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Geotectonic Position and Metallogeny of the Greater Altai Geological Structures in the System of the Central-Asian Mobile Belt

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1. Introduction

According to the geotectonic position the Greater Altai geological structures are located in the Central Asian (or Kazakhstan-Okhotskij) global mobile belt of a sub lateral direction embracing geo-structures of Kazakhstan, Northern China and Mongolia. Within its border the structures of the Greater Altai are located on the north-western flank of Altai-Alashan curved shape mobile zone that envelop the Siberian platform from the south-west and the south.

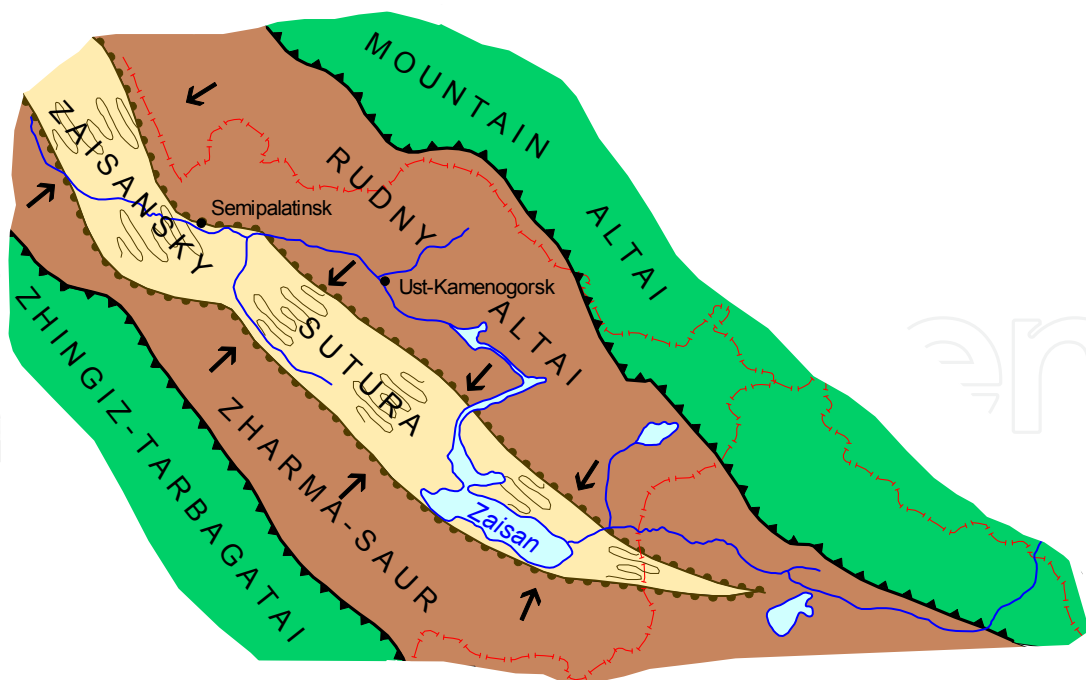


Fig. 1. Main geological structures of Great Altai

The territory comprises the Rudny Altai, Kalba-Narym zone, West Kalba and Zharma-Saur which are considered in the Irtysh-Zaisan geosynclinal fold systems. The board structures of

the north-east are the Rudny Altai caledonides (Charyshskij, Holzunskij-Chuiskij-Sitsikheskij and Tsunhu-Chinkheskij structural zones), and the caledonides of Chingiz-Tarbagatai fold system are on the south-western part (Fig.1). On the south-eastern flank of the Greater Altai structures is narrowing sharply due to the thrust from the Djungarian array and West-Siberian plates. The north-western flank can be observed up to Russia and is mostly blocked by loose cover of the Kulundinskij cavity. The total length of the territory in up-to-date coordinates is more than 1000 km at an average width of 300 km.

Minerals of the Greater Altai are the natural stocks of huge deposits containing non-ferrous and precious metals and other resources. By processing these minerals copper, zinc, lead, gold, silver, platinum, titanium, rare and dissipated elements can be obtained. On the basis of these metals and elements the mining industry infrastructure with plants, towns and villages has been established in this region. For the purpose of mining industry enterprises sustainable work the metals stock should be continuously renewed.

Thus, high rates and volumes of exploration for the last ten years have led to the exhaustion of easily-discovered deposits. The scientific ideas in the field of geology governing for many years, particularly geosynclinal concept of fixism came to their self-exhaustion. That is why the methodology of metallogenic research, forecasting and new deposits exploration needs to be improved. New approaches to the geology, ore deposits depth-geological forecasting criteria development are required, especially in the exploration of loose and concealed deposits (up to 1000-1500 m).

2. Geotectonics and metallogeny

The overall progress of Earth sciences, new data on paleomagnetism, paleoclimatology, new mobilist hypothesis emerging in the 60th of the last century (plate tectonics, mantle plumes, terranes, new global tectonics) have determined the necessity for reviewing the traditional paradigms on tectonic and metallogenic development of the given region. In this connection on the basis of global mobilism hypothesis the practical material generalization in the field of geology, geophysics and the Greater Altai and adjoining territory metallogeny has been carried out. This provided the identification of new principles for metalliferous geological structures development and the deposits formation under different geodynamic circumstances (Geodynamics..., 2007; Greater Altai..., 1998, 2000; Shcerba et al., 2000). As a result of research activity productive mineragenical levels and patterns have been determined with the perspective for non-ferrous, precious and rare metals exploration and the directions of exploration works have been defined.

2.1 Geodynamic development

The Greater Altai is a holistic geostructure of a vast territory, including the geological structures of the Rudny Altai, Kalba-Narym, West-Kalba, Zharmasaur and nearby territories of Russia and China. In the tectonic outline it is a linear fault-fold structured pattern in the system of Central-Asian mobile belt. The space is located between the stable continental arrays - Gornoaltaiskij (on the north-east) and Kazakhstanskij (on the south-west).

From the point of global mobilism, huge geological structures nucleation and formation in Kazakhstan, Siberia, Ural and other regions are connected with the break of the Eurasian continent into separate plates, geoblocks, arrays and xenoliths at the period of late

Proterozoic. They were drifting in the Paleoasian ocean and made significant horizontal relocations. According to the paleomagnetic and geological features, the lithospheric plates and xenoliths relocations are supposed to originate from the east to the west (with clockwise rotation). The Greater Altai structures are possibly the xenoliths of the ancient paleo-continent (Eastern Gondwana). In the process of the Paleoasian ocean evolution, some xenoliths joined, perhaps, the Siberian craton, others formed the Kazakhstan microcontinent which then at the Devonian and Early Carboniferous periods were separated from the Gornyi Altai by Irtysh-Zaisan paleobasin (Greater Altai..., 1998).

The Greater Altai as a unified structure has transformed into the stage of the Hercynian collision (in Early Carboniferous and later) as a result of subsidence and interfacing of Kazakhstan continent borders and Siberian sub-continent which were divided by Zaisan sutural zones (Dyachkov et al., 2009). In later tectonic cycles the formed structure was complicated in the process of late-Hercynian intraplate rifting and then stabilized at the Mesozoic and Cenozoic periods. The modern Greater Altai structure is considered as a system of earlier separated blocks that are parallel to the structural-formation zones or collage terranes. The emerged tectonic structures (Altai Mountains, Rudny Altai, Kalba and others) are limited by deep faults, sutural zones and are differentiated according to the development geodynamics, geological structure and metallogeny specificity.

In the process of paleo-geodynamic reconstruction the geodynamic model of the Greater Altai formation has been developed. It is a modern type of structural-formation zone sub-parallel systems distinguished by deep faults. This geodynamic model of lithosphere rhythmic tension and compression having significant horizontal relocations of lithospheric plates by interlayer surfaces of the upper mantle, characterizes the Altai type of the Siberian and Kazakhstan subcontinents global interaction. The Greater Altai unique structures and its metallogeny are due to the geological processes grandiosity and duration.

This article considers the peculiarities of geological development, depth structure and leading types of the Greater Altai deposits having been formed under different geodynamic conditions. The overall geological formations development direction at the Precambrian was at the oceanic rifting mode, then in the early (rifting and insular), medium (collision) and late (post-collision) stages of the Caledonian and Hercynian cycles. This process terminated by the continental rifting and stabilized in the Mesozoic and Cenozoic. The indicators of paleo-geodynamic and landscape-geological conditions are the certain geological formations reflecting their emergence pre-conditions.

In the Precambrian cycle, at the oceanic rifting mode the pre-Riphean crystalline basement of small arrays destruction took place. They were split into separate fragments and blocks and then moved. Within the Greater Altai the fragments of the Precambrian basement are fixed in the Charsk-Zimunai zones and Irtysh zone of collapse. They are complicated tectonic-metamorphic structures with intensive dynamo-metaphoric reformations of rocks that are suppressed by folds, thrusts and polycyclic metallogeny. They contain schists, gneisses, amphibolites, granite-gneisses with hyperbasite protrusions and serpentinite melange blocks. In hyperbasites there are magmatic deposits of Cr, Ni, Co (Pt) which form Charsk ore-bearing level with later form gold mineralization.

In the Caledonian volcanic arcs of basalt-andesite-dacite series with iron-manganese and gold-chalcopryrite deposits (Akbastau, Kosmurun, Mizek) were formed at the side structure of Zhingiz- Tarbagatai in rift-insular-setting of an early stage (ϵ^1 - O^3) (Table 1).

Cycle	Geodynamic setting	Zhingiz - Tarbagataj	Zharma-Saur	Shar Zone	West Kalba
Precambrian	Oceanic rifting			Ultramafic rocks, Shar group (Cr, Ni, Co)	
Hercynian and Caledonian	Rifting and insular arc formation	Middle-Late Ordovician basalt-andesite-dacite, Akbastau (Cu, Zn, Au)			
	Collision		Middle-Late Carboniferous gabbro-granoid-diorite-granite, Sekisovskij (Au, Ag, Te)	Metamorphic and hydrothermally altered rocks, Kyzyl-Shar (Au, Hg)	
			Late Carboniferous rhyodacite and grano-diorite, Vasilevskij (Au)		Late Carboniferous Grano-diorite-plagiogranite, Bakyrchik (Au, As, Ag)

Cycle	Geodynamic setting	Zhingiz - Tarbagataj	Zharma-Saur	Shar Zone	West Kalba
	Post-collision within plate reactivation		Late Permian-Early Triassic alkali granite, Upper Espe, (REE, Nb, Zr)		Late Permian Granite and leucogranite, Delbegetei (Sn, Be)
Kimmerian	Continental rifting and stabilization		Late Cretaceous-Eocene kaolinite-hydromica zone of weathering, Zhanan (Au)	Late Cretaceous-Eocene nontronite zone of weathering, Belogorskiy, (No, Co)	Late Cretaceous-Eocene kaolinite zone of weathering, Karaotkel (Ti, Zr)

Table 1. Geodynamic settings and main epochs of ore formation in East Kazakhstan

On the Greater Altai territory and in the Altai Mountains there was a marine mode with the formation of calcareous-siliceous-terrigenous elements. At the medium stage (O_3-S) there emerged the tendency for Irtysh-Zaisan small oceanic-basin degradation due to the growth of accretion zones in Gorno-Altai and Kazakhstan continental arrays. The collision magmatic front was located in the doming spreading zones with the formation of gabbro-diorite-granodiorite intrusions ($O-S$, S_2) at the focal parts of Zhingiz Tarbagatai and Rudnoaltaysko-Ashalinskij zones. The mineralization is represented by Fe, Cu, Zn, Mo, Au. The most productive level of pyritic copper-zinc ores was located in the active Kazakhstan suburbs and is connected with O_{2-3} insular-arc basalt-andesite volcanism (Mines Akbastau, Kosmurun, Mizek in Zhingiz Tarbagatai).

At the final stage (S_1-D) the unified caledonian structure of the Greater Altai under general rotation of the Siberian continent and its adjacent folded structures in a northern direction was formed. In the process of the Greater Altai borders intraplate activation in the Altai Mountains, granodiorite-granite intrusions D_2 (Mo, W, Bi) emerged, and in Chinghis Tarbagatai - arrays of granit- granosienite -leykogranitovoy series (D_2-D_3) with a poor rare-metal mineralization appeared.

The Hercynian cycle was marked by a repeated division and spreading of the Caledonian continental borders and the formation of a secondary Irtysh-Zaisan oceanic basin with a large magmatism and mineralization. At the early stage the main ore-bearing structures of the Rudny Altai formed under the rifting and insular-arc geodynamic conditions in the process of echeloned deep faults system activation. This contributed to the inflow of mantle basaltic magmas and mineralizing fluid flows into the upper parts of the granule cells. Major industrial chalcopyrite and pyrite-polymetallic deposits are genetically connected with an intensively displayed Devonian basalt-andesite-rhyolite volcanism. The most productive deposits are volcanic arcs of round structure flanking the Caledonian paleoelevations and having long volcanic process and mineralization (Ridder Sokolnoe, Maleevskoe, Nikolaev, etc.)

At the medium stage (C_1-C_3) as a result of geodynamic mode change and prevailing compression (in the Early Carboniferous and later) the unified geological structure of the Greater Altai formed after the Gorno-Altai and Kazakhstan continental borders collision, their connection took place in Zaisan sutural zone. This stage was implanted by syncollision gabbro-diorite-granodiorite intrusions, small hypabyssal intrusions and dikes of gabbro, diorite, granodiorite containing Cu, Ni, Au, Ag. In Zaisan sutural zone in the mode of rhythmic-pulsating tectonic movements of tension and compression the belts of gold-bearing small intrusions and dikes of Kunushskij complex (C_3) are located. The diagonal systems of cross-cutting faults of late-collision stage with gold objects in the terrigenous-carbonate and black shale sequences (Bakyrchik, Suzdal, Kuludzhun, etc.) were the ore-controlling elements. At the late stage (C_3-T_1) under the conditions of intraplate activation of deep faults the granitoid belts with rare metal and rare-metal-rare earth mineralization - Ta, Nb, Be, Cs, Sn, W, Mo, Zr, Tr et al (deposits Bakennoe, Belya Gora, Verkhnee Espe, etc.) have formed.

The Cimmerian and Alpine cycles of the Greater Altai epihercynian structure development had a noticeably relative mobility in the Triassic and Jurassic, were significantly stable in the Cretaceous-Paleogene and during activation in the Neogene-Quaternary. This period is characterized by the formation of deposits in weathering crusts (Au, Ni-Co, Zr-Tr), placer gold, ilmenite, tantalite, cassiterite and other minerals. So, the geodynamic development of the Greater Altai mobile belt reflects a long and complicated history of geological structures

formation in the process of collisional displacement of the Siberian and Kazakhstan subcontinents and the Irtysh-Zaisan paleo-basin degradation. It also emphasizes the intensity of ore-magmatic processes and metallogeny.

As a result of tectonic-magmatic processes polycyclic development the main periods of mineralization have been determined. They reflect vertical and lateral mineralization zoning in the frames of ore belts and the region of the Greater Altai.

2.1.2 Deep structure

The deep structure of the given region is considered according to the complex of geological and geophysical data (gravimetric, magnetic prospecting, seismic exploration and other activities) and is characterized by multilayered crust (MC) and upper mantle (M). According to the modern interpretation of geophysical material MC has the power equal to 50-55 km and includes heterogenic linear -mosaic blocks complicated with deep faults (Greater Altai..., 1998; Shcherba et al., 1984).

The upper mantle is characterized with the inhomogeneous structure and stratified to a depth of more than 250 km. In its structure there is supposed to be an undepleted mantle (pyrolytic) and drained including spinel containing dunites and harzburgites, garnet eclogites and alpine hyperbasites. The surface of the M is under the depth of 40-55km and is immersed in different directions. According to the works of V.N.Lyubetskoy, G.P. Nakhtigal and other researchers there is a scheme of asthenosphere layer topography where the ore-belts are marked and the asthenosphere topography location. The highest elevation of the asthenosphere layer (Semipalatinsk, Zaisan) of the north-west direction is in the Zaisan sutural zone, i.e. in the Kazakhstan and Gornoaltaiskij borders collision zone (Fig.2). The elevation of the Mokhorovich surface is fixed on the north-western flank of the sutural zone (Gornostaevskij) and on the south-eastern part (Zaisanskij) (Fig.3). Stratified asthenospheric zones in the upper mantle, deep faults system dissection are obviously the consequence of magmatic chambers generation, their metallogenic specialization and activation of geodynamic processes in the multilayered crust. The consolidated multilayered crust of the Greater Altai comprises four layers: meta basalt, meta diorite, meta granite and sedimentary.

The power of the meta basalt layer is 20-24 km and is up to 28 km at the crest thickenings of the north-western direction. Here there are also linearly elongated modern thermal anomalies. Deep faults (Charsk-Zimunaysky, Terektinsky and Baiguzin-Bulak, Siretasky), falling in different directions penetrate into the upper mantle and form marquee-type structures.

The meta diorite layer is represented by deeply metamorphosed rocks of the Precambrian (the average density of 2,8 g/cm³, the wave velocity 6,4-6,6 km/s). Its greatest power (12-16 km) is noticed in Kalba-Narym, Beloubinskij- Sarymsaktinskij and Sirektas-Sarzanskij zones). In Zaisan suture the power is minor and is 4-12 km. According to G.P. Nakhtigal in the meta diorite layer there are the lower edges of the most magnetically active objects and the root parts of the large granitoid plutons.

The meta granite layer embraces the metamorphosed Caledonian formations and major arrays of granitoids. It is exposed on the surface of Zhingiz Tarbagatai, Aleisk and the Rudny Altai and Sinyuhinskij blocks, fragmentary it can be viewed in the Irtysh, Sirektas and Sirektas- Sarsazan zones, and also in the Charsk block. The maximum power of the layer (up to 12-14 km) is in Kalba-Narym and Beloubinskij-Sarymsaktinskij zones.

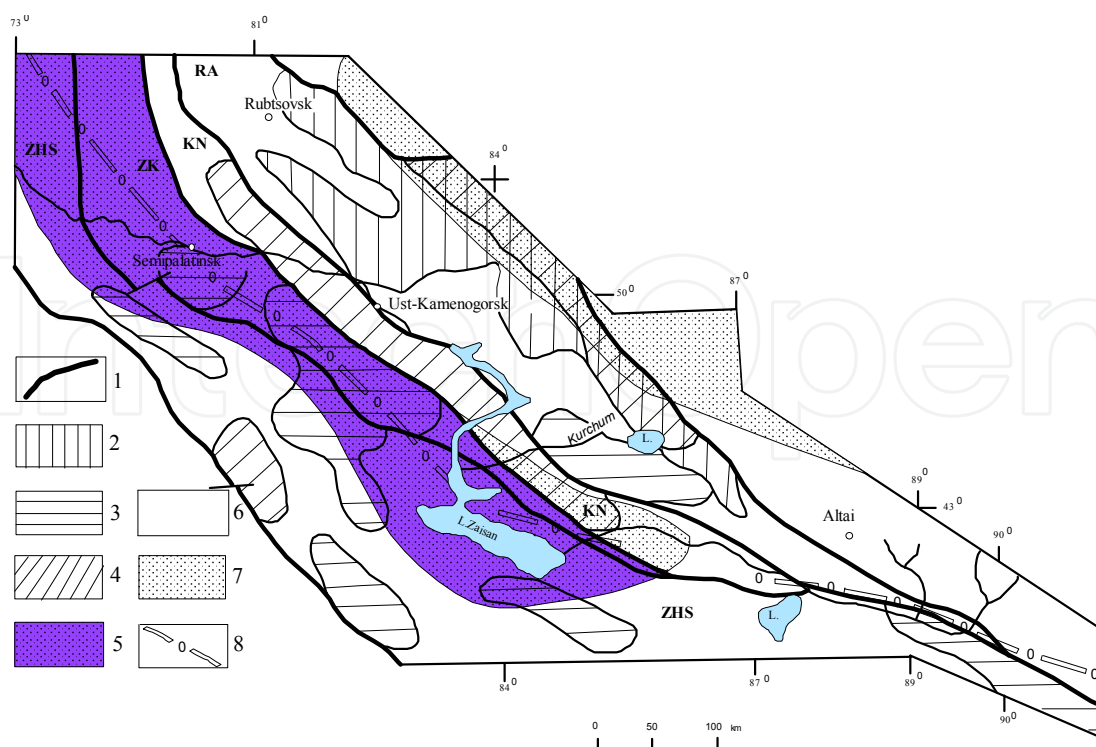


Fig. 2. Great Altai ore belts and asthenosphere layer topography

1- borders of the region, 2-3: Hercynian stage ores (1- rift stage and island-arc borderland stage, 2- collision stage, 3- postcollision stage); 5-8: asthenosphere layer topography (5- elevation of the asthenosphere layer, 6-slope of the elevation, 7-depression, 8- depression axis. Ore belts: RA- Rudny Altai, KN-Kalba-Narym, ZK- West Kalba, ZHS- Zharma-Saur

Sedimentary layer is formed by non-metamorphosed Paleozoic and Mesozoic and Mesozoic-Cenozoic sediments. According to F.S. Moiseenko (1981) it is divided into two sub-layers: volcano-genic-sedimentary and loose sedimentary cover. The powers of the hercinides volcano-genic-sedimentary sub-layer is 0-9 km with minimum values (0-3 km) on the elevations (Rudnoaltayskij, Kurcch-Kaldzhirskij, Tersayrykskij) and with the maximum values in troughs. The loose sediments with the power of 50-100 m and up to 400 m and more are in hollows and troughs (Zaisanskij, Kulundinskij, etc.).

2.1.3 Zoning

The Greater Altai territory as it was mentioned above embraces the geological structures of the Rudny Altai, Kalba-Narym, West Kakba, Zharma-Saur and adjacent regions of Russia and China. The borderlines are north-western deep faults on the north-east (Loktevsko-Karairtyshskij fault). It divides the structure of the GA from the Gornyj and Chinese Altai and borders with Zhingiz - Tarbagatai on the south-west of Zhingiz - Saur. The total length of the geological structures is more than 1000km at the width of 300 km.

According to the geotectonic zoning and considering the adjacent territories of Russia and China, the Greater Altai is subdivided into two major sub-regions:

1. South -Western Altai Xinjiang, formed in the active borders of the Sibirean platform (on the north-east) and
2. Zharma-Saur-Baganur, located on the board of Kazakhstan microcontinent (on the south-west)

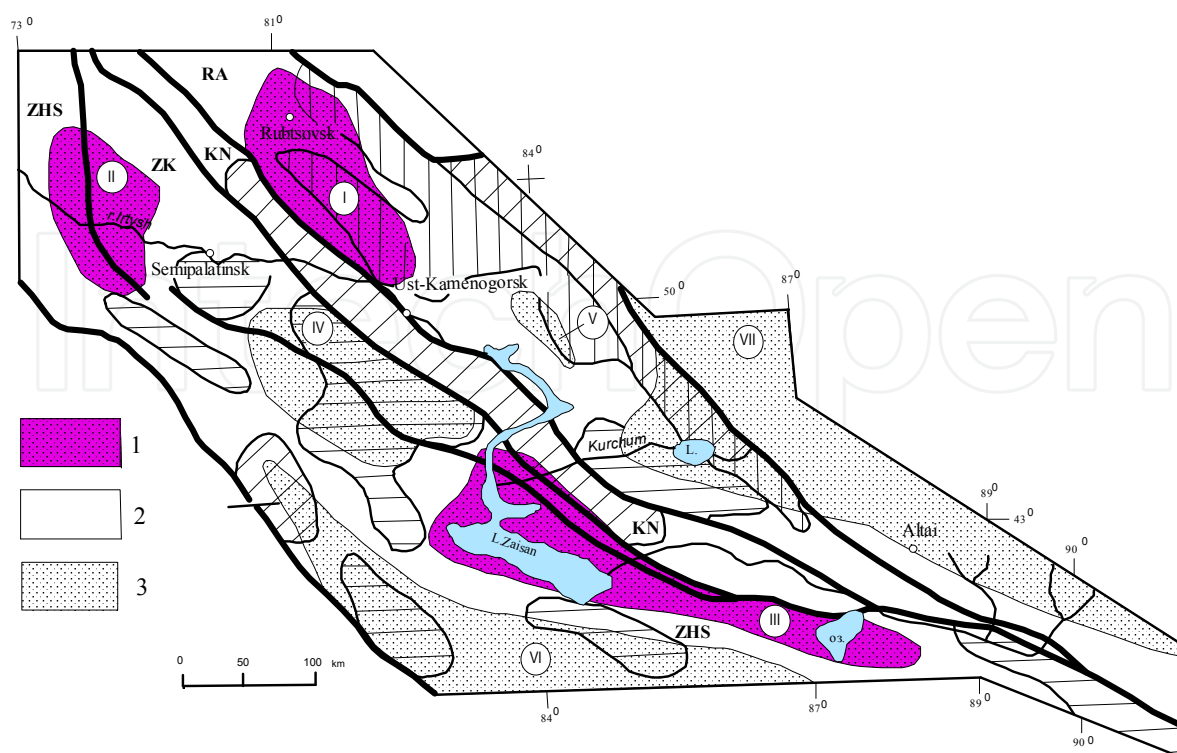


Fig. 3. Greater Altai, ore belts, and relief of the Moho surface

1-3 the Moho layer topography: 1-elevations, 2- slopes of elevations, 3- depressions; elevations: I-Rubtsovskij, II- Gornostaevsckij, III- Zaisaskij; slopes: IV-Kalbinskij, V-Bukhtarminskij, VI-Saur-Manraksckij, VII- Gornoltaisckij

The borderline between the given sub regions lies on the Charsk-Zimunai deep fault or sutural joint. The junction area coincides with Zaisan sutural zone or Irtysh Zaisan, Ob-Zaisan according to other authors (V.N.Lyubetskoj, B.S. Uzhkenov, A.V.Smirnov).

The South-Western Altai-Xinjiang subregion embraces the geological structures of the Rudny Altai, Kalba-Narym zones and Western Kalba. In the Rudny Altai are three tectonic zones (from the north-east to the south-west): Beloubinsko-Sarymsakty-Kurtinskaya, Rudnoaltaysk-Ashalinskaya and Irtysh- Fuynskaya and from the Kazakhstan side their reflections are Beloubinsko-Sarymsaktinskaya, Rudnoaltayskaya and Irtysh zones. The last one with the terrane tectonic position corresponds with the sutural zone, dividing heterogeneous tectonic blocks (terranes) of the Rudny Altai and Kalba - Narym. The Zharma-Saur-Baganur subregion is divided into three tectonic zones: Sirektas-Sarsazan-Kobukskaya, Zharma-Saur-Haratunguskaya and Charsk-Zimunayskaya zones. On the territory of East Kazakhstan they are Sirektas-Sarsazanskaya, Zharma-Saur and Charskaya zones respectively.

The Zhingiz Tarbagataiskiy belt bordering with the GA on the south-west comprises two tectonic zones: West Zhingiz and East Zhingiz. On the north-east of the Altai Mountains the Charyshskaya, Holzun-Chuysko-Sitsiheskaya and Tsunhu-Chinhenskaya zones flank the Greater Altai.

There are four ore-belts according to the metallogenic zoning within the Greater Altai:

1. Rudny Altai copper-polymetallic (Fe, Mn, Cu, Pb, Zn, Au, Ag, etc.).
2. Kalba-Narym rare-metallic (Ta, Nb, Be, Li, Cs, Sn, W).

3. West-Kalba gold-ore (Au, Ag, As, Sb).
4. Zharmasaur polymetallic (Cr, Ni, Co, Cu, Au, Hg, Mo, W, Tr).

In the structure of ore belts the ore bearing minor structures are considered: metallogenic zones (sub-zone), ore area, ore zone, ore node and ore field and also, deposits, ore occurrences and points of mineralization.

The main features of the geological structure and minerals of the given ore belts are displayed in the work (Dyachkov et al., 2009).

2.1.4 Metallogeny peculiarities

The discussed region is characterized by the variety of mineral types differentiated in genesis, age, scale of mineralization and other features. Below the peculiarities of the Greater Altai main ore-bearing structures metallogeny are being considered (Table 1).

In the Precambrian cycle in the oceanic rifting mode the destruction of the pre-Riphean small arrays crystal basement took place, they were divided into separate blocks-fragments and moved on the weakened slip surfaces with further complicated litho-mélange accretion. Within the GA the fragments of the Precambrian basement are fixed in the Charsk-Zimunai zone and the Irtysh zone of collapse. These are complicated tectonic-metamorphic structures with intensive dynamic-metamorphic transformations of the rocks, intense folding, thrust faulting, and polycyclic metallogeny. The crystalline schist, gneiss, amphibolite, granite gneiss with protrusions and hyperbasite blocks of serpentinite melange are typical of these structures. The Precambrian metallogeny has not been studied well yet. Under the oceanic rifting the hyperbasite bodies with the primary mineralization (Fe, Mn, Cr, Co, Ni, Cu, etc) have been formed in the deep faults. In the process of collision they were squeezed into the upper floors of the structure in the form of hyperbasite and plates serpentinite melange protrusions (Charsk and Irtysh zones).

In the Charsk zone magmatic chrome formation has grown. It is associated with the serpentinitized hyperbasites, blocks of ophiolites and metamorphic rocks in the structures of the melange. It is represented by small blocks and lenses of chromite and disseminated ores in serpentinites, which are considered as fractured fragments of larger bodies, the initial bedding has been defined yet (Andreevskoe, Suuk-Bulak, etc.). The estimation of these deposits is still incomplete. Insufficient studies of the Charsk mélange, identification of new hyperbasite bodies by geological and geophysical data, possibility for ore bodies clustering in sutural area allows to further study the Charsk zone.

In the Irtysh zone of collapse there is a golden metamorphic formation represented by gold-manifestations of Polevaevskij-Predgornenskij ore zone (Zolotar, Polevaevskij, Avrorinskij, etc.) Earlier they were considered as small quartz vein sites with limited prospects. Later, they were referred to a more prospective metamorphic-hydrothermal type of gold mineralization connected with dynamo-metamorphic and contact-hydrothermal regeneration of shale (increased content of carbonate and gold) in the process of the Irtysh zone of collapse transformation into the collision stage. According to the conditions of mineralization these objects are corresponded to the metamorphic types of deposits by Ya.N.Belevtsov (1982).

The acquired data testify the fact the greenschist sequences are the primary source of gold that then was mobilized in the process of regeneration. Another source is ore-bearing fluids connected with the intrusive magmatism (small granodiorite intrusions, dikes of plagiogranite porphyry, quartz porphyry and albitophyre). Besides the quartz veins

containing pyrite, chalcopyrite and gold, the great importance is given to mineralized zones of increased gold content. They are silicified, tourmalined, pyritized and carbonated host rocks of a significant length with abnormal ore elements contents (Ag, Cu, Pb, Zn, etc). Significant sizes of these zones in length and depth provide a new approach to the evaluation of the Irtysh zone of collapse in gold mineralization. The main prospects of this zone are not quartz vein objects, but more prospective deep-bedded gold-sulfide zones. In this connection the re-evaluation of the known ore objects depth, new deposits survey in the concealed structures is expedient.

In the Caledonian cycle in the border structure of the Zhingiz -Tarbagatai under the rifting and insular-arc geodynamic conditions of an early stage (ϵ_1 - O_3) the volcanic arcs of basalt-andesite-dacite series of iron-manganese and gold-chalcopyrite deposits (Akbastau, Kosmurun, Mizek) have formed. On the Greater Altai territory there is a marine mode with the formation of calcareous-siliceous- of basalt and terrigenous structures.

In the middle collision stage (O_3 -S) the overall tendency for the Irtysh-Zaisan small oceanic basin degradation from the growth of the accretion zones on the Gornoaltaiskij and Kazakhstan continental arrays. Collision magmatic front is located in arc up-lifts of spreading zones with the formation of gabbro-diorite-granodiorite intrusions (O -S, S_2) in local parts of the Zhingiz -Tarbagatai and Rudnoaltaiskij-Ashalinskij zone. The mineralization is represented by Fe, Cu, Mo, Au.

At the final stage (S_1 -D) the unified Caledonian structure of the Greater Altai has formed under the conditions of total rotation of the Siberian continent and adjacent folded structures in the north direction. In the process of intraplate activation in bordering parts of the GA granodiorite-granite intrusions D_2 (Mo, W, Bi) have located in the Altai Mountains and arrays of granit - granosienite -leykogranite series (D_2 - D_3) with poor rare-metal-rare earth mineralization in the Zhingiz Tarbagatai.

In the early Hercynian stage the most powerful tectonic and magmatic processes of the Devonian times took place in the Rudny Altai being active continental suburbs of Altai-Sayan folded area. Here under the influence of tectonic stress (compression and tension) the system of contiguous sub parallel deep faults of north-west direction, penetrating in the activated upper mantle, has formed. The activation of deep faults (pushings) in the rifting and insular-arc geodynamic conditions was accompanied by a powerful basaltic volcanism and unique copper-pyrite and pyrite-polymetallic deposits with rich complex ores formation (Cu, Pb, Zn, Au, Ag, Pt, etc.). That is why the Rudny Altai is considered as a unique gold-copper-polymetallic belt including original rudnoaltayskii pyrite deposits together with the famous world types (Kuroko, Ural, Cyprus, filizchaysky and others).

As a result of the Altai geologists long-term research the certain tendencies of ore-bearing geological structures and pyrite-polymetallic deposits formation and location have emerged.

1. In the Devonian the suburbs of the ancient Altai continent underwent the destruction and were fragmented into a grid of deep faults, separate longitudinal plates and blocks were spread, displaced and drawn apart giving way to the deep fluid flows, mantle and intracortical magmas. Subsequent oncoming movment of the Kazakhstan array was accompanied by convergence of micro-continents and blocks, insular arc, their accretions and bonding into a single continental formation (Zoneinshein, 1990). Such "altai" type of inter-continental structures formation was due to the formation of longitudinal astenoval in the upper mantle as a result of moving lithospheric blocks trans-pressing and astenomass injection and fluid-flow into the deep faults (Greater Altai..., 1998). This process was accompanied by formation of prevailing complicated

homodrom magmatites and local antidrom bimodal volcanic series connected with intracortical basaltic centers. The emerged geological structures in the final geodynamic modes (collision compressions, sub-vertical tensions, horizontal movements in the tectonic zones, etc.) were significantly transformed and complicated with pyrite-polymetallic ores (Shcherba et al., 1984).

The location giant halos of magmatites and deep zones of earth crust according to the geophysical data (Lyubetskij et al., 1994) allows us to presuppose the existence of local fluid-saturated systems at the depth of 60-80 and 160-180 km with complicated real differential in the past, possibly, these are north-western removals of the Northern-Asian superplumes (Greater Altai..., 1998; Yarmoluk et al., 2000). Accumulation of fluids and concentrated migration of ore saturated flows is supposed to be the main feature for the potential productivity index of the ore-forming system of the Rudny Altai. The existence of favorable structural elements contributed to the deposition of ore material and the deposits formation.

2. The main pyrite deposits are concentrated in the rod Rudnoaltaiskij-Ashalinskij zone, limited by the Irtysh and North-Eastern zones of collapse. The given zone is characterized by increased femic index of the EC section, has high magma saturation and mineralization density. The location of the pyrite mineralization is clearly correlated with the elevation of the upper mantle, meta-basalt layer, and the Proterozoic and Caledonian basement blocks. The main pyrite-polymetallic and polymetallic zones in the EC deep section are related with the thickened parts of the meta-basalt layer (power is 20-24 km) and concentrated over the crest show of the mantle surface relief (depth is 40-43 km).

The ore-formation model reflects the connection of the pyrite deposits with the Devonian volcanism, multi-staged ore process and multi-layered mineralization distribution (with vertical ore range up to 1000-1500 m). The deposits are bound with the group of basalt-andesite-rhyolite formations differentiated and forming several ore-bearing geo-chronic levels from D_{1e} to D_{3fm_1} . The most productive formations are – emskij (Fe, Mn, Pb, Zn (deposits Kholzunskij, Ridder-Sokolnyj)), ems-eifelskij – Zn, Pb, Cu, Au, Ag (Tishinskij, Zyryanovskij), eifel-zhivetskij – Cu, Zn, Pb (Orlovskoe, Maleevskoe), zhivetskij – Cu, Zn, Pb, Au (Artemyevskoe, Nikolaevskoe) (Shcherba et al., 1984; Bespaev et al., 2000).

The ore formation took place under the sub-marine conditions, obviously at ascending vadose-hydrothermal system of solutions with povenil source of metals (Fe, Cu, Pb, Zn, S, Au, Ag, etc) and dissolved gases (CO_2 , N_2 , H_2S , S, Cl, etc.). There are two ore types according to the formation way: 1) stratiform (volcanic-sedimentary) and 2) hydrothermal-metasomatic, represented in a majority of industrial pyrite-polymetallic deposits (Zyryanovskoe, Maleevskoe, Tishinskoe, etc.). The volcanogenic-ore centers, volcanic domes and volcano-tectonic depression, the nodes of faults intersection, horizons of carbonaceous clay and calcareous shale and others are referred to the ore-bearing structures. The most productive structures among them are the Devonian volcanic arcs of a ring structure surrounding the Caledonian paleo-elevations (Sinyushinskoe, Revnyushinskoe, Alejskoe) and characterized by the length of the volcanic processes and ore-formation (deposits Ridder-Sokolskoe, Tishinskoe, Zyryanovskoe, Nikolaevskoe, etc.).

The main role in the deposits location is given to sub latitudinal ore-controlling faults (Leninogorskij, etc.), especially in their intersection nodes with the breaks of other directions, where there were volcanogenic-ore centers. The characterizing feature of this

phenomenon is the linear-nodal distribution of Devonian volcano-tectonic structures with pyrite-polymetallic deposits in the longitudinal ore zones (Leninogorskaya, Zyryanovskaya, Orlovsko-Belousovsky, etc.) (Fig.4). The spacing of ore nodes (at the intersection of the north-western faults with meridional and sublatitudinal faults) is 20-40km. Reconstructed ore zones of considerable sizes (longer than 100 km, at width of 10-20 km), with ore nodes contain major reserves of Cu + Pb + Zn of all known deposits of the Rudny Altai.

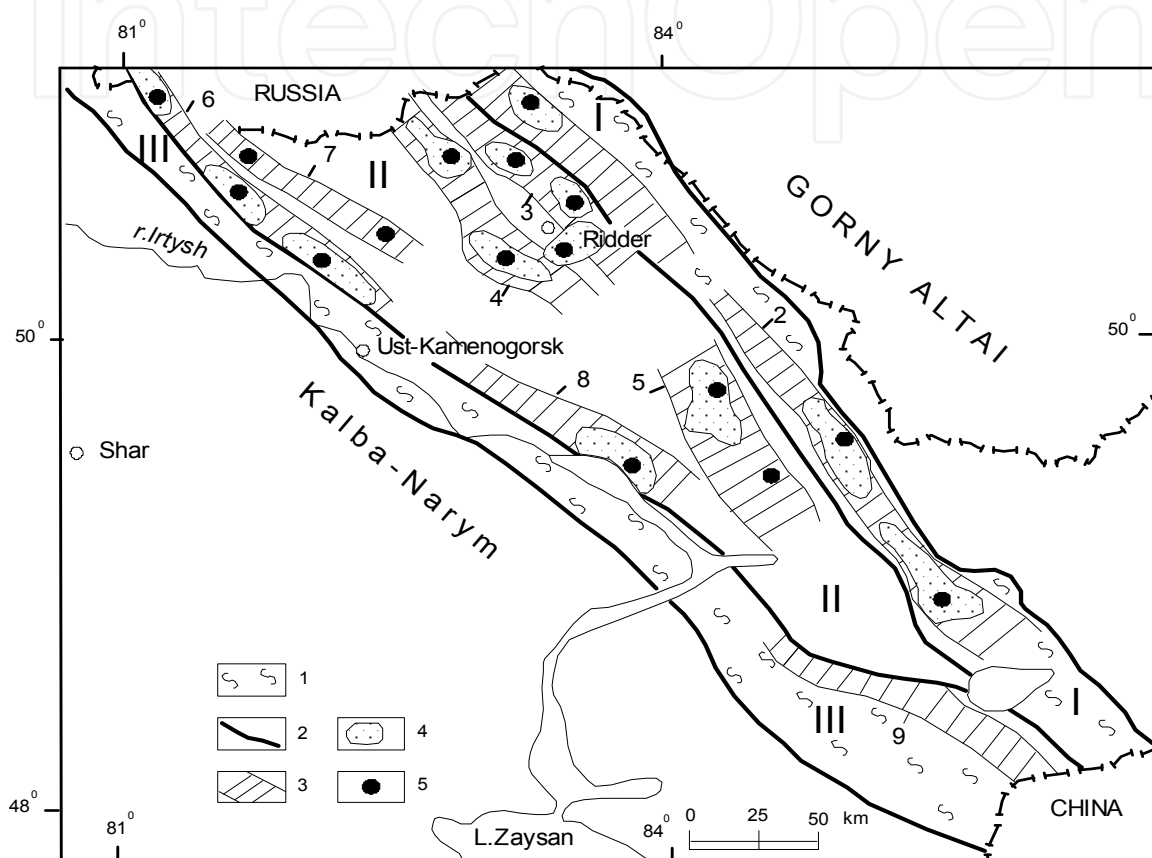


Fig. 4. Metallogenic demarcation of Rudny Altai

1- Shear zone, 2- boundaries of metallogenic zones, 3- ore zones, 4- ore districts, 5- copper-base-metall polymetallic deposits

Metallogenic zones: I-Belay Uba-Sarymsaqtinskij, II-Rudnoaltay-Ashalinskij, III-Irtysh-Fuyungskij.

Ore zones: 1-Gyslaykovskij, 2-Yuzhno -Altaiskij, 3-Leninogorskij, 4-Tishinskij,

5- Zyryanovskij, 6- Orlovsko-Belousovskij, 7- Shemonaikhinskij, 8-Bukhtarminskij,

9- Dzhaltyrsko-Alexandrovskij.

Major ore area are: Leninogorskij, Zyryanovskij, Priirtyshskij, Rubtsovskij and Zmeinogorskij contain major reserves of copper, lead and zinc (Ridder-Sokolnoe, Tishinskoe, Orlovskoe, Nicholaevskoe, Artemyevskoe, etc.). In the south-eastern extension in China there are well-known deposits such as Ashaly, Timurty (Fe, Pb, Zn), Koktal (Fe, Pb, Zn) and others. This is considered to be an important verification for the unity of ore-bearing structures in the border region of Kazakhstan and China (Bespaev et al., 1997, Shcherba et al., 1984)

Forecasting-metallogenic studies show that in the Rudny Altai the industrial pyrite deposits formed under the rifting and insular-arc conditions in the process of a powerful rhythmic-pulsating volcanogenic mineralization of the Devonian period. The pyrite-polymetallic and copper-polymetallic have belt distribution in the longitudinal ore zones of considerable sizes. The former preserves significant prospects for mineral resources increase at certain ore-bearing geo-chronic levels, within a flank and deep horizons of known ore nodes, ore fields and deposits. The medium stage of the Hercynian cycle (C_1 - C_3) differed by the sharp change of the geodynamic mode (prevailing compression), closing of the Irtysh-Zaisan paleo-basin, exertion of folding and thrusting major phases, accretion of structures and collision of Kazakhstan and Gornoaltayskij arrays. The result of it was the collision of two continental suburbs having formed a single coherent structure of the Greater Altai. In large volumes the sin-collision gabbro-diorite-granodiorite intrusions have infiltrated, volcanic-plutonic belt and molasse formation have localized. In the region geological structure under the collision geodynamic conditions the magmatic copper-nickel, copper-porphyric and hydrothermal gold deposits formed.

In the Rudny Altai the most powerful intrusive magmatism emerged in the focal part of the deep mobile zone (above the elevations of the meta-basalt layer and anomalous upper mantle). The large arrays of multi-phase gabbro-diorite-granodiorite of plagiogranite series have formed (Zmeinogorsk complex C_{2-3}). The tectonic broken apical zones of separate gabbro-granitoid massifs have undergone hydrothermal-metasomatic changes and are prospective for the detection of copper-porphyric and gold deposits.

The Sekisovskoe deposit refers to the gold-telluride formation of propylites Berezite-type. It is represented by brecciated gold-sulphide mineralized zones and stockworks in the magmatites of the Zmeinogorsk complex. The faults of the north-western direction associated with the Irtysh zone of collapse had the ore-controlling importance. According to Yu.A. Kostin, G.G. Freiman, G.I. Dudukalov and other researchers, increased tectonic dislocations of rocks fixed by brecciated and crushed textures of rocks are characteristic of the ore fields. Ore-explosive breccias in the form of gabbro, diorite and plagiogranites debris cemented by the bulk of propylite and beresite content with the gold-sulphide mineralization are also one of their features. The types of the ore-bearing meta-somatites depended on the original rocks content: 1) propylites-sulphide (by gabbroids, diorites) and 2) beresites-sulfides (by plagiogranites and porphyries), on which the ore-bearing quartz and carbonate-sulfide veins have laid.

The ore-formation was accompanied by Fe, Cu, Pb, Zn, Au, Ag, Bi, SO_3 , CO_2 entry and Si, Na exit. Gold and silver in beresites and propylites content are positively correlated with Pb, Zn, Bi, Cu, and in pyrite-quartz veins content and quartz meta-somatites have another correlation of Au Mo (+0,76). Ore bodies in the mineralized zones are characterized by lenticular or column forms due to the conjugation breaks nodes; mineralization is disseminated and veinlet-disseminated. The main ore minerals are pyrite, sphalerite, chalcopyrite, gray ores and gold, minor are arsenopyrite, magnetite, ilmenite, rutile, tetradimit, bismuthinite. Non-metallic minerals are quartz, calcite, sericite. All types of ores are enriched with pyrite (over 17 kg / m). The gold is represented by two types: 1) free, having irregular, vein-like and elongated forms, performing fissures in pyrite and quartz, and 2) finely dispersed in pyrites (Au - 10 g / t, Ag - 100 g / t, Bi - 290 g / t). The deposit has an industrial value.

On the south-eastern flank of the Rudny Altai drastic narrowing of the structural-formational and metallogenic zones, associated with tectonic compression in the process of Jungar and Siberian plates collision is notices.

The emerged structures of conjugation, converging into a single virgational beam in the south-eastern-part of the Lake Markakol differ by complicated geodynamic development, intense exertion of magmatism and metamorphism, and diversified mineralization (Fe, Cu, Pb, Zn, Au, Ni, W, etc.). In the Irtysh sutural zones quartz-vein gold deposit of Mank in genetic linkage with small intrusions and dikes of diorite-granodiorite composition (C₃) emerged, the analogue of it is gold-ore deposit Dolonosai on the Chinese territory.

This fact allows to mark the single ore field of Mank-Dolonosai on the bordering territory and this area should be thoroughly studied.

In the Zaisan sutural zone in the process of complicated geodynamic development the Charsk-Gornostaeviskij ophiolite belt of a planetary rank has formed. It fixes the zone of the mantle deep fault. Here, there are also zones of melanging, fold-thrust structures, olistostrome complexes, auriferous small intrusions and dikes infiltrated. The collision geodynamic conditions turned out to be favorable for different gold-ore deposits formations. The leading deposit is gold-arsenic-carbon type in the black shales, covering the largest reserves of gold deposits in Western Kalba (Bakyrchik, Bolshevik, Glubokij Log, etc.) (Bakyrchic..., 2001). The ore-containing deposits are sediments of molasse limnic coal-bearing formations (bukonskaya formation of C₂₋₃), exposed to intense dynamometamorphic and hydrothermal-metasomatic changes in the zone of deep faults (Fig.5). The ore bodies are represented by broken, fragmented and silicified black shales with abundant inclusions of gold-bearing pyrite and arsenopyrite. The main ore-minerals are pyrite, arsenopyrite and gold. The gold content is 8-9 g/t at average. The deposits have an industrial importance.

Gold-*vein-disseminated type* also has a practical value. It is characterized by the concentration of gold in the hydrothermally altered carbonate rocks of the island-arc type volcanic-carbonate-terrigeneous formations (deposits Suzdalskoe, Mirazh, etc.) (Greater Altai..., 1998; Dyachkov et. al., 2009; Kovalev et. al., 2009). Ore bodies have formed as a result of dzhasperoid silicification of limestones, and are represented by mineralized zones, nests, veins and stockworks.

The main minerals are pyrite, arsenopyrite, gold, and rarely –stibnite. The gold content in indigenous ores and weathering crusts is 8-10 g / t. According to the range of features the deposit is compared with the famous “karlinskij” type of ore-mineralization in the carbonate formations (Rafailovich, 2009).

In Zharna-Saur intense tectonic-magmatic activity of the collisional stage, was accompanied by intensive development of the gabbro-granitoid intrusions which were located in ring structures in the focal part of the deep mobile zone (Saur complexes C₁, maksutskij C₂₋₃, saldyrminsky C₃). Magmatic formations are characterized by metallogenic specialization on Cu, Ni, Co, Au, Ag, Mo. The wide development of ore-bearing intrusive formations indicates at the possibility to detect hidden and buried deposits (Bazarskij deflection, Severnoe Prizaysanye, etc.).

There are certain prospects for exploring gold in Zhanan-Boko-Zaisan ore zone where the gold-sulfide deposits exploration with primary ores as well as in weathering crusts is forecasted (sites Kempir, Zhanan, Akzhal-Boko and others).

In Kazakhstan, the copper-porphyry deposits are an important source of copper and molybdenum (Kounrad, Bozshakol, etc.). In Eastern Kazakhstan the largest deposits are porphyry- copper fields of Aktogai, Aydarly, as well as other known objects - Shar, Kyzyl

Kain, Kensal, etc. These deposits are characterized by significant resources of copper, molybdenum, perhaps gold, and can make a significant contribution to the economy of the region. Low metal contents did not give the opportunity to assign them to categories of industrial deposits in the past. The emergence of new technologies opened new possibilities of exploiting deposits with poor content of ores.

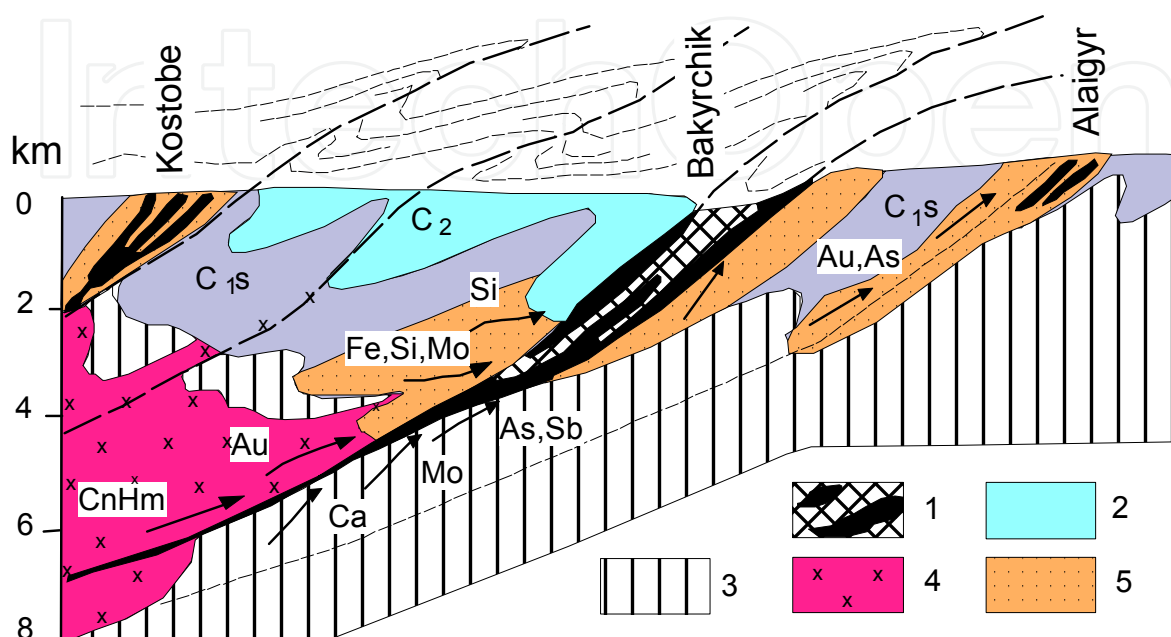


Fig. 5. The model of Baqyrchik deposit forming

1-surface of gold bearing carbonaceous molasses (C_{2-3}), 2- submarine molasses (C_2), siltstone-sandstone formation (C_1), 3- volcano-silica, volcano-terrigenous formation (D_3-C_1), 4- plagiogranite-granodiorite formation (C_3), 5- zones of mineralization (Greater Altai ...2000)

Copper-nickel mineralization is genetically related to small intrusions gabbro-norite-diorite-diabase (C_{2-3}). On the Maksut deposit the ore-bearing fields are melanocratic gabbro and gabbro-diabases, which are associated with solid and disseminated pyrrhotite-chalcopyrite-pentlandite ores in the form of tabular and lenticular deposits, connected with the bottom of the cup-shaped array. The main ore-field has the length of 1000 meters and the power of 21.5 m at an average content of Cu 0,47%, Ni 0,35%. The exploration works are carried out at the moment. There are real prospects of detecting new sulfide Cu-Ni deposits within Maksut-Petropavlovskij-Kharatungskij belt of disseminated gabbroid intrusions (C_{2-3}), bordering with a large deposit of Kharatung or Kolotong on the south-east flank (Bespaev et al., 1997, Shenghao et. al., 2003). This increases the possibilities for the similar deposits exploration on the Kazakhstan territory as well.

The facts mentioned above indicate that in the middle Hercynian formation range in the Greater Altai region the sin-collision intrusive formations were prevailing (up to 60-80% from the total volume) over volcanogenic and sedimentary elements. The magmatism evolution in each tectonic rhythm was carried out in homodrome sequence (from basalts, gabbroids to rhyodacite, granodiorites and plagiogranites) and the mineralization change in time range respectively: Cu-Mo-Au (C_1) → Cu-Ni-Au (C_{2-3}) → Au-Ag-Sb-Bi (C_3).

The later stage of the Hercynian cycle was marked by the shift of collision geodynamic mode to post-collision or orogenic mode (P_1-T_1). At this stage ascending crest-block movements, intensive processes of intraplate tectonic-magmatic activation, accompanied by the outbreak of granitoid magmatism with rare metal and rare-earth profile of mineralization were dominating (Ta, Nb, Be, Li, Cs, Sn, W, Mo, etc.). The largest granitoid belts are Kalba-Narymskij, Tigereksko-Chernevinskij and Akbiik-Akzhaiyauskij. They formed in zones with increased siality of the continental Earth crust (Kalba-Narymskaya, Beloubinsko-Sarymsaktinskaya and Sirektas-Sarzasanskaya). The granitoids of the Permian age (Kalbinskij, Monastyrskij, Zharminsky and other complexes) are prevailing in their composition. The magmatism evolution was in the overall tendency for the leucocratic alkalinity of granitoid series increase. Every petrochemical type of granitoids formed under certain geological conditions and was characterized by its ore potentia (Dyachkov et. al., 2009).

The Kalba-Narymskij granitoid belt is the main ore-bearing structure of the region having regional development (length is more than 500 km). It is characterized by sialitic profile of the Earth crust section with an increased power of meta-granite layer and of the Earth crust in general. The large scale of granitoids distribution emphasizes the fact that there are rather a lot of energy and material resources for rare-metal mineralization processes. The structural metallogenic model of the given belt reflects the connection of ore-magmatic systems with deep zones in the Earth crust and the upper mantle and, consequently, the granitoid belt has formed as a result of long-term deep evolution of the lithospheric element.

In the Kalba-Narym there are following ore-formation types of deposits: 1) pegmatitic rare metal (Ta, Nb, Be, Li, Cs, Sn), represented by major industrial deposits (Bakennoe, Belaya Gora, Yubileinoe, etc.); 2) pegmatitic beryl, microcline, in which minerals are blocking microcline and quartz, muscovite, beryl and columbite (deposits Asubulak, Lobaksaj, Nizhny Laybulak etc.); 3) albite-greisen tin-tantalum (apogranite) in hidden granite dome, potentially prospective for the identification of Ta, Be, Li, Sn (Karasu deposit); 4) greisen-quartz-vein tin-tungsten represented by ores of wolframite, scheelite and cassiterite (deposits Cherdoyak, Palattsy, Kaindy, etc.); 5) clastogene Tantalum - Tin - Tungsten forming placers of tantalite, cassiterite, wolframite, scheelite and monazite.

The carried out studies show that ore-generating ability of granitoids together with petrologic factors depend on geodynamic conditions of arrays formation and scale ore-bearing melts degassing. From these positions there are various ore-magmatic parts determined. They are close to ore-bearing fluid systems (Letnikov, 2000). There are the following favorable conditions and criteria for rare-metals mineralization forecasting:

1. mobile geodynamic conditions of granite arrays formation and this contributed to the intensification of mineralization process under non-equilibrium PT conditions and the formation of industrial deposits of rare-metal pegmatites (Central Kalba ore region);
2. determination of ore-controlling role in latitude deep faults of prolonged activation, particularly favorable nodes are their intersections with the faults of other areas, where the most important ore fields have formed (Asubulakskoe, Belogorsk, Ognevsko-Bakennoe and others);
3. apical parts and over-intrusive zones of granite arrays, their apophysis, hidden domes and tectonically weakened zones, ore nodes in the thickened parts of the granite intrusions, over the magma-feeding roots or at their peripheries are the most perspective structures for the mineralization concentration;

4. establishing the genetic relationship of rare metals from each intrusive phase of Kalba complex at the spatial confinement of the main rare-metal - pegmatite mineralization (Ta, Nb, Be, Li, Cs, Sn) to the granites of I phase with increased base (deposits Bakennoe, Yubileinoe, Belaya Gora, Verkhnyaya Baymurza etc.)
5. identified petrographic, petrochemical and mineralogical and geochemical criteria for ore content evaluation of different age granitoid complexes and their intrusive phases.

On the continental border, in zones of sub-continental earth crusts (West- Kalba, Charsko-Gornostaevskaya) and in the faults of sutural zones on the surroundings of the Greater Altai (North Eastern zone of collapse, Zhingiz- Saur suture) the subalkaline granite granosienite (Zr, Ti, Sn, Be) and alkali granite (TR, Zr, Nb, Ta) intrusions have localized. They are connected with deeper crust and mantle centers. The known ore objects refer to the epi magmatic Niobium - Zirconium - rare-earth formations (Verhnee Espe, Azutau).

At present the most important objective of the region is exploring new deposits of rare and rare-earth metals considering modern tendencies of world geological science and market economy development.

The Cimmerian cycle (T-Pg₂). The Cimmerian formations emerged under the continental rifting mode and had an autonomous development. They are represented by Semeitau volcanic-plutonium association (T₁) of a contrast content and high alkalinity (trachybasalt-trahiriolites and subvolcanic analogues), trap formations J₂ (Iugovskij complex), northeastern belts of colored dikes from gabbro-diabase to quartz porphyries (mirolyubovsky, Bugaz complexes) and molasse coal-bearing formations (T₃-J₁, J₂). The latter unify sedimentary-coal-bearing strata imposed animations (Kendyrlykskaya, Zhemeneiskaya, Abaevskaya, etc.). At the ending stage of the tectonic stage under the epigerian plate stabilization mode the silt-clay variegated hematite - kaolin deposits K₂-Pg₂ have accumulated on the vast territory and have the power of 200 m (north-zaisan formations).

In a humid subtropical climate the Paleozoic and older rocks formed with crust of weathering. In the Charsk-Gornostaevskij ore zone the Ni-Co and mercury bearing weathering crusts of a nontronite type have formed on the serpentized hyperbasites as well as ore-bearing crusts in ore-containing rocks and ores (Semipalatinsk Priirtyshie). In the West- Kalba belt the Zr-Ti weathering crusts of kaolin type developed with sub-alkaline granites (Karaotkel deposit). The Cimmerian cycle had a destructive character. Huge masses of loose material together with the disseminated ore element were taken into the Kulundinskaya and Zaisanskaya depression, West Siberian Plain and smaller intermountain depressions.

Alpian cycle (Pg₂₋₃-Q). During the Alpian cycle, the given region was an area with intense denudation with removal of products of destruction to the West Siberian Plain and large depressions forming continental sedimentary formations (Paleogene-Neogene-Quaternary period). They are widely developed in the Zaisan basin, Semipalatinskoe Priirtyshye, intermountain depressions and lake basins differing by some lithologic ore peculiarities and deposits power.

In the sedimentary cover there are also sustainable ore minerals placers (gold, ilmenite, tantalite, cassiterite, etc.) which are subdivided into alluvial, deluvial and proluvial according to the genesis. Some of them were explored (Kurchumskaya - Au, Satpaevskaya - Ti, Asubulakskoe - Ta, etc.).

3. Conclusion

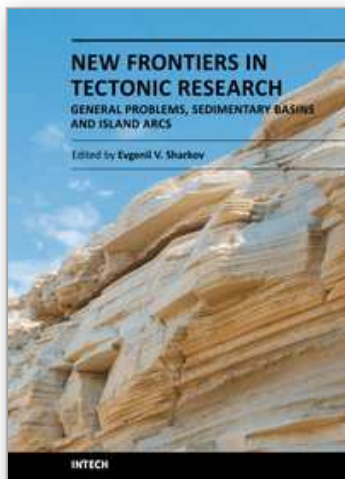
So, on the basis of the global mobilism hypothesis, the overall tendencies of the Greater Altai geological and metallogenic structures formation located in the system of the Central Asian mobile belt have been identified. Modern structures – the Rudny Altai, Kalba-Narym, West-Kalba zone and Zharme-Saur are the fragments, xenoliths of the ancient paleocontinent (terrane collage) that were drifting in the paleoasian ocean and joined into one single formation during the Hercynian collision stage in the process of a complicated interaction and the Kazakhstan microcontinent and the gornoaltaiskij border of the Syberian platform interfacing. Now it is a system of sub-parallel structural formational and metallogenic zones divided by deep faults and differing in the geodynamic development and the peculiarities of the geological structure and metallogeny. From the point of mobilism the common trend of the Greater Altai geological structures development and minerageny, under different geodynamic modes and conditions for the long period (from the Precambrian up to Quaternary) has been defined. The identified trends of the deposits connection with certain geodynamic modes based on the principles of ore-formation analysis speak for the fact that there is a genetic connection between geological and ore formations considering the geological formations as the indicators for certain paleogeodynamic and landscape geological conditions.

The research shows that the energy potential of the ore-forming processes in each ore belt theoretically tends to be one certain value. In the Rudny Altai belt in the Early Hercynian stage under the rifting insular arc conditions (on the continental crust) the powerful processes of basaltic vulcanization were accompanied by the major copper-pyrite and pyrite-polymetallic deposits formation in East Kazakhstan (Fe, Cu, Pb, Zn, Au, Ag, Pt, etc.). The scope of ore-content of the following medium (collision) and late (post-collision) periods was weakened. The West-Kalba zone had the largest tectonic-magmatic activity during the medium collision stage, and it was rich with ore minerals (Au, Ag, As, Sb), under appropriate depressed development of other stages metallogeny. The example of this is the Kalba-Narym rare-metal belt where the energy potential was accumulated in the early and medium stages and then it passed into the late stage (post-collision) in the form of granite magmatism flash and the deposits of rare-metals related to it (Ta, Nb, Be, Li и др.). In this regard, the study of mineragenetic specialization of geodynamic conditions along with detailed structural - elemental studies of geological formations and ore sites, is one of the main methods of forecasting and search for new deposits, particularly in poorly studied, and closed areas.

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**New Frontiers in Tectonic Research - General Problems,
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This book is devoted to different aspects of tectonic research. Syntheses of recent and earlier works, combined with new results and interpretations, are presented in this book for diverse tectonic settings. Most of the chapters include up-to-date material of detailed geological investigations, often combined with geophysical data, which can help understand more clearly the essence of mechanisms of different tectonic processes. Some chapters are dedicated to general problems of tectonics. Another block of chapters is devoted to sedimentary basins and special attention in this book is given to tectonic processes on active plate margins.

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