Rare Metal Deposits of East Kazakhstan: Geologic Position and Prognostic Criteria

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ABSTRACT

In the article the features of the formation and metallogeny of the geological structures of Great Altai (Rudny Altai, Kalba-Narym, Western Kalba and Jarma-Saur) which are included into the system of the Central Asian mobile belt are considered. The characteristic of the main types of rare metal minefields of the Kalba-Narymsky belt genetically connected with the Perm granitoid magmatism of the post-conflict orogeny stage of activization is given. The rhythmical and pulsation model of pegmatitovy ore formation in the conditions of the half-closed magmatic system, reflecting the phasic development of mineral complexes from graphic and oligoclase-microcline (barren) to microcline-albite and albite-spodumene ore (Ta, Nb, Be, Li, Sn, etc.) is developed. On the basis of the revealed criteria of ore formation recommendations about the direction of the further researches are made.

Keywords: Rare Metals; Pegmatite; Albitite-Greisen Metasomatits; Kalba-Narym Belt; East Kazakhstan

1. Introduction

The examined territory is a part of the Central-Asian mobile belt zone and unites geological structures of Great Altai including Rudny Altai, Kalba-Narym, Western Kalba both Jarma-Saur and abuted areas of Russia and China (Figure 1). Borders are the northwest deep breaks separating hercine structures of Great Altai from caledonid formations of Gorne Altai (in the northeast) and Chingiz-Tarbagatay (in the southwest). General extent of territory is more than 1000 km while 300 - 400 km at width.

The Kalba-Narym zone is composed of Upper Devonian and Carboniferous terrigenous rock that are intruded by the major Kalba-Narym granitic pluton. The main litologies are granodiorite, granite and leucogranite, aplite-like granite, aolite dikes, pegmatite and quartz veins. Early granitic rocks are assigned to the Kalba Complex (P₁), whereas the later leucogranite is referred to the Monastyrsky Complex (P₂).

Rare metal pegmatite deposits in the Central Kalba ore district (Yubleineinoe, Belogorsko, Verkhne-Baimurzinsko, Ognevskoe, etc.) are of the most economic importance. Two deposits of the pegmatitetype (Yubleineinoe) and greisens-quartz vein type (Cherdoyak) are discussed in the text below.

Last years from new theoretical positions—the hy-
potheses of global mobilization problematic questions of
ged dynamics development of Great Altai main ore-bear-
ing structures were considered. The results of researches
are published in the monography “Great Altai” [1,2].

2. The Geological and Metallogenic
Evolution
The formation of geological structures contacts to gen-
eral geodynamic model of Paleoasiatic ocean evolution
and was defined by system of complex cooperating contin-
tental lages of the Siberian and Kazakhstanian subconti-
nents. Modern geological structures of region are tec-
tonic enclave of ancient paleocontinents and litospheric
blocks (or collage terrains), which drifted in Paleoasiatic
ocean and have confronted in the process of hercynic col-
lision (C1-C2,3), having formed uniform structure of
Great Altai [3-5].

According to the region’s metallogeny we allocate
here four ore belts of a belt zone: Rudnoaltai (copper-
polimetallic), Kalba-Narym (rare metals), West-Kalba
(gold ore) and Zharma-Saur (multimetal) [2,6]. The geo-
formation development and mineralization oc-
curred in a mode of oceanic riftogene (PR1), then in early
(riftogenic, islandarctic), average (collision) and late
(postcollision) stages of coledanic and hercynic cycles,
and was finished by continental riftogenes and neote-
tonic orogeny in mezoic and cainozoic [1,6]. In Pre-
cambrian during the process of proterozoic base riftoge-
genesis in mantled breaks magmatic deposits of a Cr, Ni,
Co (Pt, Hg) were generated. In Rudny Altai in riftogenic
stage (D1-3) were formed large pyritespolimetallic depos-
its of volconogenic genesis—Cu, Pb, Zn, Au, Ag etc.
(Zyryanovsk, Maleevsky, Ridder-Sokolny, Artemevsky
etc.) [2,6-8]. For an average conflict stage (C1-3) sul-
phidic copper-nickel, copper-phosphory and gold ores de-
posits connected with magmatism of gabbro-diorit-
granodiorit-plagiograniat series are characteristic.
The most significant deposits of gold (Bakyrchik, Suzdal etc.)
were located in Zaisan surnzon zone generated on contin-
tental edges interface [6,9,10]. In a late stage (P1-T1)
under the conditions of innerlakes activation were gener-
ated granitoid belts (zone) with rare metals and rare
earths ores, placed on lithospheric blocks borders. In
immerian cycle in conditions of continental riftogenesis
and subsequent stabilization the deposits of crustores
(Ni-Co, Zr-Ti-Au) were formed.

Thus, main rare metal-bearings structures of granitoid
region belt have appeared during late hercynion activiza-
tion differing on geotectonic position, the scale of de-
velopment, internal structure, material structure and ore-
bearing (Figure 2). Natural spatial time of rare metals belts
to tectonic weakened zones in continental blocks terres-
trial crust of raised sialic is established. There is marked
northwest line and significant extent (500 - 800 km).

3. Kalba-Narym Belt
Kalba-Narym belt is the largest adjoining to Irtysh shear
zone and extends in the northwest direction on 500 km
and further proceeds in Russia and China. On the geol-
ogy-geophysical data it is supposed, that this granitoid
belt is placed in a head part of huge techtono-magmatic
zone, steep fallic on the northeast under Rudny Altai [2].
The centers of magmaformation arose, by granite melts
structure in metagranited layer or on its border with
metadiorited layer. The transit ore-bearing solution have
penetrated from the bottom parts of Earth crust and top
mantle on system of deep breaks [2,11].

The belt is combined with mainly normal granits and
leucograniat of the Perm age, to which the deposits of
rare metals are generically connected (Ta, Nb, Be, Li, Cs,
Sn, W) [12,13].

We allocate the following ore formations types of de-
posits:
1) pegmatitic rare metals (Ta, Nb, Be, Li, Cs, Sn),
submitted by the main industrial deposits (Bakenny, Be-
laya Gora, Yubileiny etc.);
2) pegmatic beryl-microcline in which mineral depos-
its are blocked microcline and quartz, muscovite, beryl
and columbite (deposits: Asubulak, Lobaksai, Nijn-
leibulak etc.);
3) albite-greisen tin—tantaletic (apogranitic) in the
latent granite domes, potentially perspective on revealing
Ta, Sn, Be, Li (Karau deposit);
4) greisen-guartz vein cassiterite wolframite submitted
by ores of wolframite, scheelite and cassiterite (Cher-
doyak, Palasy, Kaindy deposits, etc.);
5) clastogene tantal-cassiterite-wolframite, forming
mantalite looses, cassiterite, wolframite, scheelite and
monazite.

3.1. The Model of Rare Metal Pegmatite Deposits
The basic model of formation for main industrial rare
metal—pegmatite of Kalba-Narym belt deposits is de-
ified by their genetic connection with granite kalba of
complex P1 and spatial accommodation of ores veins
mainly in granite files and their exocontact (Figure 3).
The processes of pegmatite formation probably occured
in open or semi-closed magmatic system at rhythmic—
pulsating receipt of ore-bearing distillates (H2O, F, B, Cl,
Ta, Nb, Be etc.) from cameric center of granite files (un-
der the conditions of the increased activity of ore-con-
trolling breaks). Pulsating receipt of ore-bearing solu-
tions has determined multirhythmical zones of ash value
pegmatic veins, the colour quartz—lepidolite-cleave-
landite and spodumene with rich complex ores (Ta, Nb,
Li, Cs, Be, Sn) and increasing concentration of minerali-
ation veins stagic development of mineral complexes
from oligoclase-microcline up to albite.
The carried out researches have shown, that ore-generating ability of granitoide, alongside with petrologic by the factors, in many respects depends on geodynamic conditions stand of files and scales degasazion ore-bearing solution melts [2,6]. From these positions certain oremagmatic systems differing on the scale miner were planned.

The above-intrusive system of active interaction granite intrusion with lateral breeds raised carbonaceous and calcindition in mobile tectonic conditions. Rare metal mineralization (Ta, Nb, Be and others) concentrated in a frontal part of stratified intrusive bodies, in their apofise and branches, and also in lateral breeds of eksocontakte. The main industrial type is Bakenny deposit (Figure 4).

The inside-intrusive system of cameric conter formation of ore pegmatite veins in granite files complicated by explosive tectonic. Ore-controlling was the regional breaks of sublatitudic stream line, opening residual cameric of ore-bearing melts, and ore-locading were zones raising cracks and zones of increased fissing and independent system of cracks in granite at oreformation rare metal pegmatites of albite subformation, uniting various mineral complexes (albite-microcline, albite, albite-spodumene etc) were generated. Ore bodies contain the unique minerals clevelandit, coloured and polychrome tourmalines, lepidolite, spodumene, petalite, pollucite and others. The deposits have industrial values (Yubileiny, Belaya Gora, Upper Baymurza etc.) [2,6,7,14]. These objects are compared with the large pegmatite deposits in other regions-Bernic Lake (Canada), Koktokay (China) and other [15-17].

### 3.2. Types of Deposits

**System of ore-bearing granite domes.** It is characterized by concentration of Sn-Ta mineralization in albitic and greisenic granite intrusive-above-intrusive zone of a blind dome (type Karasu) (Figure 5). Rare metal mineralization is generically connected with medium musco-
Figure 3. A model formation pegmatite rare deposits. 1—coarse-and medium-biotite granite; I phase and 2—fine-and medium-grained muscovitized granite, II phase kalba complex (P₁); 3—aplite-like, aplite; 4 - 10—pegmatites (4—oligoclase-microcline barren, 5—grafic, 6—microcline in blocks with beryl and columbite 7—microcline-albite with tantalite, cassiterite, beryl (rarely spodumene), 8—albitic (productive) with tantalite, cassiterite, beryl, pollucite, spodumene, lepidolite; 9—albite (cleavelandite)-spodumene, with tantalite, ambygonite, petalite, polychromatic tourmaline; 10—faults; 11, 13—direction of the fluid movement; 12 —ore-controlling deep fault.

vite phase of granites the II phase of Kalba complex. The latter on geochemical features are referred to Sn-W-Ta type of ore-bearing granite close to lito-floric granite according to W. I. Kovalenko (1977).

The prognosic resources of tantalite and tin are significant.

System of imposed rare metal mineralization. It is characterized by migration of ore-bearing fluidizations from crystallizing granite melts in the tectonic weakened zones in containing breeds and imposing here mineralization on earlier hypabyssal small intrusions and dykes of Cunush complex C₃. The latter became favorable physics-chemical environment for adjournment and concentration of mineralization, acting in a role of structural—litologic and geochemical traps (deposits Medvedka, Tochka etc.).

The system field of dispersion RE is typical for large files of leucogranite Monastyr complex (P₂), which differ by flying and mineralizer riches (H₂O, F, B etc.) and geochemical specialization on Ta, Li, W, Sn, TR etc. However owing to crystalle-chemical dispersion of rare elements leucogranitic formation has appeared to be loose ore bearing. It is connected with chamber crust-bearing pegmatite and fine greisene-quartzvein wolfram demonstration (deposit Dungaly).

Concerning rating of territory prospects it is possible to note, that Kalba-Narym belt is the main rare metal structure of Great Altai. Perspective are the northwest and southeast flanks granitoid of a belt where the detection of new rare metal deposits are latent on depth and hide under a cover of friable deposits. Further we’ll briefly consider the characteristics of others granitoidic belts [6]. On the border of Great Altai with caledonion of Gorny Altai Tigireksko-Chernevinsky belt of normal and increased alkali granite was generated. The main here are skarnic and greizic deposits with W-Mo (Ekipetsky, Ivanovsky etc.), and in alkaline granite Nb-Zr—rare earths mineralization is shown (Azutau). In Gorny Altai
Figure 5. Geological structure of Karasu deposit. (a)—geology plan; (b)—geology-geophysical section; (c)—geology-genetic model [2]. 1—guaternary; 2—gravelly-pebbly sediments of turangy series; 3—calcic sandstones, aleurolites of kystav-kurchumskoy series (D2gv); 4—diabase-porphyrites; 5—plagiogranite-porphyry of the kunushsky complex; 6—II phase kalba complex granites; 7—albitization and greising zones with Sn-Ta mineralization; 8—mineralized dikes and apophysis of granites; 9—linear-stockwork zones with cassiterite and 10—sulfite mineralization; 11—development area of stanniferous muscovite-gilbertite-quartz veins; 12—quartz ledges barren; 13—concealed granites and 14—depth of their occurrence (km) according to gravity exploration.

and Chinese Altai in zones of hercinic tectonic-magmatic activation Uryl-Koktokay belt of normal and subalkaline granite with pegmatite Ta-Nb-Be-Li is allocated with greisene and hydrothermal W-Mo-Be deposits (Koktokay, Kalguty, Kokkol etc.) and displays rare earths.

In Kazakhstan continental edges in zones of insideplithic activation (on caledonids border of Chingiz-Tarbagatay and hercineds of Zharma-Saur) Akbiik-Akzhailay belt of granit-leukogranite and alkaline granite was located, specialized on rare-metal (W, Mo) and rare-earths (Zr, Nb, TR, Mo) mineralization (deposits Shar, Zhaman-Koitas etc.). With alkaline granites (P2-T1) the formation of rare-earth elements pegmatites and riebechite-albite metasomatite with pyrochlor-zircon mineralization are connected (deposit Upper Espe).

In an axial part of Great Altai (on the Kazakhstani border and Gorny-Altaisk continental edges) in Zaysan saturen zone with suboceanic type of earth crust Semi-palatinsk-Buran-Byrgyn belt of monzonite sienite and granosienite with Zr-Ti geochemical specialization was generated. Granitoid masses of this belt (Preobrazhenska, Buran etc.) are perspective for search of zircon-ilmenite deposits in mesozoic residual soils (Karaotkel deposit), on the account of washupagain which the ilmenite looses (Satpaev placer) are formed.

The revealed laws of formation and spatial accommodation of deposits of rare metals in Kalba-Narym zone and other geological structures are the important criterion for forecasting and searching the new ores objects on East Kazakhstan territory.

4. Conclusions

Kalba-Narym is considered as allogenic cluster (Terrane), attached to the structure of the Great Altai in Hercynian collision period. The main ore-bearing structures are confined to clusters of sialitic profile with increased capacity of Meta granite layer and the earth’s crust in whole. Granite Belt has a regional growth (the length of more than 500 km). Large scale of granitoids expansion emphasizes high energy and material resources for the processes of ore formation. Structural and metallogenic model of Kalba-Narym belt reflects the connection between the ore-magmatic systems with depth zones of the Earth crust and upper mantle, and therefore granitoid belt was formed as a result of long-term abyssal evolution of earth’s sial zone matter.

Granite intrusions are presented to be the most ore-bearing, which are formed in the mobile geodynamic environment that promotes more intensive processes of ore formation in nonequilibrium PT conditions and, ultimately, formation of commercial deposits (Priirtyshsky, Belogorsky solids). On this basis, ore and magmatic systems of varied productivity degrees have been identified and described. Developed geological and genetic models and ore petrochemical typification of granitoids seem to be major factors for rare metal deposits prediction.

Recommendations to geological explorations: Involvement in the assessment reserve perspective areas, and semi-closed and covered unconsolidated sediments (Shulbinsky area, etc.). Additional appraisal of flanks and deep levels of the known ore fields and deposits (Belaya Gora, Bakenny, Upper Baymurza, Yubileiny, etc.). The search for hidden tin-tantalum mineralization in the hidden granite domes of the (Karasu, Shuruk, etc.). Development by small enterprises of small pegmatite deposits with tantalum reserves (Medvedka, Ahmetkino, Tochka, Komarovsky, etc.). Development of new prognostic and search technologies based on modern geological and geodynamic concepts of ore formation, leading ore petrological, geophysical, and mineralogical and geochemical estimation criteria, using high-precise analytical base.

Conducted metallogenic studies have shown that there
are perspectives in the region to strengthen the mineral resource base for rare metal production.

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REFERENCES


