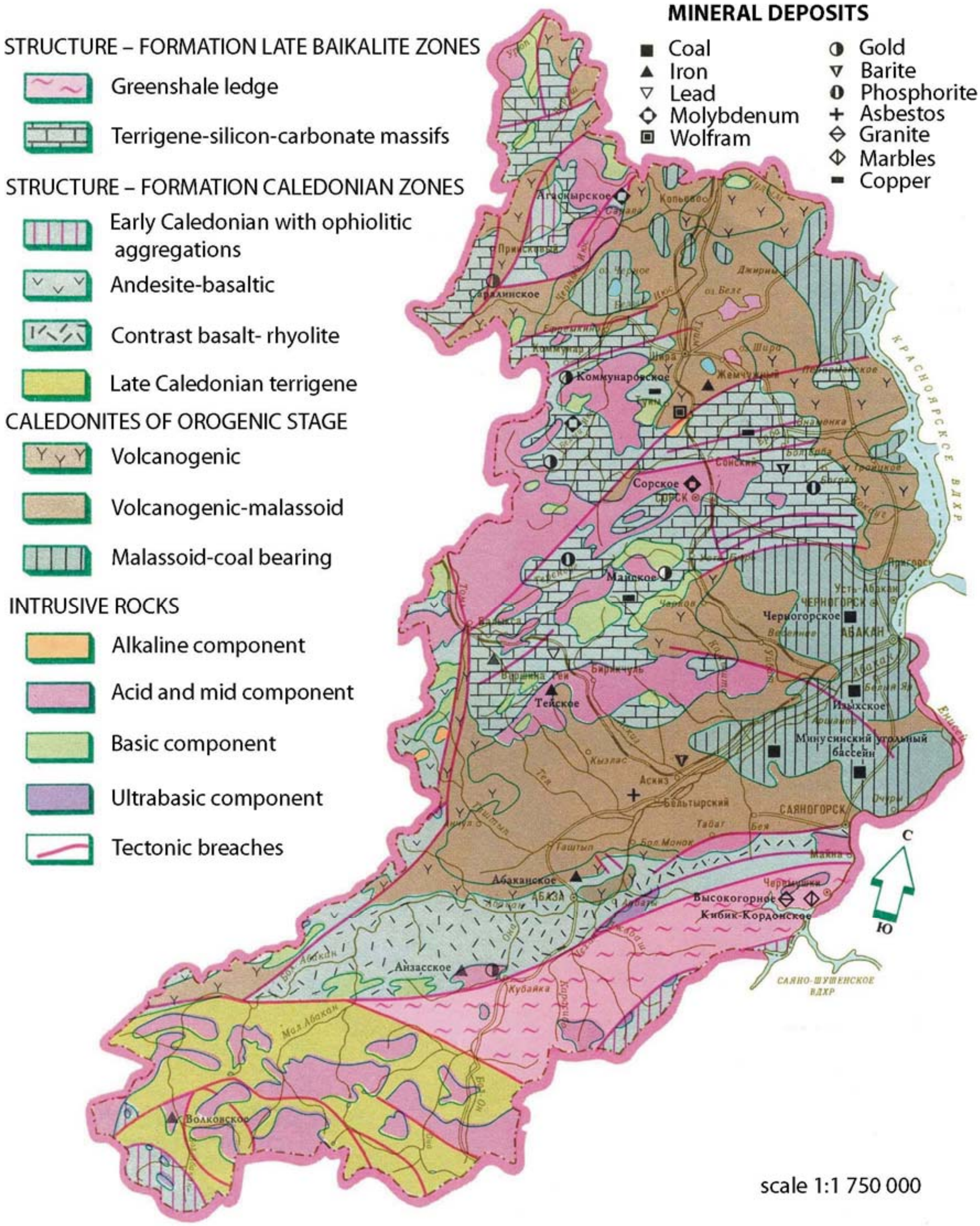
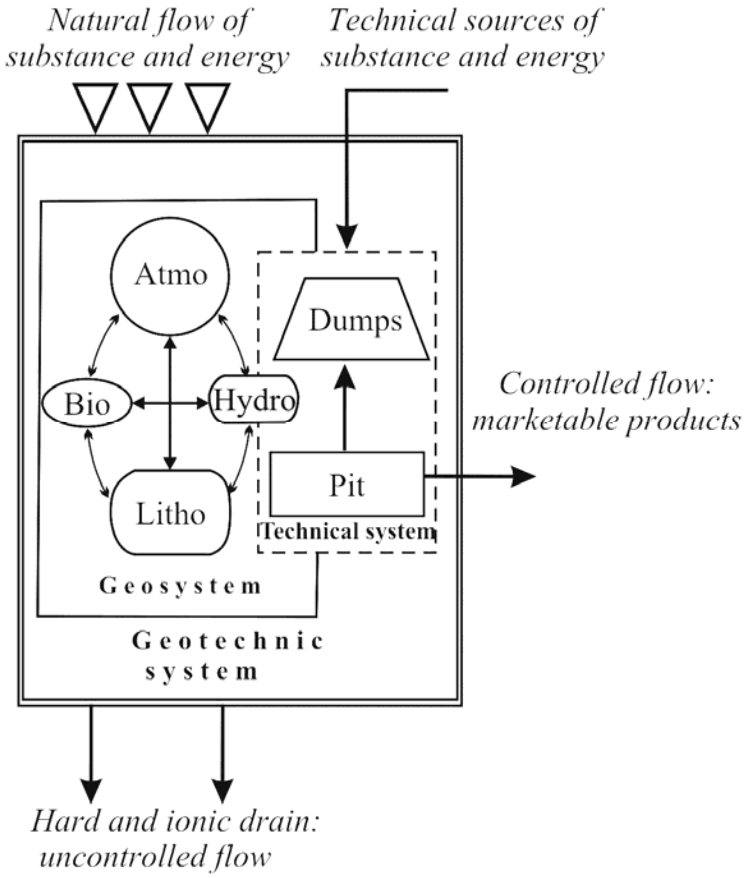
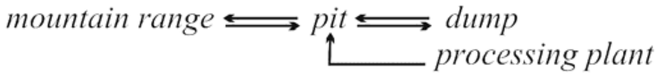


Fig. 11. Minerals
(according to the atlas of Khakasian republic, 1998)

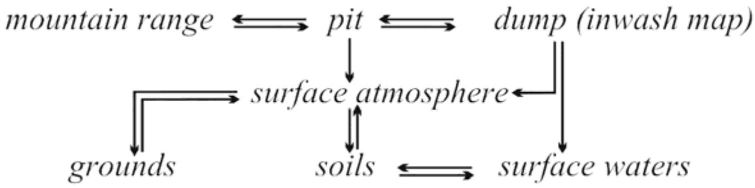


I stage – simple geotechnical system
(starting of field development)



OVOS project is developed, PDV and environmental regulations are established.

II stage – complex geotechnical system
(geomechanic, hydrogeological, electrochemical, biogeochemical processes make this system complex



Controlling units realize strict control.
Environmental measures are carried out.

III stage – completion of active field development
Collection of ecological problems, completion of ecological control.
Degradation and destruction of the plant, housing.

Fig. 12. Scheme of natural-geotechnical system structure at mineral deposit operation and main stages of its development (according to E.F. Yeromin et al)

Table 1

Classification of man-caused ecological violations at ore mining production (Panichev, 1993)

Type	Technological process	Man-caused factor	Object under influence	Result of negative influence	Possible ways of negative influence elimination	
					partial	total
1	2	3	4	5	6	7
1.	Renovation	Removal of biologically active vegetable mass on the site	Flora and fauna. Soil	Elimination Withdrawal of agricultural fields	Using of skimmed vegetable layer for the rest area elevation	Vegetation layer recovery not later than in 3 years
2.	Overburden operations	Creation of sizeable hollows in the Earth's crust	Earth's interior Hydrology	Destruction of microorganism's life. Breaking of dynamic processes, genesis. Breaking of water regime	Inner overburden operations with vegetable layer covering	Revegetation with potential vegetable layer recovering
3.	Piling	Creation of large piles from unserviceable rocks.	Flora and fauna. Soil Earth's interior Hydrology	Elimination Withdrawal of agricultural fields Destruction of microorganism's life, breaking of dynamic processes, genesis. Breaking of water regime	Inner overburden operations	Development and introduction of low-waste and nonwaste technology, using of mineral resources from slag-heaps

Continuation of table 1

1	2	3	4	5	6	7
4.	Drilling	Creation of cylindrical excavations in rocks	Atmosphere Hydrology	Dust and gas pollution. Breaking of water regime	Air aspiration Regime optimization	Drilling with water and mud. Refusing from fuse drilling rigs
5.1.	Massive explosion	Destruction of mount massif in large scale	Housing estate. Flora and fauna Atmosphere Earth's interior Hydrology	Seismic danger. Extinction. Dust and gas pollution, noise. Destruction of microorganism's life, breaking of dynamic processes, genesis. Breaking of water regime	Process optimization	
5.2.	Secondary explosion	Destruction of single mount units in large scale	Housing estate Flora and fauna Atmosphere	Seismic danger,noise. Extinction Dust and gas pollution, noise	Optimization of massive explosion process	Applying of nonexplosive method of destruction
6.1.	Mining operations without «volatiles» in component	Creation of significant excavations in the Earth's crust	Earth's interior Hydrology	Breaking of dynamic processes. Destruction of microorganism's life in the Earth's interior. Breaking of water regime	Optimization of massive explosion process Laying of waste area	Applying of nonexplosive method of destruction

Continuation of table 1

1	2	3	4	5	6	7
6.2.	Mining operations with «volatiles» in component	The same	Earth's interior Planet Space Hydrology	Breaking of dynamic processes. Destruction of micro-organism's life in the Earth's interior. Rising of «Greenhouse effect». Earth mass decreasing. Breaking of water regime	The same	Mineral processing without «volatiles» generation
6.3.	Fuel resources extraction		Earth's interior Planet Hydrology Space	Breaking of dynamic processes, genesis. Destruction of micro-organism's life. Breaking of water regime. Rising of «Greenhouse effect». Earth mass decreasing.		
7.	Drainage	Surface and subsurface water exhaustion	Hydrology	Breaking of water regime	Water purification and further application for life support	

Continuation of table 1

1	2	3	4	5	6	7
8.	Transportation	Transport gas discharge (including loading and unloading)	Atmosphere	Dust and gas pollution, noise	Optimization of device operation	Renunciation of devices polluting the atmosphere
9.	Crushing and grading	Crushing pieces of minerals and grading in size	Atmosphere	Dust and gas pollution (in crushing sulphur ores), noise	Irrigation	Aspiration Noise insulation
10.	Grinding and classification	Grinding grains to mineral opening degree and their classification in fractions	Atmosphere Hydrology	Dust pollution Water pollution and depletion	Irrigation Purification	Aspiration Closed water cycle
11.	Gravity	Grading grains in specific gravity	Hydrology Atmosphere	Water pollution and depletion Dust pollution	Purification Irrigation	Closed water cycle. Aspiration
12.	Flotation	Grading grains in surface properties	Hydrology	Water pollution and depletion	Purification	Closed water cycle
13.	Magnetizing roasting	Thermal mineral processing with formation of «volatile» ones	Atmosphere Planet Space	Dust and gas pollution Rising of «Greenhouse effect». Earth mass decreasing.	Aspiration	Utilization Development and implementation of the volatile-free process

Continuation of table 1

1	2	3	4	5	6	7
14.	Electromagnetic separation	Grading grains in magnetic sensitivity	Atmosphere	Dust pollution	Irrigation	Aspiration
15.	Special and other methods of enrichment	Grading pieces and grains in shape, wettability and other features	Atmosphere Hydrology	Dust pollution Radiation Water pollution	Irrigation Protection Purification	Aspiration Protection Closed water cycle
16.	Dehydration	Separation of solid and liquid phases	Hydrology	Water pollution	Purification	Closed water cycle
17.	Tailing dumps	Formation of dumps and fluid mass on the earth's surface	Flora and fauna. Soil Earth's interior Hydrology	Elimination Withdrawal of agricultural fields Destruction of microorganism's life. Breaking of dynamic processes, genesis. Water pollution	Tailing dumps in waste areas	Development and implementation of nonwaste technologies using tailing minerals

CHAPTER 2. THE HISTORY OF ORE – MINING INDUSTRY FORMATION ON THE TERRITORY OF KHAKASIA

The territory of Khakasia where geoecological educational training takes place has been the man's ecotope during the whole period of historical development. This was due to favorable nature – climate conditions, geographic and geological factors. The exhibits of Khakasian historical museum, which students attend during their educational training, are the evidence to this.

Numerous archeological monuments evidence the fact that this land has been inhabited since the ancient period: burial mounds and barrows, sculptures and writings; sites and settlements. Archeological findings on the area of TPU's educational training base were thoroughly studied and described in written works by V.D. Slavin and L.I. Sherstova (1999) which students are recommended to read.

Archeological researches confirm that this territory contains all the basic eras of man's culture development, periodization of which, is realized according to the type of mineral material usage ("Archeological Monuments…", 1986):

I. Stone Age: paleolith, mesolite, zeolite.
II. Bronze Age: Afanasievskaja, Okunevskaja, Andronovskaja, Karasukskaja cultures.
III. Early Iron Age: Tagarskaja culture.
IV. Iron Age of steppe and taiga regions: Tashtikskaja culture.
V. Medieval age.

The most ancient findings are dated to the Middle Paleolith era (cave "Dvuglazka" in 50 km from Abakan) the period of Neanderthal man.

In relatively dry and warm climate about 50 thousand years ago (Karginskoe interglacial period) a man was hunting koulans, horses, rhinos and etc. and in everyday activity he used stone tools: strickle, sharpened arrow – heads, nucleuses and etc.

A very interesting Stone Age settlement is located near the village Malaja Sija which students can visit during the excursion to the gold mining field Kommunar.

The most severe Sartansk glaciation in Siberia happened about 15 thousand years ago. It lasted for 15 thousand years with minor warming. This region was a tundra zone with forest islets. Here reindeers, mammoth were met. Wild animal skin handling was widely spread; it was sewed together with permanent needles. For making stone tools (leather plates, arrow – heads and etc.), technology of press technique was applied (Archeological Monuments…, 1986).

Among archeological findings the most noticeable are those which witnessed the development of art and culture.

The sharp warming of climate about 9–10 thousand years ago formed the new landscape. New species of animals (fast moving) started to appear. For hunting that animals, bow and arrows were used.

In Late Stone Age (5 000 B.C. – 3 000 B.C.) stone tools were improved. Chopping tools made from silicon and nephrite appeared and people started to apply tool grinding. Ceramic foodware started to be widely used.

In Copper-stone Age (3 000 B.C. – the middle of 2 000 B.C.) people began to make tools from native copper: knifes, needles, accessories and etc.

Native copper in Khakasia is found in the oxidation zone of Mainskoe copper – pyrites field (Sajano-Shushenskoe GES region), Sorskoe copper – pyrites field and also on the native copper fields Voroshilovskoe, Polindejka, Pochischenskoe. The extraction did not require mining

During that period people began to breed domestic animals, agriculture appeared.

Copper working led to the rising of bronze metallurgy (Afanasjevsk culture). But its development was impossible without carrying out of mining and creating of primitive metallurgical workshops and metal-working machines.

For bronze producing, except copper, other component were needed: tin, arsenic, lead, stibium. The last three components can be found in Khakassko – Minusinsk region, but the display of tin on this territory (if not to take into consideration rare places of mineralogical findings) is not known by the authors of this guide book. The nearest display of tin occurs in Altaj, Zabajkalje and Yenisej mountain – ridge about 1000 km. down the Yenisej river. J.I. Sunchugashev (1975), after careful and thorough study supposed that Baliktichsk field in Tuva was the possible area of tin display. But it is located hundreds of kilometers from the place of bronze making.

All this shows the high level of human culture development and wide connections with the other territories.

The development of copper industry was influenced by the development of small and average copper fields with high technological qualities (Fig. 13) and also by presence of wood resources which provided ore melting in the region of extraction.

This period can be marked as the earliest period of man – caused system functioning and as a period of mining complex geoecological problem rising.

The scale of copper ore extraction and processing is impressive. Twelve ancient copper slag heaps, round or arched shaped at about 26 m in diameter and

2,5 m in height (Sunchugashev, 1975) were found near Cvetnogorsk village (field Julia, which students visit during geoecological educational training).

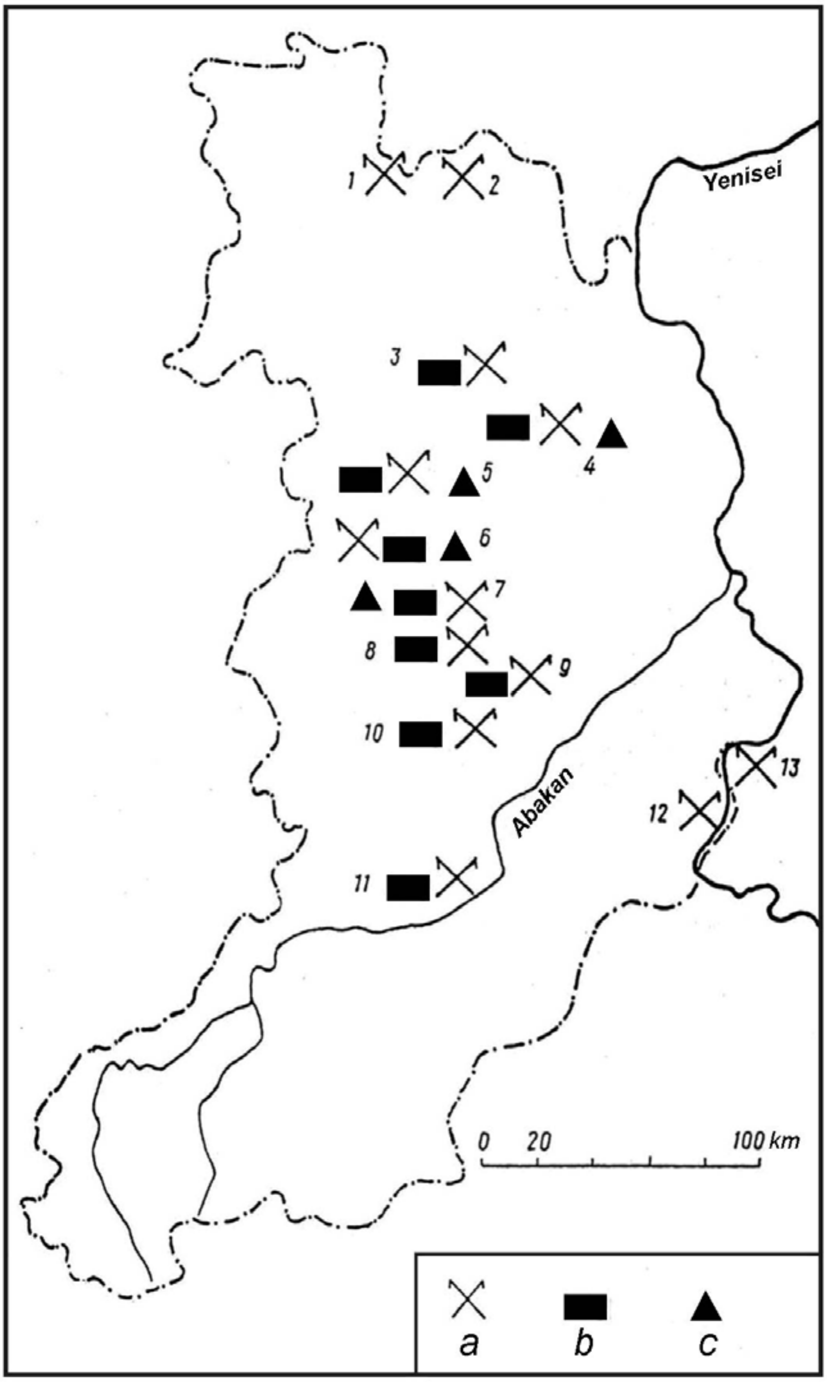


Fig. 13. Ancient copper mines of Khakassko-Minusinsk basin (Sunchugashev, 1975)
a – excavations, b – copper slag, c – researched copper-smelting furnace. 1 – Pechische; 2 – Chulim; 3 – Itkuhl; 4 – Julia; 5 – Ulenj; 6 – Temir; 7 – Uzun-Zhuhl; 8 – lake Bulan-Kuhl; 9 – Bolshoj and Malij Sari; 10 – Base; 11 – Butrakhti and Kharadzhul; 12 – Majna; 13 – Shuneri

At the end of VI – beginning of the V centuries B.C. Karasuksk culture changed to Tagarsk. Thousands of mounds dated to that culture cover the steppes of Khakasia, including the area of the educational training base (Fig. 14).

Fig. 14. Fragment of Salbikskij mound in the Czar valley (III century B.C.)

People of Tagarian culture began to melt iron and to make iron wares which step by step replaced bronze.

The culture of “iron” in this region totally replaced “bronze” during the peak of Tashtikskaja culture. (2 century – 5 A.D.).

Raw material source of the iron ore and plenty of woodlands allowed getting a large quantity of metal and metal wares.

After that the development of mining and metallurgy in the region came to a standstill until the 18th century.

New stage in mineral resource development started from the moment of secondary development of Mainskoe copper-pyrites field (1730) and Irbinskoe iron-ore field (1732).

The description of Khakasian coal fields is dated back to 1772 (Pallas, 1788).

The most scaled mining works in the region started in the second half of the 19th century – the beginning of the 20th century.

At present Khakasian republic is one of the largest mining regions in Russia. Here the intensive extraction of coal, iron-ore, non-ferrous ore, rare and noble metals, and of other minerals is carried out.

It should be noted that information about raw mineral material source were retained in toponymy – language of geographical names (Vorobjev, 1973; Maloletko, 1992 et al).

Temir – iron (there are several iron fields in Khakasia which have such name).

Altin – golden;

Altaj – golden taiga;

Altin sora – golden knight;

Tuus– salt, lake Tus;

Akh pas – white head. Asbestos field – Akspagashskoe;

Kara bas – black head. Coal basset on the top;

Molat – steel;

Arzan (arshan) – curative spring;

Taskhil (taskil) – bare mountain;

Tas (tat) – stone;

K(h)iziltas(t, sh) – red stone;

K(h)aratas(t, sh) – black stone;

Aktas (t, sh) – white stone;

Karasuk – spring;

Tag – mountain;

Tosh – icy;

Aj – moon;

Kun – sun;

Pagir – copper;

Pagiraj – bronze;

Hara (kara) – black;

Hizil – red;

Hazir (kizir) – brown;

Sarig – yellow;

Puzun – glauberite salt, extracted from lakes for the cattle in winter.

The language of the land is very complicated especially for such ancient region as Khakasia were language is a mixture of Indo – Iranian (Uba, Kojbal, Ubrus, Borus, Turan, etc.), Turkic (jus – river; kann – river; aba – bear; it – dog; kulj – lake; etc.) and Celtic (chulim-chul – water; kamzas-kam – goose; zas – river; etc.)

It should be remembered that in previous text books of field geology, as it was noted by V.D. Slavin et al (1999), it was recommended to start prospecting works with the questioning of indigenes about “ancient mines”, extraction marks, with toponymy acquaintance (“earth language”), which is marked on toponymy map and archeological monuments. This touches not only geology, but also ecology: previous generations knew about “bad” (geopathogenic zones) and “good” places much better than today’s “young generation”.

CHAPTER 3. MAIN GEOECOLOGICAL PROBLEMS, DETERMINED BY MINING INDUSTRY DEVELOPMENT IN THE REGION

Republic of Khakasia – a mountainous country on the South of Siberia, which is represented by different nature landscapes. Among them four fifth of the square is mountainous, the rest area is represented by steppes and forest-steppes. The leading place of economical activity in Khakasia is taken by mining industry. The extraction of coal, gold, molybdenum, barite, iron, marble, granite, limestone and other minerals is carried out on the territory of the republic. Dozen of mining industries develop the fields leaving excavations (open pits, mines, adits), slag-heaps, tailing dumps, slurry collectors and other man-caused objects. In Khakasia, the areas of intensive mining works created man-caused landscape. Sometimes slag-heaps of overburden rocks and tailing dumps closely approach the streets of towns and villages, for example village Vershina Tei, towns – Sajanogorsk, Sorsk, Abaza. Extracted from the great depth minerals, which originated in last geological epochs, after getting to the surface start to destruct under the influence of airing force, hazard chemical elements start to wash out and all these lead to the pollution and poisoning of rivers and water sources.

The main factors which influence the environment, during mining works, is: requisitioning of agricultural and wooden areas, breaking of landscape, destruction of fertile soil bed, distribution of overburden rocks heaps and tailing pits, pollution of air by dust and toxic gases, pollution of the territory in the affected zone of mining industry by slacks, supposed pollution of underground waters, underflooding of land surface, breaking of underground water natural regime, pollution of land by oil products, burning of active/inactive slag-heaps of overburden rocks and coal beds pollute the atmosphere, water resources, pools and etc. (Table 1).

Partial inventory of slag-heaps and waste products of mining industries showed (Khudjakov et al, 2001) that mass of overburden and waste rocks, tails of the ore mills form 1 billion tons, occupied square is not less than 3 thousand hectares (Table 2).

Over the last 40 years the republic has been checking underground and surface waters of mining factories. Nevertheless, the absence of evaluation works concerning the estimation of factories influence on soil, air and biota, nowadays does not allow drawing the whole picture of factories' influence on the environment. Lithogeochemical filming of Abakan city (Vasilenko et al 1994), ecology-geochemical filming of Chernogorsk city (Vasilenko et al 1994) and also the research of Sorsk molybdenum plant influence (Kashin et al 1995) touched mainly settlement zones and didn't give the whole scale of pollution.

Table 2

Results of the inventory of mining industries waste placements objects in Khakasian Republic (Khudjakov et al, 2001)

Company	Field	Place and waterway	Area of waste stowage	Waste square, hectare	Volume (thousand. м^3)/ waste weight (thousand tons)
OAO "Ugolnij razrez Chalpan"	Bejskoe coal field	village Dmitrievka (4 km), lake chalpan (4 km)	Overburden rock slag-heaps	7,9	13060,9
OAO "Razrez Izikhskij"	Chernogorskoe coal field	village Belij Jar (3,5 km), river Abakan (2 km)	Overburden rock slag-heaps	271,9	100000 230063,5
OOO "Sajansojuz servis"	Chernogorskoe coal field	village Solnechnij (500 m)	Overburden rock slag-heaps	51	5400
OAO "Baliksu"	Alluvial gold field	village Baliksu (1 km)	Overburden rock slag-heaps Tailing pit	75,0	1127 1916
OOO "Sorslij GOK"	Cooper and molybdenum field	town Sorsk (2,5 km)	Tailing pit	567,9	54000 144000
			Overburden rock slag-heaps	637,0	392000 1050168
			Ash-and-slad settler	4,5	120
			Authorized dump	1,2	42
OAO "Argillit"	Lime field	station Erbinskaja (13 km)	Tailing pit	3,2	450
			Overburden rock slag-heaps	3,0	320
	Alluvial gold field	–	Overburden rock slag-heaps	51,6	823,7

Continuation of table 2

Company	Field	Place and waterway	Area of waste stowage	Waste square, hectare	Volume (thousand. м^3)/ waste weight (thousand tons)
ЗАО "Tonnelj"	Rail tunneling	0,05	Rock heaps	1,5	131,6
OAO "Tejskoe rudoupravlinie"	Ore field	village Vershina Tei, exactly in the village	Tailing pit	19,1	12245
			Sludge storage	0,5	1,48
			Overburden rock slag-heaps	230,2	133056
OAO "Abakanskoe rudoupravlinie"	Ore field	town Abaza exactly in the town	Tailing pit	72	410 / 820
			Ash-and-slad heap	5,4	37,291
Artelj staratelej TPK-300	Alluvial gold field	on the river Temir	Overburden rock slag-heaps	6,5	135,5
OAO "Sajan-mramor"	Marble field	town Sajanogorsk			
		18	Heap№ 1	14,0	595
		18	Heap № 2	14,0	1029
		0	Sludge storage	0,1	11,3

The research works, started in 1999 by TPU members together with MGP "Ekogeos", directed to the evaluation of factories wastes toxicity AOOT "Tejskoe rudoupravlenie" (Jazikov et al 2000[1]), Open Joint Stock Company (OJSC) "Sajanmramor" (Jazikov et al 2000[2]) and the toxicity of overburden rocks, ash-and-slad wastes, commercial coal of OJSC "Ugolnij razrez Chalpan" (Jazikov et al 2001) allowed the specialists to get the complex geochemical information about valuable and toxic waste components of the Khakasian republic factories, to calculate the class of toxicity according to the amount of summary pollution index, to detect the level of pollution and basing on biotest results to define which wastes have the mutagenic activity (Jazikov et al 2003).

The results of the research allowed for evaluation of the influence of slag-heaps on soil. During geoecological educational training in 1997–1998 with students of "Geoecology" specialty, TPU members of geoecological and geochemical departments collected the samples from tailing pits of fields

Julia and Sorskoe (Jazikov et al 1999). Preliminary researches defined the high quantity of valuable (Cu (60 g/t), Pb (300 g/t), Zn (1000 g/t) и Ag (5 g/t)) and toxic (Cd (20 g/t) and Bi (10 g/t)) in tailing pits of concentrating mills of Julia field. High concentrations of Cu (150–200 g/t) and Mo (200 g/t) were found out in tailing pits of Sorskoe field.

Coal producers create definite geoecological problems which can be examined in details on the example of OOO "Chernogorsk ugolnaja compania". The main problem is connected with overburden rocks slag-heap. Brief slag-heap parameters: square – 652 hectares, volume – 358921 thousand m^3, infill estimation – 20 %, operational date 1960–2008. Along with slag-heap the following problems can be pointed out:

- absence of mountains – ecological monitoring resulted in absence of overburden and country rock toxicity and their influence on the environment, soil, surface and underground waters, air and biota;
- lack of information about exogenous processes, arranging of spontaneous ignition prevention and endogenous fires liquidation training is very expensive and not effective enough, fire supervision materials are scares and not systematized;
- lack of control under the emission of harmful substance from active/inactive burning slag-heaps according to the following polluting components: sulfur dioxide, carbon oxide, nitric oxide and hydrogen sulphide. In 2000, six overburden slag-heaps were burning, among them 3 active and 3 inactive. The damage caused by the emission of harmful substance from endogenous fires on slag-heaps of OOO "Chernogorskaja ugolnaja compania" in 2000 estimated 16,771.423 rubles (according to "Juzhkuzbassugolj" data).

CHAPTER 4. BASIC GEOECOLOGICAL ROUTES

4.1. Study of recreational zones. Khakasian lakes and their geoecological problems. Lake Beljo nekk

Route: TPU training base – lake Shira – lake Tus – lake Beljo – lake Beljo nekk – lake Itkuhlj – lake Sobachje –TPU's training base.

Route aim: Acquaintance with Khakasian lakes and geoecological problems of the region. Peculiarities of subsurface geology of Ostroj city (lake Beljo nekk).

Along the route on the right from the terrace or in 1…2 km to the south-west from the training base, there is a degenerative lake Marekuhl. Basin of the lake Merkuhl is situated in a large Karishskaja basin and represents an ancient artifact of the large lake Karishskoe the banks of which were inhabited by the ancient Khakasian population. At present it is a swamp which keeps relicts of five meter depth water basin. The increment of sedge peat is carried out in the swamp, and sapropel – in water basins. Peat and sapropel stock estimate 2 million m^3 on Marekuhlskoe field, total square – 2 km^2. The attempts of field running were taken and peat collars were made for that purpose, but the lack of demand stopped the process of running. In 1998–1999 because of dry weather peat collars were dried out and started to burn. Nowadays the major part of peat was burnt.

Mineral lakes of Northern Khakasia are highly competitive in chemical components and curative properties with the famous lakes of Crimea, Caucasus and central Europe (Machkasova, 2003; Klopotova, 2004). Unfortunately in the presence of large potential resources of mineral curative waters, only three health centers on the lakes Shira, Uchum and Tagarskoe are functioning on the territory of Minusinskaja basin.

Mineral lake Shira (Fig. 15), famous balneary which is situated in 17 km to the east from the regional center Shira and is located in a blind hollow within Shirinskaja denudation accumulative sub plain. Morphological parameters: water surface area – 35,9 km^2, length – 9,35 km, max. width – 5,3 km, coast lane length –24,5 km, max. depth – 21,8 m, average depth – 11 m.

In geological aspect this hollow is referred to red sandstones, siltstones, mudstones, gritstones of Upper Devonian Oidanic suite which built large Shirinskaja synclinal structure. Mineral water volume 0,387 km^3, total curative mud stock 18 million m^3, this places the lake in one raw with the largest curative mud fields of Russian Federation. Analogies of lake Shira curative mud could be found in Odessa firth and balneary Sakki (Caucasus).

Fig. 15. Panoramic view of the lake Shira, village Zhemchuzhnij

In chemical composition water is sulfate – chloride sodium – magnesia with alkaline reaction (pH 8,9–9,2). Common water mineralization is 16…21 g/l.

$$M_{21,0}\frac{(SO_4)_{71}Cl_{21}(HCO_3)_4}{(Na+K)_{60}Mg_{38}}.$$

Salt composition includes the following components: (K + Na) – 4,6 g/l; Ca – 0,06 g/l; Mg – 1,52 g/l; SO_4 – 10,91 g/l; Cl – 2,58 g/l; HCO_3 – 1 g/l.

Mineral water basin formation is connected with water bearing horizon of the Oidanic suite. Waters of these salty rocks, originated in conditions of arid climate, are discharged into the lake and evaporation assists in mineral salt accumulation

From the year 1897 balneary started to function on the territory of the lake Shira, at present it is a large resort of federal significance.

Complex treatment is carried out at the resort "Ozero Shira". Mud extracted from the lake Utichje-3, curative drinking water and also brine treatment is used. At the beginning of 20^{th} century water from the lake Shira was sold in bottles at the majority of Russian drug stores. But in bottles water could not be stored for a long period as it looses its therapeutic properties. Later salt from the lake was used for treatment, which was obtained in process of water evaporation. This salt successfully competed with the famous Karlsbadsk salt.

The resort can accept 200 patients, during a year 17 thousand of people improve their health here. Gastrointestinal tract, liver, gall-bladder, pancreas and also arthropathy (polyarthritis, arthritis, Bechterew's disease and others) is treated here. The resort also has special child's health centre.

Curative mud of lake Shira lies on the depth of more than 9 m. It covers the square of 19,7 km^2. Reservoir thickness vary from 0,5 m at the edge up to 1,47 m in the centre at depth about 13 m. Total balneal stock estimates 18 million m^3. High level of hydrogen sulphide is common here (up to 25 mg/l). Black mud has the highest curative properties, dark-grey mud and grey sludge has lower index. By chemical composition the mud is reach in sodium sulfate, magnesium, carbonate, silicate, aluminum and potassium oxide, iron and lot of micro components.

Common mineralization of mud reaches 31,8…32,3 g/l. Insoluble residue makes 14,8…19,6 %. Nowadays due to technical and economic reasons Shirinskoe field is on the stage of preservation.

Geoecological lake problems are mainly connected with water pollution. Lake is replenished from the following sources:

- 40,8 % –surface waters(river Son);
- 17 % – underground springs;
- 31,6 % – atmospheric precipitates;
- 6,1 % – health centre discharged waters.

The main source of lake pollution is the water from river Son, on the bank of which there is a farm "Borets": active land use, fertilizer and pesticide applying, cattle pasture. Farm fields surround the lake and in spring snow waters carry large quantity of mineral fertilizers into the lake. Resort heating comes from the boiler-house which burns coal and big amount of soot accumulate on water surface.

Lake Beljo is situated in 25 km from the regional center Shira to the north – east. (Fig. 16). This is the largest lake of Khakasian republic (75 km^2). The lake basin is a wide trough-shaped cavity elongated to the north – east direction. Cavity edge morphology varies: southern and south-eastern framing is located in the outline of denudation accumulative Shirinskaja sub plain and northern, north-western and western edges are framed by cuesta-hilly shallow mound peaks (mount Chalpan – 586,2 m, mount Ostraja – 582,7 m). River Tuim and river Darguzhul run into the south-western end of the lake. Rocky ledge in the middle part of the lake cavity divides the lake into two water basins which gained the status of independent lakes – Bolshoe and Maloe Beljo. The width of the neck which is connecting two basins narrows up to 50 m and is dammed. Water runs through the pipe system from Bolshoe to Maloe Beljo with the speed of 0,3–0,4 m/sec. Basic parameters of lake Beljo: water surface area – 75 km^2, max. depth – 48,2 m, average depth in Maloe Beljo – 28,2 m, in Bolshoe Beljo – 12 m.

Fig. 16. Panoramic view of the lake Beljo

In geological aspect the lake cavity is referred to evolution field of red conglomerates of Upper Devonian Oidanic suite and is located in the area of Beljovsk tectonic trough.

Hydrological regime is influenced by periodic deviations and depends from the amount of river Tuim drainage, atmospheric precipitates and subsurface water inflow.

Water volume is considerable: 729,45 x 10^6 m^3 in the lake Maloe Beljo and 594,36 x 10^6 m^3 in the lake Bolshoe Beljo, total amount 1,32 km^3. According to the chemical component it is sulphate-chloride magnesia-natrium water with low mineralization:

$$M_{10,3}\frac{(SO_4)_{63}Cl_{18}}{Na_{61}Mg_{38}}.$$

Members of Tomsk Science Research Institute of balneology and physiotherapy highly estimate hydromineral Khakasian resources which play significant role in sanatorium and spa branch development of the republic (Dzhabarova, Klopotova, 1997). Lake water is classified as curative drinking water with alkaline reaction (pH = 8,9–9,2) and medium mineralization.

Studying of bottom sediment of north-eastern part of the lake allowed to fix Sr, Cr, Sn Mo, which exceed the Earth crust clarke in, corresponding, 1.8, 1.8, 1.2 and 2.7 times (Table 3).

The bigger part of littoral lake zone is represented by State nature preserve "Chazi". Recreation department of Krasnojarsk aluminum plant and

Krasnojarsk railway is located in the Figturesque part of the lake near Chalpan city. There is a fishery on the lake Maloe Beljo were troute, Siberian salmon and hunchback salmon are grown.

Table 3

The content of microelements (mg/kg)
in bottom sediment units of Khakasian mineral lakes

Elements	Bottom sediments								Clarke according to Vinogradov A.P. (1962)
	Lake Shira		Lake Itkuhl		Lake Beljo		Lake Zavodskoe		
	C	K	C	K	C	K	C	K	
Ba	1500	2,3	400	0,6	600	0,9	300	0,4	650
Sr	1000	2,9	1000	2,9	600	1,8	300	0,9	340
Cr	200	2,4	300	3,6	150	1,8	100	1,2	83
V	80	0,9	300	3,3	80	0,9	200	2,2	90
Ni	20	0,3	50	0,9	20	0,3	40	0,7	58
Co	8	0,4	15	0,8	4	0,2	30	1,7	18
Zr	300	1,8	800	4,7	200	1,2	150	0,9	170
Nb	15	0,8	40	2	15	0,8	6	0,3	20
Li	40	1,3	40	1,3	40	1,3	50	1,6	32
Y	30	1	30	1	30	1	30	1	29
Yb	3	10	4	13,3	3	10	3	10	0,33
Ga	20	1	15	0,8	10	0,5	15	0,8	19
Cu	30	0,6	30	0,6	30	0,6	60	1,3	47
Pb	15	1	15	1	10	0,6	10	0,6	16
Zn	40	0,5	60	0,7	40	0,5	60	0,7	83
Cd	–	–	–	–	–	–	–	–	0,13
Be	3	0,8	2	0,5	1	0,3	2	0,5	3,8
Sc	8	0,8	20	2	8	0,8	30	3	10
Sn	3	1,2	4	1,6	3	1,2	4	1,6	2,5
Ag	0,05	0,7	0,05	0,7	0,05	0,7	0,05	0,7	0,07
Bi	–	–	–	–	–	–	–	–	0,009
Mo	2	1,8	2	1,8	3	2,7	2	1,8	1,1

Note: microelements were defined by emission-spectral semiquantitative analysis at GGP “Berezovgeologija” (Novosibirsk); C – content of the element (mg/kg) and K – concentration coefficient.

Lake Tus is located in 30 km to the north from the regional center Shira and in 4,5 km to the east from village Solenoozernij (Fig. 17). In geomorphological aspect its drainage area (60 km^2) represents the alternation of low bald peak ridges and shallows of north-eastern stretch which border closed lake cavity.

Fig. 17. Panoramic view of the lake Tus (salt can be seen in the bank)

To the east from northern end of lake Tus in 2,5 km of submeridian direction there is a chain if three Slabitelnie lakes, the most large has the square of 0,18 km^2.

In 5,5 km to the south-west from lake Tus there is a sweet lake Kiprino (0,32 km^2).

In geological aspect lake Tus is situated in the field of red terrigenous deposits of Upper Devonian Oidanic suite. Water surface area is 2,65 km^2, coastline length – 8 km, max. Depth – 2,0 m, absolute height of the shore line is 386,2 m. Lake water, according to the results of the 1995 year research by Dzhabarova N.K. and others, was related to brines with low alkaline reactions (pH 8,3–8,4). In comparison with other Khakasian curative lakes mineralization of lake Tus nowadays is the highest. Total water mineralization varies in different years from 70 to 250 g/l, in frames of the following chemical formula of salt component

$$M_{124,82}\frac{(SO_4)_{57}Cl_{42}}{Na_{62}Mg_{38}}.$$

Mineralization raises top-down. In the central part of the lake, on the bottom, lies the horizon of mirabilite (Na_2SO_4). In definite years the deposits of salt form the crust along the coastline (Fig. 17).

Together with the salt lakes there are sweet ones. The most notable are lakes Itkuhl and Sobachje (Pionerskoe).

Lake Itkuhl is located in 4,3 km to the south-east of the resort "Ozero Shira" (Fig. 18). Absolute mark of water surface area –465,2 m, this is 102 m higher than for lake Shira (353,9 m). Lake size 6,5×5 km, lake square 23,25 km^2, max. depth – about 17 m at the average index 9,1 m, water stock reaches 0,21 km^3, level of mineralization 0,6…0,7 g/l.

Fig. 18. Panoramic view of the eastern part of lake Itkuhl

Water chemical component can be expressed through the formula

$$M_{0,7}\frac{(HCO_3)_{48}(SO_4)_{21}}{Mg_{72}Na_{27}}.$$

Water is hydrocarbonate-sulphate, sodium-magnesium, sweet. Water reservoir square – 372 km^2.

Western and south-eastern banks of the lake are swamped, northern and southern are represented by accumulative sand-gravel bank formations. River Karish and two springs – Karasuk and Shel-Sukh run into the lake from south-western side, only one small spring – Tushininskij runs out. In dry years this spring completely dry up

In geological aspect lake cavity is dated to the same synclinal structure consisting of carbonate deposits of Mid Devonian Beiskaja and Saragashskaja suite. Water from lake Itkuhl is used as a water-supply for the resort "Ozero Shira" and village Shira, amount of water offtake in summer reaches 4500 m^3/day.

At present lake Itkuhl acquired big recreational importance. Taking into account the fact that significant part of the lake cavity is a part of steppe preservation "Chazi" it is prohibited for vehicles and those who want to rest can use only special leisure zones. Lake is rich in fish. Here industrial fish catching is carried out.

Lake Sobachje (Pionerskoe) is located near TPU's training ground (Fig. 19). Lake square is 0,4 km^2 at max. depth 5 m. Water is ultrasweet with mineralization of 0,2 g/l. According to the chemical component – carbonate-hydrocarbonate, sodium-calcium-magnesium.

Fig. 19. Panoramic view of the lake Sobachje (Pionerskoe)

Formula of salt composition:

$$M_{0,2}\frac{(HCO_3)_{66}\left(CO_3\right)_{25}}{Na_{21}Ca_{31}Mg_{48}}.$$

These lakes allow for study of geological peculiarities of the formation, geoecological and ecological problems which rise due to men's economical activity (Silaenkov, 1927; Bukatin et al 1997; Parnachev et al 1997; Parnachev et al 1999).

During the study of the lakes, samples of bottom sediment units were collected on the western bank of lake Shira in 300 m to the north from the resort "Ozero Shira" at depth 3,5–4 m, on the southern bank of lake Itkuhl at depth 3,5–4 m, in north-eastern part of the lake Beljo at depth 3 m and on the eastern bank of lake Zavodskoe at 3 m deep. These samples allow to judge about heavy metals accumulation. According to the research data of bottom sediment microelement composition it was determined that lake Shira exceeds clarke in the Earth's crust (Vinogradov, 1962) in Ba 2.3 times as much, Sr – 2.9, Cr – 2.4, Zr – 1.8, Li – 1.3, Sn – 1.2 и Mo – 1.8, as for lake Itkuhl in Sr – 2.9, Cr – 3.6, V – 3.3, Zr – 4.7, Li – 1.3, Sn – 1.6 and Mo – 1.8, for lake Beljo in Sr – 1.8, Cr – 1.8, Zr – 1.2, Li – 1.3, Sn – 1.2 and Mo – 2.7 and for lake Zavodskoe in Cr – 1.2, V – 2.2, Co – 1.7, Li – 1.6, Cu – 1.3, Sn – 1.6 and Mo – 1.8 (Table 3).

Total pollution index by all these elements for lake Shira – 11.5, lake Beljo – 7.1 and lake Zavodskoe – 10.9, which corresponds to the low level and for lake Itkuhl – 23.1, mid level of pollution (Geochemistry …, 1990). Close indexes for soil were obtained by A.L. Arkhipov and other scientists (1998) in recreational zone of lakes Beljo, Shunet, Firkal, Tus and Utichje-3 (Table 4).

Table 4

Soil element component (according to Arhipov et al 1998)

Lakes	Quantity of samples	Elements	Maximum concentration limit exceeding	
			Mid	Maximum
Shunet	67	As Mo V Cu	0,2 0,76 1 0,6	4 2 2.7 1,7
Tus	92	Sr	2	16,7
Beljo	173	Zn Ni	0,7 0,7	1,4 1,6
Utichje-3	45	As V	0,05 1,25	0,5 2

As, Pb, Zn pollution of soil is supposed to be of man-caused character. High concentration of Sr and Li, was possibly caused by Mid Paleozoic sediment origin having arid character, Mo, V and Cu could appear from basement rocks during soil formation process (Arhipov et al 1998).

Unauthorized camps are a big ecological problem for Khakasian lakes as they greatly pollute the environment with poison substances. This can lead to microbiological water and soil pollution.

At present the attempt to change the situation for better is made, but this does not solve all the problems.

The excursion grants a unique opportunity to acquaint with geological formation of lake Beljo nekk.

Lake Beljo nekk (mount Ostraja). Nekk is situated in 2,5 km to the south from lake Beljo. Originality of this geological formation is in the fact that this is the youngest abyssal formations in Altaj-Sajanskaja folded region. Its age estimates 70…90 million years (Mantle xenolites…, 1988).

Nekk has isometric form with the foundation diameter 150–200 m. In section this column-like body cuts into Earth crust per 40…50 km. At present neck – city Ostraja – has cone-shaped form with relative surface exceed in 150 m and absolute mark 583 m (Fig. 20).

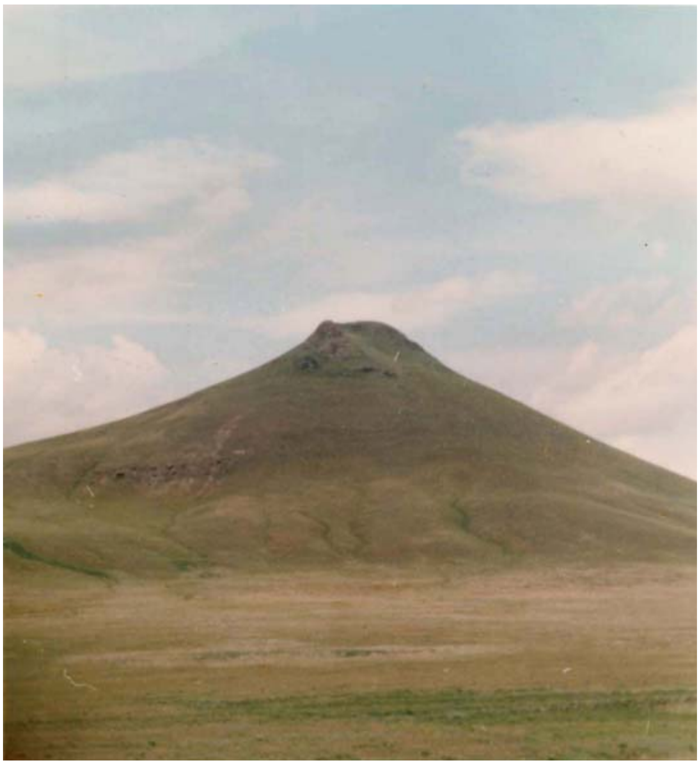


Fig. 20. Panoramic view of lake Beljo nekk (mount Ostraja)

Nekk has a complicated structure (Fig. 21). Central part (~ 100 m in diameter) has irregular shape; it is formed by column-like basalts rocky outcrops of which crown the mound. Edge facies is presented by strongly weathered and ironed plosive volcanic breccias, uncovered bore holes and caves near the mound slopes. Basalts contain a great number of crusted and mantle xenolites with the size from 1 to 20 cm, and also monomineral nodu-lars – megacrystals.

Rocks containing xenolites are referred to alkali basaltoids of basanite type. Content of silica is about 52 %, sum of alkalis (Na + K) – about 7…10 %. Rocks color is – from dark-grey to black, according to the content they refer to gabbro-diabases with fine-, close-grained structure and massive texture. Among pnenocryst augite and Ti-augite prevail over olivine.

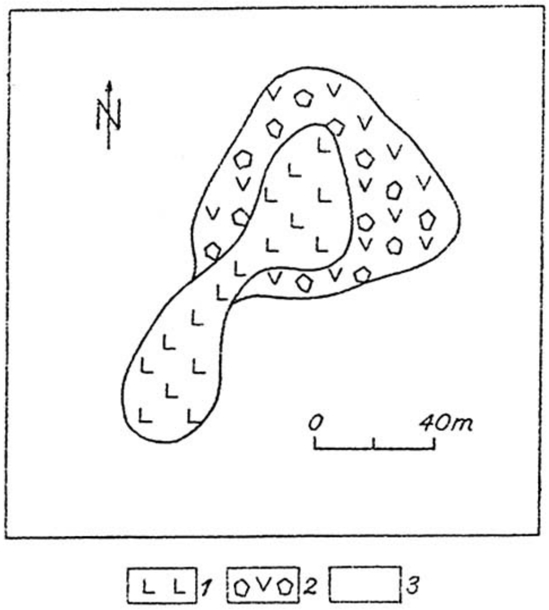


Fig. 21. Scheme of Beljo volcanic pipe geological structure (Mantle xenolites..., 1988):
1 – alkali basaltoids; 2 – eruptive breccia;
3 – terrigenous Paleozoic sediments containing volcanic pipes

Abyssal xenolites are represented by crusted (granulites) and mantle (lherzolites, pyroxenites) rocks. Lherzolites correspond to ultrabasic rocks and consist of chromediopside, chromespinel, rhomb shaped pyroxene and garnet of Arizona ruby type.

Megacrystal association is presented by large (2×5 cm) crystals of spinel and clinopyroxene.

Uranium, fluorite, diamond and other mineral fields can be connected with the development of volcanic pipe fields.

4.2. Features of gravel and ledge gold field geological structure. Staining of semiprecious raw material. Copper-molybdenum field Ipchul. Geoecological problems

Route: TPU's training ground – Tupik settlement – Berenzhak settlement – Balakhchino field – Ipchul field – TPU's training ground.

Route aim: Acquaintance with geological features of gravel and ledge gold field structure, properties of semiprecious raw materials, Cu–Mo-field Ipchul and Geoecological problems appeared in the course of gravel field exploration.

Gold placers of Pygiz and Andat riversides.

Along the route in the direction to Berenzhak settlement, nearly 10 km from railway passing place, close to former Kirpichiki settlement in the upper river Pygiz there is a gravel gold field (see Fig. 22). As in the case of commercially beneficial gold content it is a typical valley alluvial placer in the basis of which there is a balsa, then come sands (a stratum), composed with sandy-pebble material. Upper there is non-auriferous peats presented by sand-argillaceous, sand-gravel materials (Fig. 23).

Fig. 22. General view of the field exploration on Pygiz river

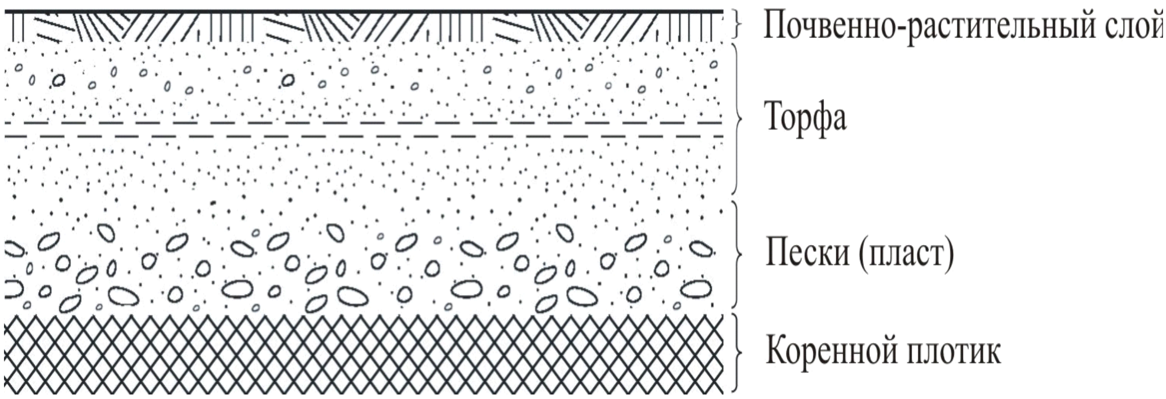


Fig. 23. Structure of the gold field

Next on the route along river Andat, the left tributary of the river Belyi Yus, a greater gravel gold field is situated. A significant thickness of peats causes great efforts in accessway operations. Placer depletion is carried out by the traditional bulldozer-excavator-dredging-water-jet method.

At first soil-vegetable layer is uncovered and stored. Because of great thickness of peats uncovering operations are made by means of walking excavator EW 9-70.

Overburdens are stored on the right side of the valley, sands are on the left (Fig. 24, 25). Washover unit is installed at the same place (Fig. 26). Washover is made by using hydraulic giant (Fig. 27, 28).

Fig. 24. General view of gold field exploration on river Andat

Water is fed to the giant from clearing pool made for primary water purification contaminated at the field exploration. Restoration of the explored placer regions is performed in the reverse order: firstly, washed “sands”, then overburdens and at last, soil-vegetable layer.

At field development of similar type, mining is performed in river and stream floodplains and valleys, where richer biocenoses are developed (Leshkov, 1985). The presence of mine along the whole valley results in troubles with natural stream regime, course displacement to the wastes, their straightening and blocking with dykes, dams and mine damps, recession of ground water table and base level, changes in natural turbulence, oxygen saturation and changes in chemical composition of surface water. Placer mining is connected with relatively large process water waste used to wash out the rocks, their disintegration and extraction of valuable elements.

Fig. 25. Layout of overburdens and «sands»
at gold field exploration on river Andat

Fig. 26. Washing unit on river Andat

Fig. 27. Hydraulic giant operation at sand washing

Fig. 28. Discharge of used «sands» from the washout unit

On the average up to 18 m^3 of process water which contains difficult mineral sewage polluting rivers and ponds, damaging biological environment, flora and fauna is used per 1 m^3 of sand.

There are three types of water pollution: physical (in the form of slurry composed of mineral particulates), chemical (caused by solution of mineral salts and different substances including toxic ones) and microbiological. Besides, industrial sewage can bring some fuel and lubricant residues and discharge used in mining machine operation. The highest degree of water pollution occurs at placer mining mostly due to physical pollution by fine solid suspensions as a result of rock washing out in working face and their disintegration at washing unit to separate mineral particles and valuable components more completely. At placer mining the content of solid particulates in sewage water ranges widely and depends on rock grain-size distribution, method of mining, presence of treating facilities and quality of water treatment. The degree of pond or river pollution at placer mining is determined by content of suspended particles in sewage water, their size and density, waste of sewage water as well as natural water turbidity and flow of a river. One of the main tendencies in water conservation at placer mining is maximal application of water recycling that provides reuse of sewage and its separation from natural water course (Mirzayev et al, 1991).

Investigations show that in most cases mining sewages contain up to 98 % particles of <0,05 mm size. Therefore application of once-through water supply without water clarification is limited in such conditions because absence of sewage clarification elements in water consumption system results in natural water pollution.

As a rule, at placer mining a significant area of arable land is used where mines, dumps, access ways, different hydroengineering and industrial units are situated. The degree of soil surface and landscape disturbance as a result of mining is determined by the square and depth of disturbance. Landscape disturbance can be complete and partial. Complete disturbance is accompanied by destruction of vegetation and soil cover of large floodplain, slope and terrace areas, but partial disturbance – by soil degradation and destruction of vegetation. Complete surface disturbance damages natural resources to the highest degree according to its character and covered areas. That is why development of new placers and extension of working enterprises should be based on observance of the fundamental laws of natural equilibrium to prevent the growth of anthropogenic factor to irreversible processes when reclamation of disturbed soil is of low benefit.

Balakhchino deposit

It is situated on river Andat valley. The field has been intensely developed from the beginning of the XX century to the 60’s when there happened a conflagration at the plant resulted in its close.

Quartz veins in andesite-basalt strata and intrusive bodies of gabbro-diorite composition were of commercial importance. Average gold content amounted 5 g/t. Ore zones were accompanied by development of hydrothermally changed rocks in the form of propitilisation and berezitation processes.

The field was processed by 8 galleries. At present tails of concentration plant are washed out by the washing unit that results in additional geoecological problems in the given region (Fig. 29).

Fig. 29. Balakhchino gold field. Destroyed concentration plant. At the background one an see a waste treatment unit

Staining of semiprecious rocks

Staining of blue diopcide is situated in vicinity to Balakhchino field on the right side of river Andat valley (Fig. 30). Mineralization is of hydrothermal-metasomatic origin and conditioned by magnesia metasomatism. The dolomite serpentization processes are fixed at outcropping. In strip mining the radioactive abnormality of thorium nature has been stated. The exposure rate is 95 mkR/h.

The given staining is a mineralogical rarity according to presence of blue diopcide, the analog of which was found in St-Marcel (Piedmont, Italy).

Ipchul deposit

The old exploration mines of Cu-Mo-field Ipchul are found 8 km from Berendjak settlement along Ipchul river on the left bank (Fig. 31), which is an analog to Sorsk field. The field reserves are confirmed by the Government Resource Committee and belong to the government entity. Ore bodies are of strata-stockwork type. The main minerals: molybdenite, chalkopyrite, quartz, fluorite and pyrite. Bi, As, Ag, Re and Au are found as admixtures in the field ores.

Fig. 30. Open pit at semiprecious staining (blue diopcide)

Fig. 31. Exploring gallery entrance at Ipchul Cu–Mo field

By the example of the given field one can perfectly see the natural landscape existing before the beginning of the field development (only exploration has been made with reserve calculation) which changes essentially at development of such fields.

Visit to the field and then that to Sorsk concentration plant gives chance to see the development stages of natural-anthropogenic system at different steps of its exploration using comparison and contrast method by the example of two similar ore field.

4.3. Peculiarities of geological structure of Sorsk copper-molybdenum field and copper-lead-zinc field Julia. Study of geoecological problems connected with development of nonferrous metal fields

Route: TPU's training ground – Julia field – Tzvetnogorsk settlement – Bolshaya Erba settlement – Sorsk field.

Route aim: Acquaintance with geological features of Julia field, the first uranium field in Siberia in vicinity to Potekhino village (Labazin, 1930), and Sorsk copper-molybdenum field as well as their geoecological problems.

Along the route to Julia field there is Zavodskoye lake (Fig. 32) which served a source of drinking and process water for mine and Tzvetnogorsk settlement.

Zavodskoye lake has an isometric shape and belongs to upland subwater lakes.

Fig. 32. General view of Zavodskoye lake

Julia field

The field is situated 30 km from TPU's training ground. Large-scale mining was performed in the first half of the XX century, but the last production operations finished at the beginning of the 60's of this century because of the fire at the concentration plant. Commercial ores corresponded to garnet and garnet-pyroxene skarns with impregnation and sulphide clumps. Along with copper Mo and Au were extracted simultaneously. Content of gold didn't exceed 300 mg/t.

Next to Julia Mednaya field (Fig. 33) there is Julia Svitsovaya field (Fig. 34).

Fig. 33. General view of Khakasian typical landscape.
Transition from taiga zone to forest-steppe and steppe zones.
On the foreground there is a dump of Julia Mednaya field

Mineralogical peculiarity of the given field is blue calcites, the coloring origin of which is not clear yet.

At Julia field the rock dumps are on the earth surface where rock debris with visual copper and lead mineralization is accumulated. Samples are of mineralogical value; however, under the action of atmospheric precipitation there occurs mineral oxidation, rock loss and environmental pollution. Down Tzvetnogorsk settlement there is a tailings dump of the field concentration plant of approximate size 1,5 x 0,5 km (Fig. 35, 36). The material of tailings dump is kept in thin sand fraction, the surface being dry, that creates the possibility of dust storms. Study in microelement composition of sand fraction from the tailings damp surface has a significant increase in Clarke in the crust with respect to Bi (1111 times much), Cd (154), Pb (18,8) и Zn (12). Elevated content of Ag in the sample – 71,4 mg/kg (Table 5) is of particular interest. The value of total sum in all element contamination is 1359, which corresponds to a very high level of pollution (Geochemistry …, 1990). Dust ablation from tailings dump surface with elevated concentration of microelements as well as dissolution of these components by atmospheric precipitation and surface water pollution influence negatively the ecology of the given region.

Fig. 34. Dump of Julia Svitsovaya field

Table 5

Microelement content (mg/kg) in single samples of tailings dumps at Khakasia natural-commercial fields

Elements	Tailing dump material						Vinigradov Clark (1962)
	Sorsk field (2 samples)				Julia field (1 sample)		
	C	K	C	K	C	K	
Ba	1000	1,5	2000	3,1	200	0,3	650
Sr	600	1,8	600	1,8	–	–	340
Cr	150	1,8	100	1,2	–	–	83
V	150	1,7	200	2,2	6	0,07	90
Ni	20	0,3	20	0,3	–	–	58
Co	6	0,3	10	0,6	–	–	18
Zr	200	1,2	200	1,2	30	0,2	170
Nb	20	1	20	1	6	0,3	20
Li	30	0,9	40	1,3	–	–	32
Y	30	1	30	1	3	0,1	29

Continuation of table 5

Elements	Tailing dump material						Vinigradov Clark (1962)
	Sorsk field (2 samples)				Julia field (1 sample)		
	C	K	C	K	C	K	
Yb	3	10	3	10	–	–	0,33
Ga	15	0,8	20	1	1	0,05	19
Cu	150	3,2	200	4,3	60	1,3	47
Pb	15	1	20	1,3	300	18,8	16
Zn	60	0,7	100	1,2	1000	12	83
Cd	–	–	–	–	20	154	0,13
Be	4	1,1	4	1,1	0,6	0,2	3,8
Sc	8	0,8	10	1	3	0,3	10
Sn	4	1,6	4	1,6	3	1,2	2,5
Ag	0,15	2,1	0,3	4,3	5	71,4	0,07
Bi	–	–	–	–	10	1111	0,009
Mo	200	182	200	182	10	9,1	1,1

Note: microelements are determined by emission-spectral semiquantitative analysis at ГГП "Berezovgeology" (Novosibirsk); C – element content (mg/kg) and K – concentration factor. Dashes mean that content of element is lower the threshold of analysis detectability

Fig. 35. Old tailings dump of Julia field makes possible wind ablation of harmful chemical elements. At the background there the remains of the concentration plant

Fig. 36. Areas of old tailings dump at Julia field

By the example of Tzvetnogorsk settlement one can see a typical fate of numerous mining settlements where after termination of mine operation there appeared a lot of social problems which in most cases remain unsolved. Unemployment makes people, capable of working, leave their native land. At present Tzvetnogorsk settlement pointed on the Khakasia administrative maps is absent.

Sinks in the vicinity of the field as well as uncivilized extraction of cable from underground mines are accompanied by human deaths.

Uranium field

Near Potekhino village (Bolshaya Erba) on the left side of Bolshaya Erba stream the uranium field is situated in the stratum of bituminous Lower Cambrian limestone. Uranium field was first discovered in Siberia by G.S. Labazin in the 30's of the XX century (Labazin, 1930). At the field both surface and underground mining openings have been well preserved.

Uranium mineralization is connected with intensely ochernized loose brown formations filling the cracks in bituminous limestone. In the dumps one can see debris of oxidized ore with signs of manganese mineralization, but in the mine walls there are white carbonate streaks. The field is considered to be non-commercial, and it indicates general uranium contamination of host rocks at the given region. A large number of radioactive abnormalities have been registered here (Dikoye Ozero region), radon water with elevated concentration of Ag is found, including that in the self-emission well next to railway crossing Tumanny near which health resort "Tumanny" is being intensively built.

Along the route in vicinity to Dabydkovo village on the right side of the river Bolshaya Erba the phosphorite beds were uncovered by mining on Obladjan mount. Obladjan field phosphorites contain elevated uranium concentration which can be an obstacle in their commercial development. Phosphorite ores of such origin usually contain significant concentration of U and TR. As a rule, their development requires complex approach and strict radioecological control.

Along the way to destination the dumps of Sorsk Cu–Mo-field are seen at 12–15 km distance against the mountain background. It indicates great displacement of rocks at its development.

Sorsk field

The field was discovered in 1937, but the construction of combine began in 1949, field operation – from 1953. The combine includes quarry, concentration plant, tailings dump and some other industrial objects.

Sorsk stockwork Cu–Mo-field is located within Batenev ridge, in the Eastern prong of Kuznetskiy Alatau (Mining encyclopedia, 1988). The ore field is composed of Lower Paleozoic granitoid of Uybat batholite (composition is from gabbro-diorites to leucokrat granites). The deposit is plutogeneous-hydrothermal formed at several stages of ore mineralization divided by subalkaline granite-porphyry dyke and stock intrusions in time (more than 80 %). The time of formation for the given object is estimated as tens of million years. The main ore minerals are molybdenite, pyrite, chalcopyrite; the basic vein mineral is quartz. In the ore field of the deposit the 2 main ore zones are distinguished – “West” and “East” divided by barren interval. Zone mineralization is not uniform: in the middle and central parts there are large, nearly barren quartz-feldspar formations, brecciated ores being typical for northern regions. Zones of primarily copper mineralization combine often with those of molybdenum mineralization. The lower boundary of molybdenum mineralization in both zones has not been stated and at some core holes the mineralization signs were found at the depth up to 1 km. In fact, the pitch angle of external boundary at both mineralization zones is vertical. At some deposit areas the uranium mineralization has been found in the form of brannerite (Rikhvanov, 2002).

The field is developed by strip mining. Quarry mineral field is 250 m deep, 1,5 km wide and 2,5 km long. The quarry bed level is 570 m. Pit edge angle is 21…37°. 3 dumps were formed on the territory; the dump height is from 10 to 90 m. The square occupied by dumps is 745 hectare. The volume of piled mass is 315 mln m^3. The basic parameters of changing square occupied by the combine objects (Table 6) are considered in the article of A.A. Potselueyev et al in details. (1998).

Table 6

Basic parameters of changing square for the combine objects

Objects	Objects square, km^2			
	1970	1980	1991	1997
Quarry	0,344	2,187	3,001	3,464
Quarry dump	0,203	4,094	7,461	7,786
Tailings dumps	0,312	2,844	5,094	6,703
Sum	0,859	9,125	15,556	17,953

The stretch of the roads amounts 119,8 km. There are 40 roads in the quarry. In the past 21 mln t were produced, but at present – 5…7 mln t of ore per year. Ores containing molybdenum more than 400 g/t are delivered to the plant, but those with 200–400 g/t content – are removed to the dump and used for underbatching rich ores.

Geoecological problems at the field are connected with the main objects:

Quarry (Fig. 37–38):

1) Underground water horizon is uncovered and depression cone is formed (Fig. 39);
2) chemical underground and surface water pollution with molybdenum, copper, fluorine and other elements;

Fig. 37. General view of quarry sector at Sorsk Cu–Mo-field

3) at quarry explosions dust clouds and nitrogen oxide blowouts are formed, that cover the city at adverse weather conditions (Fig. 40);
4) quarry faces are destructed;
5) quarry gas contamination in the course of machine operation in calm weather;
6) quarry square increases.

Fig. 38. Quarry wall of Sorsk Cu–Mo-field.
Total height is about 200 m.
General view of the quarry and external dumps at Sorsk Cu–Mo-field

Dumps (Fig. 38, 41):
1) withdrawal of areas from land use;
2) soil compaction and underground spring squeeze;
3) wind erosion of overburdens.

Tailing dump

Tailing dump (Fig. 42) was formed because of damming the river Sora valley with 30 m dyke. The tailing dump square has changed from 0,312 km^2 in 1970 to 6,703 km^2 at present. In slurry composition quartz, feldspar, fluorite and sulfides are found. In single samples of tailing dump slime elevated concentration of Mo (200 mg/kg) is stated, it exceeds Clark in the earth crust 182 times as well as Cu to 200 g/t, Ag to 0,3 g/t and other elements (Table 5). The total sum value of all microcomponent pollution is equal to 194–200, which corresponds to very high pollution level (Geochemistry …, 1990).

Fig. 39. Head fracture water in the quarry of Sorsk field.
Pumping down from the quarry is performed along the piping system

Fig. 40. The moment of explosion (dark column) at quarry of Sorsk Cu–Mo-field

Problems:

1) withdrawal of fertile land in the river Sora valley;
2) dust storms;
3) surface water and soil contamination;
4) possible dyke breach (in 1972 there was flooding and destruction of Sora village).

4.4. Geotechnology of gold heap leaching. Geoecological problems

Route: Sorsk town – Mayskiy mine – Abakan city – Kirba settlement.

Route aim: Visit of gold heap leaching unit on the river Tibek and Abakan museum of regional studies.

Fig. 41. Formation of internal dump in the quarry field of Sorsk Cu–Mo-deposit

Mayskiy pit

The method of heap leaching (HL) fo/*und widely application in the 80's of the XX century and enabled a number of developed (the USA, Australia, Canada) and developing (Mexico, Brazil, Chile) countries to double gold mining. At present nearly half of the world gold production is due to HL technology. HL technological systems are relatively simple and cheap in comparison to those applied at gold extraction plants (GEP). Engineering-economical estimation of HL shows that capital expenditure of facility construction does not exceed 20…25 % cost of GEP construction operating in complete cycle, but maintenance charges are 35…40 % cost when using traditional cyanidation technique (Sedelnikova, 2001). In the USA gold production increased from 80 to 220 t/year owing to great extension in gold heap leaching application. Moreover, more than 50 % of the metal is mined by HL method. Gold mining production cost in the US does not exceed 7,3 dollar/year in 50 % cases, that indicates high profitability of the technique (Mosinets, 1991).

Fig. 42. Tailing dump at Sorsk Cu–Mo-field which is an anthropogenic field

HL gold method was first applied in Russia at Ural region in gold production plant dumps of joint-stock company "Yuzhuralzoloto" (open joint-stock company "Colorado", 1993) and in Khakasia at Mayskiy deposit (prospecting gang "Sayany", then GPC "Zolotaya Zvezda", 1994). In 2000 there were 10 operating HL units in Russia where 11 ore and gold anthropogenic deposits were processed (Makarov, 2001). By 2003 the whole number of HL units was to increase minimum to 20.

The HL object in Khakasia visited by students is located on Tibek river falling into the river Beyka. The oxidized ores of Mayskiy deposit with gold content of 2,4…7,0 g/t are processed there. The rock mass plant capacity is 100…315 thous. t/year. The mining volume is approximately 150…1200 kg/year. Gold recovery amounts up to 83 % (Sedelnikova, 2001). Recovery manufacturing scheme begins with heap formation. For this purpose rock ores are crushed at jaw breakers to the particle sizes of 10 mm (Fig. 43). The heap of 50…100 thous. m^3 volume is formed (Fig. 44).

Fig. 43. Crushing of gold-bearing ores at Mayskiy deposit to form a heap

Fig. 44. Heap base laying. The base is covered with special durable polymer material (light) preventing from cyanide into underground waters

The clay spacer is put at the heap bottom. It is covered then by double layer of special polymer material or thick polyethylene film.

The film is covered with broken muck and then drain pipes are laid at the heap bottom, gold-mud trays are installed around the periphery (Fig. 45). On the heap surface a cell grid is formed where sodium cyanide solution of definite concentration is fed (Fig. 46). After solution seepage through muck gold-enriched fluid is delivered at storage pond through drain pipes and specially designed trays (Fig. 47). The solution is fed from storage pond to the plant where it has been passed through zinc shavings before (Fig. 48), but at present – through activated carbon (Fig. 49).

Fig. 45. Trays along which gold cyanide fluid is flowing. The tray bottom is laid with special polymer material. One can see the drain pipes along which leaching solution is fed to «heap»

Zinc shavings are processed first with acid after a definite period of time, then by heat. The resultant mass is mixed with certain chemicals and fed to electric smelter where rough gold ("Dore alloy") is produced.

In this method along with high production profitability there appear some environmental problems that should be paid attention to. Sodium cyanide solution used as a leaching chemical is evaporated into atmosphere in the process of production. Besides, aerosols and dust particulates are transported by wind. In production process solution can leak which is accompanied by soil and aquifer pollution (Sedelnikova, 1996). Everyone remembers the discharge of cyanide-bearing fluids into Danube river and its consequences. In addition, the problem of bird and animal penetration to the territory of leaching production is also very acute. In Nevada (The USA) it was solved by fencing with close-meshed net from rodents and large-meshed – from cattle. Birds are scared away by a special sound gun.

Fig. 46. Net of pond cells in the upper part of heap where cyanide solution is fed along the pipes. The solution leaks into crushed loose material and leaches Au. Ponds are filled as solution decreases. It is a so called pond method. There is also a spraying method (a specific shower for «heap»)

Fig. 47. Storage pond with cyanide solution from which gold has already recovered. Next, solution is reproduced to the necessary parameters and again is fed to heap (closed cycle). The plants of such kind uses only closed system of solution processing

Fig. 48. Reservoirs with zinc shavings for gold precipitation from solution

Fig. 49. General view of gold precipitation unit on activated carbon

In many developed countries there is computerized testing of polymer covering defects preventing cyanides from ground and underground water.

Water protection at HL is the main environmental problem.

4.5. Geological structure peculiarities of Minusinsk coal deposits. Geotechnology of open-pit mining at Chernogorsk and Beysk deposits. Geoecological problems of coal mining

Route: Abakan city – Kirba settlement – Vostochno-Beysk open-pit mine – Abakan city – Chernogorsk open-pit mine.

Route aim: Acquaintance with open-pit coal mining technology, study in geoecological problems of coal producers by the example of Chernogorsk and Vostochno-Beysk coal open-pit mine.

The main coal producers are located in the south of Khakasia, where Chernogorsk, Stepnoy, Abakan, Izykh, Vostochno-Beysk and other coal open-pit mines as well as Khakasskaya and Yeniseyskaya pits are situated. Geological regional characteristic of coal mining as well as valuable and toxic element content in coal have been presented in S.I. Arbuzov's et al research (2003).

Vostochno-Beysk coal mine is located 20 km from Sayanogorsk town near to Kirba settlement (Fig. 50). At this mine coal production of Chalpan Beysk deposit region is performed from 1920 due to construction of energy system along the Achinsk-Minusinsk railway.

Fig. 50. Vostochno-Beysk coal mine of Minusinsk coal basin. «Chalpan» area

In the deposit geological structure the main part is coal-bearing series in the form of Chernogorsk suit deposition of 270 m. thick. At the suit bottom gravelite, conglomerate, sandstone occur. Higher coal-bearing rocks are presented by sandstone and siltstone sequence. Among them to 20 coal beds are revealed among which 5…7 beds are of total thickness up to 22 m.

At present the mine capacity is more than 1 mln t/year, but planned production is 2 mln t/year in complete operating conditions.

Coal mining technology includes formation of external and internal dumps for stripping rock. Loosening geological material is performed by explosion, then it is taken away by excavator and powerful automotive engineering to the dump, coal is carried to the plant. Coal crushing and grading is made at crushing-grading unit. Coal is sorted into four grades:

CR – cannel raw;

CPL – cannel plate large (+50) ÷ (–300);

CN – cannel nut (+25) ÷(–50);

CSC – cannel seed chip.

Chernogorsk coal mine Co Ltd "Chernogorsk coal company" is the largest coal mining enterprise of Khakasia republic. At the moment (2004) its production is as much as 2,8 mln t of coal per year.

Open-pit mine is located in the south-east part of Chernogorsk field in Minusinsk coal basin in vicinity of Chernogorsk town. At the deposit coal beds of Chernogorsk suit are mined. Commercial coal mining at the deposit has begun from 1907.

At Chernogorsk coal mine coal is produced by open-pit technique from 1961. Within more than 40-year period of operation there appeared a lot of ecological problems. Geological structure uniformity, rock composition, coal types and quality at production site of Chernogorsk mine and Chalpan field mined by Vostochno-Beysk deposit permit us to compare the application of different technological approaches to deposit development.

Negative effect of industrial enterprises on the environment correlates with natural landscape disturbance, aquifer drainage which results in depletion of natural fresh underground water resources. Artesian aquifer drainage provides the conditions for depression cone formation of some tens kilometer radius. Surface and underground water pollution is due to water-migration flow conditioned by sediment pool sewers. As a result, ponds and streams are polluted, ground, alluvial, under-dump water is contaminated. Coal development is related to fires that most often occur due to mineral self-ignition. Endogenous fires present great danger for miners, as in this case toxics and damps are released, among them being окись carbon oxide sulphur dioxide, hydrogen sulphide and other pollutants (Lindenau, 1977). Average concentration of sulphur dioxide ranges from 0,27 to 0,78 mg/m^3 depending on the distance, single – from 0,46 to 1,7 mg/m^3. Action radius is as great as 800 m or more. In recent years mining enterprises have accumulated practical experience in fire prevention and suppression (Saranchuk, 1978). At Chernogorsk mine fires are extinguished mostly by heat source blocking with overburdens. This method is not efficient in most cases.

At Vostochno-Beysk mine an up-to-date dump formation technology has been applied, it consists in alteration of waste rock levels with clay levels preventing from oxygen to carbon-bearing rocks. Application of this technique is highly efficient, this shows the absence of dump self-ignition sources.

Geoecological problems of Chernogorsk and Vostochno-Beysk open-pit mines:

1. Landscape disturbance. Dumps and mine itself occupy large territory (Fig. 51). Chernogorsk field length is over 4,5 km, ranging together with adjacent “Stepnoy” field up to 7 km.
2. Surface and ground water pollution at aquifer drainage on the course of field development.

Fig. 51. General view of Chernogorsk open-pit mine (OJSC «Chernogorskaya ugolnaya companiya»). One can see a large area disturbed by mining

This problem is particularly urgent for Vostochno-Beysk mine, as it is located in vicinity of specially protected “Sorokazerka” area. There are 3 ways of solving the problem of quarry water utilization:

a) creation of surface evaporation basins with possible subsequent usage of salt water for medical purposes;

b) construction of bulkheads to isolate spaces of coal mining;

c) water pumping into porous rock.

At present the first method is applied. Basin water is partially used dust catching in mine. There is no quarry water discharge into channels.

3. Atmosphere pollution because of explosions, dusting, gas contamination and dump burning.

Explosions are applied to loose rocks and coal. As a result, dust and gas cloud is formed (Fig. 52), among which nitrogen oxide is the most harmful.

Fig. 52. Explosion at Vostochno-Beysk open-pit mine. One can see a dust and gas cloud

Burning dumps is of greatest danger for the environment. This problem is rather typical for Chernogorsk mine. Burning dumps is accompanied by large discharge of toxic gases. These processes last quite a long period of time and are capable of influencing the environment.

The method of burning dump isolation with rock overburden applied at the mine does not provide complete solution of the problem. Apparently it is necessary to develop new methods of dump storage. Such a technique is used at Vostochno-Beysk mine. The layered distribution method used at Vostochno-Beysk field for potentially combustible (ash coal, coaly rocks) and non-combustible (clay) rocks made it possible to form and reclamate the external dump as soon as possible (Fig. 53, 54).

Fig. 53. External dump of waste rocks at «Chalpan» area of Vostochno-Beysk coal open-pit mine. At the food of the formed potentially combustible rock level (coaly rocks, ash coal) one can see the level of non-combustible clay rocks

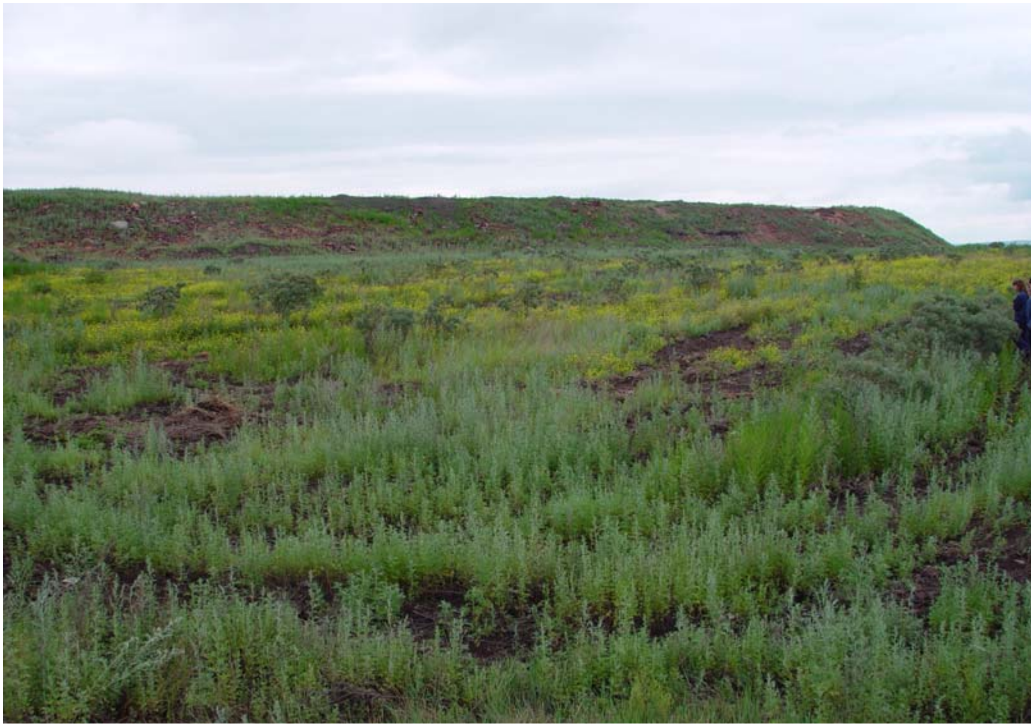


Fig. 54. Reclamated field of Vostochno-Beysk open-pit mine

Along the same route one can observe the burnt wood formation due to coal beds in their natural occurrence. The coal of Velikan bed at Achmindor mine has already been burning for eight years. In 1997 there were the sources of open fire there. Later, in 1998–1999 fire prevention measures were taken. Burning is still going on, but with less intensity (Fig. 55, 56, 57).

Fig. 55. Coal bank burning at Achmindor field.
One can see the sources of open flame. (1997)

Fig. 56. Sources of open flame at Achmindor. Velikan layer is burning. (1997)

Special attention is paid to coal and its ash being potential sources of valuable (Ge, Sc, TR etc.) and toxic (Tl, Cr etc.) elements and requiring a complex approach to their processing (Arbuzov et al, 2003).

Fig. 57. Achmindor field after fire safety actions.
One can see smoke from underground coal burning. 2002

4.6. Geological structure peculiarities of Tey iron ore field. Quarry mining geotechnology. Geoecological problems

Route: Abakan city – Tey Vershina settlement – Tey field – Abakan city.

Route aim: Acquaintance with open-pit ore mining technology, study of geoecological problems at mining enterprises by the example of Tey Fe-ore field.

The first descriptions of Tey iron-ore field were performed by the geologists I.K. Bazhenov and A.K. Kuz in 1930 checking up the hunter P.E. Tabastayev's proposal who found piles of magnetite ores here. Started in 1931, geological prospecting revealed new deposits: Tuzukhsin, Yelgen-Tag, Khabzassk and Abagass. Total resources were estimated at 120 mln t.

In 1941–1945 P.I. Petoshin and L.I. Shabynin made the first prospecting of Tey field. Resources of standard ores were estimated: 8,4 mln t of B category and 24,5 mln t of C_1 category.

In 1969–1976 Tey exploratory teams prospected hanging wall of ore zone, but in 1978–1984 A.A. Parubin made prospecting at deep levels.

As a result, significant growth in resources 123,4 mln t of C_1 category was obtained, element composition and technological ore properties as well as hydro-geological field conditions were investigated completely.

The transport development system with external dump formation is used at the deposit. Rock body is loaded with cyclic excavator and is removed by transport. Dump formation is made by bulldozer. The bench height in quarries is 15 m. Primary enrichment of magnetite ore at crushing-concentration plant includes crushing and dry magnet separation. Industrial product with iron content 30 % is delivered to Abagur concentration-sintering plant in Novokuznetsk city for re-enrichment.

From the moment of operation commencement the geological environment significant of the region has significantly changed. Formation of three quarries and four dumps in the process of field development has changed the region landscape essentially. Large squares are occupied by overburden rock dumps, base tailing dump occupies the Valley of Tuzukhsu River. The South dump rocks pollute the surface water of river Teya.

As a result of the field development secondary anthropogenic ore fields have been formed, their resources increase every year. Besides, on the surface of quarry and dump walls oxidation takes place, which results in soil, surface and underground water pollution.

4.7. Geological structure peculiarities of Kiyalykh-Uzen and Kommunar fields. Geoecological problems

Route: TPU's training ground – Tuim settlement – copper field Kiyalykh-Uzen – Kommunar settlement – Kommunar gold field – TPU's training ground.

Route aim: Acquaintance with geological peculiarities of Kiyalykh-Uzen and Kommunar deposit region as well as with their geoecological problems.

Copper-Molybdenum field Kiyalykh-Uzen

The field is located on the left edge of river Tuim valley in the settlement with the same name. It has been known for a long time and was prospected many times. A great volume of exploratory working with tunneling was performed in 1905–1908 under Delary's supervision. In 1933–1934 under the supervision of L.D. Staroverov the field prospecting by drilling-out was made, its commercial value was estimated. In the 50's, 60's, early 70's the field was developed with extraction of molybdenum and copper from ore. The ores of the field are complex molybdenum-copper-iron and molybdenum-copper. The former presents magnetite skarns with impregnations and streaks of chalcopyrite and molybdenum; the second – those of metasomatic quartzite with molybdenite rash and with impregnations of copper sulphide. Quartzite is formed mainly due to volcanogenic rocks. Seldom ore mineralization is defined by the shatter zones and hydrothermal transformations in granitoids (grano-diorites and grano-syenites) of Ulen-Tuim complex at some distance from country rocks. There are many scarn deposits of such kind in the region of practice. Most of them were formed at different time. They are characterized by unique mineralogy (Ivankin, 1953) and geochemistry (Rikhvanov, 2003).

At present field is not developed. On the field site a great sink has been formed which presents a unique object form the geoecological point of view (Fig. 58), as well as there is a large tailing dump overgrown with secondary forest.

Gold field Kommunar

Ore gold deposits of Kommunar-Balakhchin complex have been developed from 1899. By the present time gold has been found nearly in all rocks of the region with the content close to that of Clark. Gold commercial concentration is conditioned by the following types of ores: 1) gold-bearing quartz lode; 2) stockwork type; 3) gold-bearing zones of hydrothermally changed rocks and others.

Fig. 58. Tuim sink of Kiyaykh-Uzen field. The bottom is filled with water at 10 m deep

The basic type of ore at Kommunar field is stockwork. Gold is mostly localized in quartz veins forming comparatively dense network and in most cases concentrating in their casing. In some places impregnated ores in rock slab limited by quartz veins are of great significance. Usually low gold concentration in the latter ore type is an appreciable addition to gold in quartz veins that allows for development of large slabs without grading. In some cases ores are localized in magnetite skarns.

Ore is developed mostly by underground opening, but there were some quarries (region of Podlunny Goletz). Within the allotment there are a great number of barren rock dumps that results in anthropogenically transformed landscapes (Fig. 59). On the territory large rock sinks have been formed (region of Maslovo vein), which create dangerous conditions both for production and population.

Fig. 59. Dumps and depression at Kommunar field.
Nasty day and white clouds are seen

Gold is extracted at the plant. For a long time the amalgamation method has been used which was accompanied with mercury losses up to 273,46 kg per year. Now the cyanidation method is used (Fig. 60), it permits for increase in gold yield and solution of a number of environmental problems.

Within the period of the mine operation the old tailing dump of 20 m deep of 0,6 x 1 km size was formed where about 10 mln m^3 of liquid waste is kept (Fig. 61), including that of mercury-bearing (Makarov, 2001).

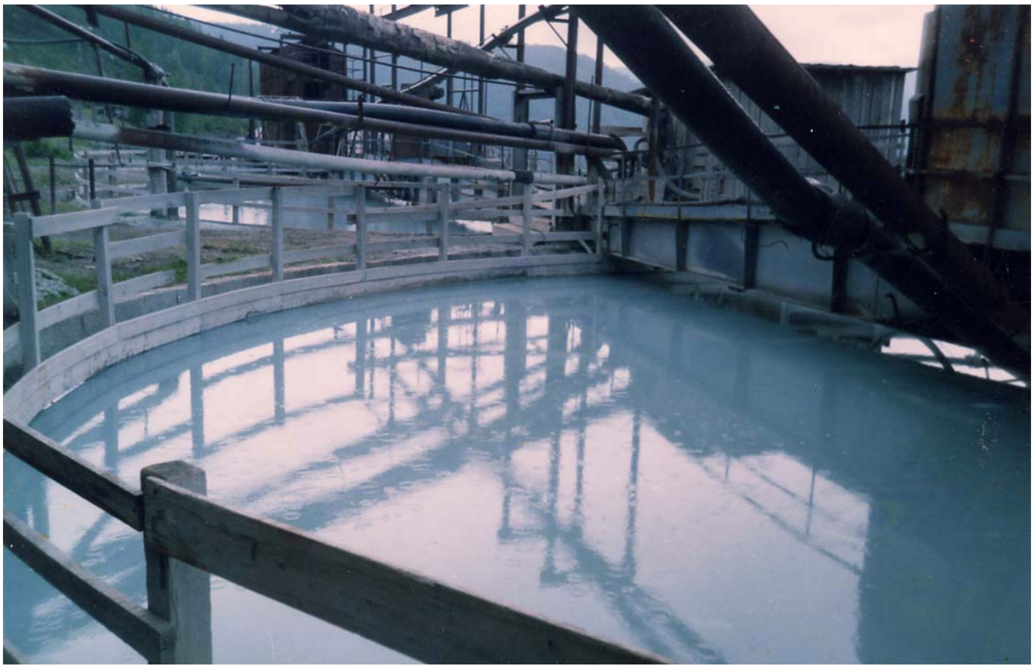


Fig. 60. Gold extraction technique by cyanidation at the plant of Kommunar deposit

Fig. 61. Sediment tank of cyanic solutions at Kommunar field

Every year about 270–300 thous. t. of wastes are formed. This required the construction of new tailing dump on the square of 103 hectares, 10 m deep. Now there are more than 5 mln t of wastes there.

Visit to ZIF ("ЗИФ") makes possible to learn all stages of production (from crushing of gold-bearing rock) of ore to gold extraction.

CONCLUSION

A variety of natural and mining complexes in Khakasia through which pass the excursion routes differ in their aims and itinerary, among which one can distinguish the following:

1. Mineral lakes of Khakasia and their environmental problems. Recreation and reservation zones.
2. Coal mining enterprises and their geoecological problems in development of minerals by open pits and mines.
3. Mining enterprises (Sorsk and Tey fields) and their geoecological problems in mineral development by opening (quarries).
4. Gold-mining enterprises of gravel and ledge field and their geoecological problems in development by industrial installations and underground openings (adits).
5. Old mines and tailing dumps at the fields, natural-geotechnical systems and their geoecological problems. Reclamation of disturbed soil.
6. Modern technologies of metal extraction (heap leaching).

In the process of geoecological educational training students have the possibility to learn the unique mineralogical (garnets, pink and blue diopside, blue calcite, large crystals of capel etc.), petrological (alkaline basalt, eruptive breccia etc.), geological formations (explosion tubes etc.), landscapes and biocenoses. They have the chance to see and feel the beauty of Khakasia primeval nature where many peoples were born and live nowadays. They create Orkhon (Yenisei) writings, rock paintings and other monuments of ancient culture (Slavin et al, 1999), developed mineral fields…, and thought about greatness of nature and eternity of life.

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