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MINERAL COMPOSITION OF RARE-METAL-URANIUM, BERYLLIUM WITH EMERALD AND OTHER DEPOSITS IN ENDO- AND EXOCONTACTS OF THE KUU GRANITE MASSIF (CENTRAL KAZAKHSTAN)

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The Permian granite massif of Kuu, making part of the Akchatau ore-bearing complex of the Central Kazakhstan, is characterized by occurences of quartz-felspathic pegmatites, some of which comprise accumulations of ore minerals — wolframite, molybdenite, cassiterite, monazite, beryl and less often others. Molybdenite is also present in some aplite dikes. Diverse veined formations, greisens, quartz and quartz-ore veins are common in the *Kuu* massif.

The *rare-metal-uranium* deposit Komsomolskoye is confined to *greisenization* zones in western *endo-* and exocontacts of granite massif, and the southern contact of *Kuu* massif *comprises a* beryllium deposit. The exocontact of massif, where quartz mineralization passes from granite into *schistose* ultrabasites, comprises an emerald manifestation and molybdenum deposit *Shalguiya*. This paper considers features of mineral composition of these deposits and ore manifestations and the history of geological evolution of mineralization.

1 table, 8 color photos, 14 references.

The region of *Kuu* granite massif has a long geological history. Late Sinian rocks of Late Proterozoic are the most ancient. Early and Middle Devonian *(D_1-D_2) rocks* discordantly *occur on the washed-out* surface of Sinian sequences. They are covered by a variegated and red sequence of Middle and Late Devonian *(D_2-D_3fr)*, which is discordantly covered by Famenian *(D_3fm)* limestones. The last are in turn covered by calcareous and *limestone-terrigenous* Carboniferous sediments.

Recent deposits are represented by Cenozoic deluvium and eluvium and Mesozoic weathering products. In addition, birbirites, rocks of ancient weathering rocks on ultrabasites, consisting of opal, chalcedony (up to 80 % of volume), limonite and smaller quantities of other minerals, develop within the Shalgiinsky ultrabasite massif. Cenozoic deposits with abundant gypsum are thin, below ten meters. Within the limits of Kuu massif, they accumulate cassiterite, topaz and monazite.

Intrusive rocks, in addition to Kuu granite, include Shalgiinsky ultrabasite massif. This Proterozoic massif is mainly composed of gabbro, amphibolites, serpentinites, schists and dikes of plagioclasites. Proterozoic basic rocks are hardly metamorphosed near the contact with granite.

The Kuu granite massif is confined the northwest part of Betpak-Dala folded structures, in the north of the large Shalguiya-Karaoba fault zone having northwest strike. The outcrops of Kuu granite extend in latitudinal direction. According to A.I. Ezhov (1964), there were three phases of intrusion and a phase of vein rocks. Aplites and quartz-felspathic pegmatites are characteristic. Ore minerals — wolframite, molybdenite, cassiterite, monazite, less often other minerals — are related to light gray quartz. In the southwest part of Kuu intrusion, some pegmatites veins show zonal occurrence of quartz and potassic felspar. Molybdenite appears when such veins pass from granite into hosting rocks. Molybdenite is also present in aplite dikes as thin flakes in mass of rock without appreciable hydrothermal alterations, as notes M.A. Konoplyantsev (1959). Beryl crystals occur in some pegmatites, for example, on the southern slope of the Kuu Mountain, west of quartz vein «Glavnaya», which crosses the Kuu massif approximately in its middle part.

Diverse vein bodies, greisens and quartz veins are widely distributed in the massif, and a number of ore occurrence are registered in the contact zone. They are typical vein bodies of quartz-wolframite-greisen association with molybdenite. Characteristic minerals of these ore veins are wolframite, cassiterite, monazite, molybdenite, topaz, fluorite, etc.

Kuu granites are specialized for beryllium. All accessory minerals are enriched with Be, beryl is present in some pegmatites and topaz veins with beryl, bertrandite and helvite are known among greisens.

The western and southwestern contacts of granite massif comprise the Komsomolskoye rare-metal-uranium deposit, the southern endocontact hosts a small uranium-beryllium deposit (site 2), and schistose ultrabasites of Shalgiinsky massif hosts an emerald and molybdenum deposit Shalguiya, which mineralogical features are considered below.

Mineralogical features of the Komsomolskoye deposit

The ore mineralization of the deposit relates to a system of feathering faults of a regional corrugation zone in the western endocontact part of Kuu granite massif and in its exocontact. Ore bodies are quartz veins, sometimes with pyrite, molybdenite, wolframite, less often with chalcopyrite, galena, and quartz-micaceous greisenization zones with topaz, fluorite, sometimes with molybdenite and less often with wolframite. Quartz veins and greisenization zones have abrupt dip, they are accompanied by zones of fracturing, caolinization, hematitization, and fluoritization of granite. Granite and greisenization zones in the ore field are pigmented by hematite, acquiring orange-red-brown coloring. Dark-violet fluorite frequently appears near silicification zones in granite, forming topaz-fluorite metasomatites. As noted A.I. Yezhov (1964), these associations are similar to fluorite-feldspathic rocks developed on the Cornwall Peninsula, England. Sericite-fluorite bodies are also distributed on the Karaoba molybdenum-tungsten deposit located southeast of the Komsomolskoye deposit.

Uranium minerals described for the first time in nonoxidized ore of the Komsomolskoye deposit are represented by pitchblende $UO_2 \cdot kUO_3$, uraninite UO_2, brannerite $(U,Ca,Th,TR)(Ti,Fe)_2O_6$ and uranium blacks (friable powder of pitchblende, coffinite $U[(SiO_4)_{1-x}(OH)_{4x}]$, brannerite and small quantities of other minerals). Pitchblende, uraninite and brannerite are little abundant being relics of altered ore in the zone of hypergenesis. Pitchblende occurs as dot colloform segregations, uraninite — as almost square cuts of crystals $n \cdot 10^{-2}$ mm. Brannerite was observed as fine and ultrafine segregations, which, in the data of spectral analysis, contain some percents of titanium, calcium, iron, lead and traces of niobium, wolfram, TR, in addition to uranium.

Hypergene zone is distinctly manifested, as was noted earlier (Chernikov, 1981; Chernikov, 1982; Chernikov, 2001). Uranium minerals in its limits are distributed by zoning. The main mineral in the upper part is schrö ckingerite $NaCa_3[(UO_2)(CO_3)_3(SO_4)F] \cdot 10H_2O$ (Photo 1). Its accumulations form a near-surface subzone considerably enriched with uranium as compared with lower parts of exogenous zone. Its vertical thickness varies from 2 to 10 m. Gypsum is common here and small amounts of uranophane $Ca(H_3O)_2[UO_2SiO_3]_2 \cdot 3H_2O$ was registered. Schrö ckingeritev appears along mineralized tectonic cracks, but more often in wall rocks, far outside of ore-bearing structures. It is also widely distributed in friable deposits.

Schrö ckingeritev in the deposit rather frequently forms large almost monomineral accumulation (Photo 2) in clayey material with abundant gypsum. Two samples from the deposit were subject to chemical analysis, which results are given in Table 1 in comparison with schrö ckingeritev from another ore locality of this region and with theoretical composition. The analyzed samples are similar to each other and differ a little from theoretical composition of schrö ckingeritev. If all aluminum and silicon to consider as admixtures, the analyzed samples have a little lower contents of uranium and carbonic acid and increased amount of fluorine, water, and the in some samples — of SO_3.

The optical properties of schrö ckingeritevs from the Komsomolskoye deposit, as well as from ore localities and radioactive anomalies of the region of Betpak-Dala and Chu-Ili mountains, differ a little from those described in literature. So, Nm values usually do not exceed 1.525 – 1.535, rarely attaining 1.540 – 1.545 cited in literature for schrö ckingeritev (Getseva and Savelyev, 1956; Soboleva and Pudovkina, 1957; Frondal, 1958). Nr of schrö ckingeritevs of the Komsomolskoye deposit is 1.505 – 1.517 and rarely goes down to values of 1.500 – 1.485 known from publications. A little lower intensity of some lines in X-ray powder diffraction pattern in comparison with published data probably reflects the worse crystallization in connection with the composition feature of the mineral noted above.

Below the schrö ckingeritev subzone, to a depth from tens to one hundred meters, only small amounts of calcium minerals of uranyl (uranophane, autenite $Ca[UO_2PO_4]_2 \cdot 8-12H_2O$ and, probably, uranospinite $Ca[UO_2AsO_4]_2 \cdot 8H_2O$) were registered.

Uranium-bearing limonite, manganese oxides and clay minerals are common here. Uranium was intensively leached from this part of hypergenesis zone, hence, it can be considered as a leached subzone. Uranyl minerals are established in it in the data of physical, optical and spectral analysis, and uranophane, in addition to these data, in X-ray powder diffraction patterns. Autenite has pale greenish-blue color, perfect cleavage by (001) and less perfect by (100). Nm = 1.580 – 1.590; rarely to 1.600 –

1.605. Its varieties with average index of refraction 1.618 – 1.620 corresponding to uranospinite are also present. However, in the samples analyzed by spectral method, the content of arsenic was 0.*n* %, at *n* % of phosphorus and calcium and n·10 % of uranium; hence, uranospinite in them, if any, is in very limited amounts.

Below the subzone of calcium minerals of uranyl (leaching of uranium), only uranium blacks are distributed (cementation zone from several meters to tens of meters thick). Clay substance containing sorbed uranium is present in smaller quantities.

With depth, the zone of uranium blacks is replaced by a horizon poor in uranium, in which pitchblende, uraninite, and brannerite are present only in dense plots of greisenized granite, whereare crushed rocks represent hematitized and argillized deep-seated zone of hypergenesis. Intensive hypergene redistribution of uranium in the section of Komsomolskoye deposit is distinctly registered by isotope composition of uranium-bearing and uranium minerals and by mineral associations.

The radiogenic additive of lead (0.01 – 0.023 %), as well as its gross content (0.03 – 0.04 %), is almost constant in the vertical section of the hypergenesis zone. At the same time, values of analytically detected uranium oscillate in a wide range of mineral associations. In the leached subzone, modern uranium content is tens of times below the value designed by radiogenic lead in minerals and rock. Sharp increase of uranium content, in times exceeding the values designed by radiogenic lead, is typical for uranium blacks of the cementation zone. These values only coincide in one ore sample from a deep-seated hypergene zone. Other studied minerals and mineral associations of deep-seated hypergene zone show a significant shortage of analytically measured uranium in comparison with that designed by radiogenic lead in them. It gives the base to consider that uranium was leached out and therefore it is possible to suppose insufficient study of the deposit regarding presence of commercial accumulations of uranium minerals at a depth.

Ratios Io(^{230}Th)/^{238}U, ^{234}U/^{238}U and ^{226}Ra/^{238}U in minerals and ore samples from the deep-seated hypergene zone are close to 1. In minerals and samples of rock with increased content of uranium from the zone of cementation and leaching of uranium, they vary within the determination error. Such isotope ratios in minerals and rocks indicate that they were formed earlier than ~ 1.5 m.a. ago. Only for ^{226}Ra and ^{234}U obvious deviations from their balance with ^{238}U are sometimes noted. Surplus of ^{226}Ra in minerals of the middle of leaching zone and some shortage in it to its balance with ^{238}U in minerals and ores of cementation zone is probably related to insignificant modern redistribution of radium in this part of hypergene zone. Preferable migration of ^{234}U from the middle part of leaching zone to the lover part of it and upper part of cementation zone was also registered. This, as well as for radium, could be explained by almost modern redistribution of ^{234}U.

Table 1. Chemical composition of schrockingeritev

Oxides	*1/71, Northern ore manifestation*	*502/71 Komsomolskoye-deposit*	*503/71, Komsomolskoye deposit*	*Theoretical composition*
Na_2O	3,32	3,40	3,42	3,49
K_2O	0,09	0,17	n.d.	-
CaO	18,90	18,56	18,76	18,91
SO_3	9,17	9,20	9,00	9,02
UO_3	30,26	30,31	30,46	32,21
CO_2	14,46	14,13	14,62	14,86
$H_2O\pm$	20,31	20,34	20,31	20,27
F	2,72	2,68	2,81	2,14
Al_2O_3	0,80	0,81	0,85	-
SiO_2	1,30	1,61	0,64	-
Σ	101,33	101,21	100,87	100,90
$O=F_2$	-1,15	-1,13	-1,18	-0,90
Σ	100,18	100,08	99,69	100,00

Note:
Chemical analysis was made in the laboratory of VIMS, Moscow (analyst S.P. Purusova)

Schrö ckingeritev from granite and greisen lenses is characterized by stable high values for all three determined isotope ratios. Such phenomenon probably indicates that during last hundreds thousands of years uranium with sharply increased ratio ^{234}U/^{238}U was introduced into the near-surface layer. Preferable migration of ^{238}U out of it occurred during the last several thousands of years. It has resulted in increase in ratios in schrö ckingeritev: Io/^{238}U (on the average, to 1.42), ^{234}U/^{238}U (to 2.85) and ^{226}Ra/^{238}U (on the average, to 1.78).

Oscillations of ^{234}U/^{238}U ratio in schrockingeritev from clay-rubbly weathering products are within 1.78 – 2.38 (mean 1.92) and Io/^{238}U ratios within 0.2 – 0.6 (mean 0.36). Such ratios of radioactive isotopes indicate obviously imposed character of schrö ckingeritev in clayey-rubbly weathering rocks in last hundreds thousands of years with essentially increased $^{234}U/^{238}U$ ratio. Uranium migrated in vertical and horizontal directions. Therefore, sites of modern accumulation of schrockingeritev not always fix places of hypogene ore exposition, making little reliable the deposit evaluation at a depth.

$^{234}U/^{238}U$ ratio in schrö ckingeritev and ore oscillates in Quaternary deposits above the clayey-rubbly weathering rocks from 1.32 to 4.59 (the last is the maximum value ever detected in minerals or rocks) giving the highest average we have detected in minerals — 3.37. $Io/^{238}U$ ratio changes from 0.89 to 2.59. The average of 1.63 also essentially exceeds the radioactive equilibrium. Such ratios of radioactive isotopes in minerals and ore indicate an essential addition of uranium into friable deposits during all Late Quaternary epoch with significant displacement of isotopes of uranium towards ^{234}U. In the last some thousands of years, due to some moistening of climate, an appreciable leaching of uranium from schrockingeritev of Quaternary formations occurred, therefore, $Io/^{238}U$ ratio in them is, on the average, above one.

As a whole, the near-surface oxidation zone of the Komsomolskoye deposit is characterized by an intensive and long leaching of uranium up to the Quaternary period and formation of distinctly manifested zone of uranium blacks of this age. Uranium also was leached from hypogene minerals in the deep-seated zone of hypergenesis, but less intensively than from minerals of the near-surface oxidation zone. Schrö ckingeritev intensively deposited in the uppermost levels of near-surface oxidation zone and in modern deposits.

Occurrence of beryl and emerald mineralization at Site 2

In addition to the above finds of beryl and bertrandite in the central sites of the Kuu granite massif, locality of emerald mineralization was met in the exocontact of a small uranium-beryllium deposit. Beryllium minerals and ore bodies are first described. Larger ore bodies of beryllium mineralization are located at Site 2, in the southeast contact of the Kuu massif. The site is composed of large-grain biotite porphyry granite, which contacts in the south with basically Devonian quartz porphyries and in the most western part of the site with amphibolous schists of Shalgiinsky ultrabasite massif. The contact strike is latitudinal, with abrupt dip to the south. Granite and quartz porphyries in the south of the site are intensively kaolinized to a depth of up to 8 m from the surface and schists are altered into birbirites.

The site comprises some greisen bodies in granite. Greisens are fringes accompanying quartz veins or ramified vein-like bodies and lenses, or irregular-shaped bodies. By mineral composition, greisens are classified as quartz-micaceous, quartz-hematite and phenakite-beryle, sometimes, with helvite. Quartz-micaceous and quartz-hematite greisens prevail. Two largest greisen bodies were explored for beryllium mineralization. Ore body # 2 was traced by superficial workings. In plan, this is a lenticular body. The lens is 50 m long and from 0.2 to 7.0 m thick. The lens strikes at 320° NW dipping to SW at 75 – 80°. The ore body is basically composed of quartz-hematite greisen with plots of micaceous and phenakite-beryle greisen with helvite. The contents of beryllium does not exceed 0.23 %.

Ore greisen # 3 is a vein-like ramified body of irregular thickness — from several mm to 8.5 m, striking almost in latitudinal direction, dipping to south at 70 – 75°. The length of greisen body is 220 m, beryl is irregularly distributed, enriching the northern part of body on the extent of about 150 m, where the average content of beryllium is 0.245 %. The ore body wedges out at a depth of 30 m. Schrockingeritev mineralization analogous to the Komsomolskoye deposit develops near the surface at a depth of 0.1 – 2.0 m in the southern part of site # 2 in argillized granite and greisens. Wells have penetrated the increased γ-activity in quartz-micaceous greisens with fluorite, pyrite, galena and limonite at a depth of 99,5 and 110.75 m as films of uranium blacks, also analogous to the Komsomolskoye deposit.

Similar schrö ckingeritev accumulations are detected on Northern and Northwestern sites (northern contact of the Kuu granite massif).

In the western part of Site 2, quartz vein with beryl occur in amphibolitic schist of the Shalgiinsky ultrabasite massif, near its contact with granite. Forms of beryl crystals change from isometric to prismatic (Photo 3). Crystal sizes vary from parts of mm to 5 cm in length at 0.5 cm in diameter. Ultrabasites and amphibolitic schists are enriched with chromium and vanadium in tens of times above the percent abundance, therefore, beryl from schist and its transparent variety emerald (Photo 4) contain chromium and vanadium in increased concentration (0.n % Cr and 0.0n % V). This is why their color changes to pale-green and bright green, whereas beryl from granite is grayish-white and brown-gray and contain 0.00n %

Photo 1. Schrö ckingeritev crystals from the Komsomolskoye deposit. Photo M.B. Leibov

Photo 2. Monomineral segregation of schrö ckingeritev. Size of segregation 2 x 1 cm. Komsomolskoye deposit. Sample of the Fersman Mineralogical Museum. Photo M.B. Leibov

Photo 3. Crystal of green beryl from schist, site #2. Size of crystal 9 x 5 mm. Specimen from A.A. Chernikov's collection. Photo M.B. Leibov

Photo 4. Emerald in quartz.
a) Size 3 x 2 cm. Sample of M.D. Dorfman's collection.
b) Size 6 x 4 cm. Sample #3533 of V.I. Stepanov's collection in the Fersman Mineralogical Museum. Photo M.B. Leibov

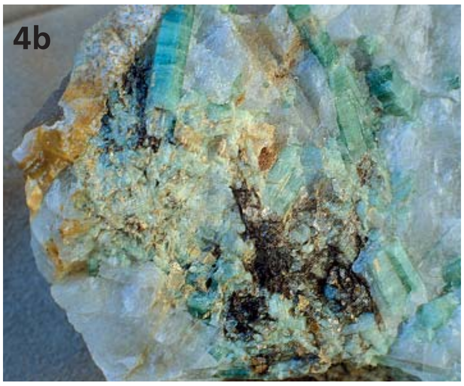

Photo 5. Change of color in emerald along the crystal. Crystal length 1.5 cm. Sample ? 3533 of V.I. Stepanov's collection of the Fersman Mineralogical Museum. Photo M.B. Leibov

Photo 6. Green beryl with change of transparency from opaque through translucent to transparent emerald green color. A.A. Chernikov's samples.
a) Crystal of beryl is crushed and healed by quartz. Length of crystal 1,6 cm
b) Crystals are crushed. Photo M.B. Leibov

Photo 7. Phenakite crystal. Size 0,9 x 0,8 cm. Site # 2 in the endocontact of Kuu granite massif. A.A. Chernikov's sample. Photo M.R. Kalamkarov

Photo 8. Phenakite replaced by bertrandite. Size 1 x 0,8 cm. Site # 2. Sample from A.A. Chernikov's collection. Photo M.R. Kalamkarov

Cr and V. Emeralds frequently have irregular color, which changes in a crystal along the long axis from rich green to pale bluish-green (Photo 5). In green beryl crystals (Photo 6) the transparency also varies from opaque through zones of translucent beryl to zones of transparent emerald of rich green color.

Beryl and emerald of Site 2 have low refractive indexes (No 1.570 – 1.575; Ne 1.568 – 1.572) and belong to varieties with small concentration of alkalis (Winchell, 1949; Dorfman, 1952; Winchell and Winchell, 1953). Sodium concentration in minerals makes tenth parts of percent.

Quartz-hematite and quartz-micaceous greisens of the endocontact parts of granite locally have increased concentration of beryl and phenakite, becoming phenakite-beryl greisens, sometimes with helvite. Phenakite in these greisens is subordinated to beryl and forms achromatic or grayish-yellow lenticular or prismatic translucent crystals (Photo 7) from dot segregations to 3 – 5 cm in length and 0.5 cm in diameter. Its hardness is 7.5 – 8, Ne-1.672 – 1.674, No-1.660 – 1.665. It is sometimes substituted by bertrandite (Photo 8), acquiring lamellar by (001) and prismatic shape of crystals with perfect cleavage by (110) and less perfect by (001) and (010). Its hardness reduces to 6.5. The mineral is biaxial (-), Ng 1.612; Nm 1.602; Np 1.588. Gem value of phenakite, as well as of other beryllium minerals is low, but their collection worth is undoubtedly very high.

Helvite in greisens is registered as individual tetrahedral honey-yellow crystals with vitreous luster and hardness of about 6 and density of 3.2 – 3.4. Schist on the Kuu granite contact comprises three quartz-hematite lenses with helvite, the dimensions of each of them are 8 – 6 m by 3.5 – 3 m, with the helvite content to 30 %. Beryl deposits on the periphery of lenses in a layer of 2 – 2.5 cm.

Further from the contact, the Shalguiya molybdenum deposit was formed. It is located between the Permian granite massif of Kuu and pre-Late Devonian granite Munglu. Serpentinites, amphibolous and amphibole-plagioclase schist are most widely developed here after rocks of the Shalgiinsky Early Caledonian basic-ultrabasic pluton.

The mineralization is multiphase. The earliest phase represent abundant monomineral streaks of quartz, sometimes containing thin magnetite impregnation. After them, judging by intersections, molybdenite-quartz streaks of several generations were formed. Thin streaks (5 mm and less) of fine crystalline quartz are most distributed. They contain molybdenite, rather regularly disseminated or concentrated as zones parallel to exocontacts of veins. Rather rare streaks of coarse-crystalline quartz with fringes of coarse-scaly molybdenite formed later. Almost monomineral molybdenite streaks in quartz and in hosting rocks formed much later.

Streaks of fine crystalline quartz with poor impregnation of wolframite and thin streaks of coarse-crystalline crested quartz with carbonates (ankerite, calcite, dolomite), sulfides (pyrite, chalcopyrite, sphalerite, galena, molybdenite, less often cobaltite and millerite) and fluorite were formed after early generations of molybdenite-quartz streaks and probably later coarse-crystalline quartz with fringes of coarse-scaly molybdenite. Streaks of potassic feldspar also segregated after coarse-crystalline quartz with fringes of coarse-scaly molybdenite, but they before fine crystalline quartz with wolframite and streaks of crested quartz with carbonates and sulfides. Monomineral molybdenite streaks are the latest, they cross all above listed mineral formations and in age they are at least much younger of femolite from the Djideli deposit (south-southwest) and molybdenite from the Bezymyannoe deposit (northwest of the Kuu massif). Femolite in ores of Djideli deposit and in molybdenite in the Bezymyannoe deposit are in close associations with pitchblende, which age by lead isotopes is 330 – 360 m.a. (Modnikov *et al.*, 1971). Early generations of molybdenite-quartz streaks could by related to molybdenite of uranium ores by the contents of elements-admixtures in them. Other generations of molybdenite-quartz streaks formed later as they cross and cement streaks of early generations. Mean of isotope age of Permian granite and related tin-tungstem-molybdenum mineralization in Kuu granite and Karaoba deposit (Yermilov, 1964) is ~270 m.a. Hence, streaks of fine crystalline quartz with wolframite and streaks of crested quartz with carbonates and sulfides including molybdenite could be correlated to this time interval. All streaks of monomineral molybdenite were deposited even later. Some monomineral streaks of fine molybdenite were probablly formed in the cementation zone as the oxidation zone of the Shalguiya deposit is practically deprived of molybdenum, which naturally deposited in reducing conditions below the oxidation zone and by age is much younger than 270 m.a. Some of them are probably modern deposits. This shows that formation of molibdenic mineral associations occupied rather a long time.

Ore streaks of early generations of quartz were formed before dikes of the second phase, while carbonate-quartz and felspathic streaks – after these dikes. Under M.M. Povilaitis observations (1990), streaks of early quartz generations have undergone intensive dynamic and thermal metamorphism at introduction of later dikes expressed in lamellar deformation. However, other ore-bearing quartz streaks cross these dikes and re-crystallized molybdenite is redistributed and concentrated in cracks of diverse orientation, which cross veined quartz.

In the oxidation zone to a depth of 40 to 60 m, sulfides are completely oxidized and molybdenum is intensively leached from oxidized ore. In the oxidation zone, only insignificant amount of powellite Ca $[MoO_4]$ and extremely rare wulfenite Pb $[MoO_4]$ were preserved, in addition, molybdenum is sorbed by iron hydroxides and manganese oxides impregnating rocks through numerous joint cracks. However, the average molybdenum content in the oxidation zone is low.

Thus, Permian granite of the Kuu massif is characterized by manifestations of diverse mineralizations. These include quartz-feldspathic pegmatites, some of which bear small amount of ore minerals — wolframite, molybdenite, cassiterite, monazite, beryl and less often others. Molybdenite is also present in aplite dikes. Various veined bodies — quartz veins, diverse greisens, fluorite and quartz-ore — are widely distributed in the Kuu massif. Many of them are most intensively manifested in contacts of massif, and some on a significant distance from the granite massif.

The endocontacts contain quartz veins, sometimes with pyrite, molybdenite, wolframite, less often with chalcopyrite and galena, as well as quartz-micaceous greisen bodies with topaz, fluorite, rare molybdenite and less often with wolframite. Feldspar-fluorite, sericite-fluorite and topaz-fluorite bodies are common; this is the pitchblende-uraninite-brannerite mineral association. Quartz-micaceous, quartz-hematite and first described phenakite-beryl greisens, sometimes with helvite, are less distributed. In exocontacts, quartz-beryl veins with emerald and, less often, poorly investigated quartz-hematite veins with helvite were registered. A large part of ore minerals is first described.

Quartz-ore stockwork of the Shalguiya molybdenum deposit, which occur in Shalgiinsky Early Caledonian basic-ultrabasic pluton, is more removed from Permian granite. Polyhronic mineral associations were first descried for the Shalguiya deposit ore.

As shown earlier (Chernikov, 2001), in Betpak Dala, Chu-Ili Mountains and in Kendytaks, the basic erosion of Paleozoic rocks has taken place before the Late Triassic. Later, tectonic evolution of the region, change of climate and exogenous processes had four basic phases. In the first phases or even earlier, before the Late Triassic and basic erosion of Paleozoic rocks, hematitization developed in granite, intensively manifested in the Komsomolskoye deposit.

Intensive exogenous formation of minerals with redistribution of ore elements occurred during long geological time in deposits and ore occurences in the contacts of the Kuu granite massif. Oxidation of hypogene minerals was accompanied by formation of limonite, manganese oxides, clay minerals, hematite and limited deposition of uranyl minerals. Uranium, molybdenum and other elements were intensively leached from the oxidized zone and newly formed minerals deposited in the near-surface and deep-seated zones of cementation.

Only in modern time gypsum began to deposit in soil, Quaternary deposits and upper levels of the weathering rocks, as well as formation of schrö ckingeritev in near-surface deposits and in upper levels of earlier leached oxidized zones. As Late Quaternary accumulation of schrö ckingeritev occurred at various distances from the primary source and leached zones are poorly investigated on the depth, the discovered diverse mineralization is insufficiently evaluated and the possibility is rather high to discover at a depth at least commercial accumulations of uranium minerals and probably of molybdenum and beryllium. Schrockingeritev from the Komsomolskoye deposit chemically differ a little from theoretical chemical composition and is characterized by high ratios of radioactive isotopes. The highest ratios $^{234}U/^{238}U$ ever detected in uranium minerals were observed in them.

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