TYPOMORPHISM OF THE COLUMBITE–TANTALITE GROUP MINERALS IN THE RARE–METAL TANTALUM–BEARING AMAZONITE–ALBITE GRANITES

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Mineralogical investigation of three tantalum-bearing granite massifs Orlovskoe and Aetykinskoe (Transbaikalia) and Maykul`skoe (Kazakhstan) has been conducted. Typomorphic peculiar features of the columbite – tantalite (Col-Ta) group minerals in these massifs according to their connection with different age phase and facial granite varieties have been revealed. It has been shown that combined with the other typomorphic signs crystal morphology peculiar features of the Col-Ta group minerals could be advantageously used during the geological prospecting for the survey and estimation of tantalum ore occurrences within the massifs of amazonite – albite rare metal subalkalic type granites. Col-Ta typomorphic signs may be also used at the stage of the detailed and exploitation exploration during the mineralogical and technological mapping of tantalum deposits in such massifs.
3 figures, 22 references.

Keywords: columbite tantalite group, manganocolumbite, typomorphism, phase variety, facial variety, rare metal granite massif, crystal morphology, habitus form.

Introduction

Minerals of the columbite – tantalite (Col-Ta) group are the most important in commercial aspect minerals of tantalum: more than 50% of the world reserves of this rare metal is connected with these minerals.

The main suppliers of tantalum are the deposits connected with granite pegmatites and rare metal granites of subalkalic type. Due to the known tendency of working out of rich in tantalum pegmatite deposits, great in reserves but poor in tantalum content and hardly enriched deposits connected with rare metal granites become more and more significant.

There are two such deposits in the Eastern Transbaikalia, Russia (Orlovskoe and Aetykinskoe) connected with the same names rare metal granite massifs. The Orlovskoe deposit was intensively exploited up to the end of the 1980s (its ore was gravity enriched at the neighboring Orlovsky mining-and-processing combine). At that time, the Aetykinskoe deposit was prepared for exploitation introducing, but failed; only recently, tantalum production was initiated in moderate volumes with consequent processing by gravity enrichment at the Pervomaysky mining-and-processing factory. At these deposits, a significant part of tantalum is contained in the minerals of the Col-Ta group along with pyrochlore – microlite (Prch-Mcr) and, to a lesser degree, with cassiterite (Css) being the main tantalum-bearing minerals. As it is known from the literature devoted to these deposits, the spatial distribution of these minerals with concentration of Prch-Mcr in the granite massifs endocontact zones and relatively even occurrence of Col-Ta and Css (Lugovskoy et al., 1972) allows to predict the increase of importance of the columbite – tantalite type ores in the tantalum balance as these deposits quarry mining.

That is why it is so important and actual to investigate Col-Ta group minerals from this type deposits and reveal their typomorphic features effecting the values of the ore technological processing during the exploration and estimation of such deposits.

The work was based on the materials obtained by the author as well as submitted for the investigation by S.M. Beskin, V.N. Pavlova, and A.E. Tsyganov (Institute of Mineralogy, Geochemistry and Crystal Chemistry of Rare Elements, Moscow), V.V. Matias (All-Russian Institute of Mineral Resources, Moscow), B.A. Levichev (Orlovsky Mining-and-Processing Combine, Chita oblast), A.M. Grebennikov and I.I. Kursinov (Pervomaysky Mining-and-Processing Combine, Chita oblast), Yu.K. Lebedev and A.N. Fedorov (Aetykinskaya Geological-and-Exploration Party, Zolotorechensk, Chita oblast).

Altogether there were investigated 224 disintegrated and panned samples from different phases and facia of the following rare metal amazonite – albite granite massifs containing Col-Ta group minerals: Orlovsky and Aetykinsky (Eastern Transbaikalia) and Maykul`sky (Southern Kazakhstan).

The massifs investigated are close to each other by the following several features: a) Late Hercynian age of formation; b) formation affiliation and connection with a unified extended Urals – Mongol – Okhotsk geosyncline belt and zones of tectono – magmatic activization of intermediate massifs; c) asymmetrical – fungiform (graptolitic) intrusion shape with intersecting interrelations with enclosing significantly silicate rocks; d) wide development of postmagmatic autometasomatic processes of albitization and greisenization; e) assembly and quantitative correlations of rock-forming, accessory, and ore minerals; f) increased concentrations of the lithophile rare elements in comparison with their clarkes. Composite geological characteristics of the mentioned granite massifs have been described in our paper (Povarennykh, 1994) and numerous publications of the other researchers (Zalashkova, 1969; Lugovskoy *et al.*, 1972; Alexandrov, 1989; Zaraysky, 2004; A. Rub, M. Rub, 2006; Beskin, 2007).

Analyses and determination of mineral features have been performed by the author and scientific researchers of several geological institutes and Lomonosov Moscow State University.

Chemical typomorphism of the columbite tantalite group minerals

Variations of chemical composition of these minerals reflect the complete isomorphism between two pares of species-forming elements: Mn and Fe, Ta and Nb. The following several mineral species belonging to the columbite – tantalite group are nowadays distinguished: ferrocolumbite $Fe^{2+}Nb_2O_6$, ferrotantalite $Fe^{2+}Ta_2O_6$, manganocolumbite $(Mn,Fe^{2+})(Nb,Ta)_2O_6$, and manganotantalite $MnTa_2O_6$. Continious isomorphic seria exist between these mineral species. Concentrations of other isomorphic impurity elements are regularly insignificant and reach as follows: Ti (<12.8%), W (<4.56%), Sn (<2.5%), TR (<2%), Al (<1.5%), Sc (<1.34%), and U (<0.5%) (Povarennykh, 1966; Voloshin, 1993; Povarennykh, 1985, 1991, 2008; A. Rub, M. Rub, 2006).

Specimens of the Col-Ta group minerals from the objects belonging to the following row of different formation types "carbonatites – alkaline rare metal granites – subalkalic rare metal granites – granitic pegmatites" are significantly distinguished from one another by content of the main species-forming cations (Ta, Nb, Fe, and Mn) and tantalic and manganiferous characteristic relations (Ta/(Ta + Nb) and Mn/(Mn + Fe), respectively). Within this row, average values of the tantalic characteristic relation in Col-Ta specimens gradually increases from 0.02 (central type carbonatites) to 0.93 (granitic pegmatites), and average values of the manganiferous characteristic relation vary approximately in the same limits.

Specimens of Col-Ta from the Maykul`sky massif of subalkalic rare metal granites (Southern Kazakhstan) are characterized by the following features of chemical composition: a) values of manganiferous characteristic relation Mn/(Mn + Fe) vary from 0.28 to 0.37; b) values of tantalic characteristic relation Ta/(Ta + Nb) vary from 0.04 to 0.17; c) rather high concentrations of impurity elements (in mas. %): titanium (1.00 TiO_2), tungsten (0.46 WO_3), scandium (0.28 Sc_2O_3), and tin (0.17 SnO_2). Contents of impurity elements in Col-Ta have been determined by microprobe analysis (Camebax), INAA and with the help of X-ray radiometric method ("Quant" device).

Variations of the main species-forming cations (in mas. %) and their correlations in the Col-Ta specimens from the Orlovsky massif (Aginsky Buryatsky autonomous okrug, Eastern Transbaikalia) are as follows: Ta_2O_5 15.7 – 65.1, Nb_2O_5 26.6 – 47.8, FeO 0.9 – 4.6, MnO 12.2 – 21.5, Ta/(Ta + Nb) 0.2 – 0.94 (average 0.44), and Mn/(Mn + Fe) 0.49 – 0.97 (average 0.89). These specimens are characterized by rather high average contents (in mas. %) of tungsten (0.75 WO_3), titanium (0.6 TiO_2), scandium (0.15 Sc_2O_3), and tin (0.2 SnO_2).

Specimens of Col-Ta from the Aetykinsky massif of rare metal granites (Eastern Transbaikalia) are characterized by the following variations of chemical composition and correlations of the main species-forming cations (by bulk samples of great weight 250 – 300 kg, in mas. %): Ta_2O_5 3.31 – 40.01, Nb_2O_5 39.26 – 75.67, FeO 1.94 – 11.18, MnO 7.93 – 16.00, Ta/(Ta + Nb) 0.04 – 0.53 (average 0.2), and Mn/(Mn + Fe) 0.29 – 0.9 (average 0.66). Concentrations of impurity elements vary in the following intervals (in mas. %): TiO_2 0.11 – 4.76, Sc_2O_3 0.06 – 1.34, WO_3 0.31 – 4.56, SnO_2 0.04 – 0.86, and UO_2 0.0 – 1.57.

In comparison with the values of tantalic and manganiferous characteristic relations of Col-Ta from the Maykul`sky and Orlovsky massifs, these parameters of Col-Ta from the Aetykinsky massif occupy intermediate position. Scandium is the most characteristic impurity element for the Col-Ta specimens from the Aetykinsky massif: its average content is very high (0.54 mas. % Sc_2O_3). Titanium, tungsten, and tin are also very common for these Col-Ta specimens (average contents, in mas. %): TiO_2 1.15, WO_3 0.85, and SnO_2 0.14.

Within the massifs investigated, Col-Ta is regularly distinguished by chemical composition depending on different phase and facial (autometasomatically altered and greisenized) varieties of rare metal granites and remoteness from endocontact. So in the Aetykinsky massif, the early phase γ_3^1 of fine-grained albite granites ("ongonites" xenoliths) and early facia of the amazonite – albite with zinwaldite granites γ_3^3 (middle-grained structure, homogenous texture) contain manganocolumbite with characteristic relations Ta/(Ta + Nb) = 0.11, Mn/(Mn + Fe) = 0.44, and relatively decreased contents of the following impurity elements (in mas. %): SnO_2 0.03, Sc_2O_3 0.42, WO_3 0.48, and TiO_2 0.48. Col-Ta from the later rare metal facia $\gamma^{4-6}{}_3$ (fine-grained structure, with lepidolite, homogenous texture; coarse-grained structure, with zinnwaldite – lepidolite, taxitic texture; coarse-grained structure, vein-like quartzitic and lithium mica quartzitic amazonitites) is presented by manganocolumbite with greater values of tantalic and manganiferous characteristic relations (Ta/(Ta + Nb) = 0.3, Mn/(Mn + Fe) = 0.78) and uplifted concentrations (in mas. %) of tin (SnO_2 0.2), scandium (Sc_2O_3 0.75), tungsten (WO_3 1.52), and titanium (TiO_2 2.11). Within the limits of the same facial variety of the Aetykinsky rare metal granite massif, the following definite vertical zonality occurs: more niobian and ferruginous Col-Ta varieties are found in the deeper sites and more tantalic and manganiferous Col-Ta specimens are found closer to the endocontact or paleo-surface.

For the Orlovsky massif, the character of zonality in distribution of Col-Ta with different chemical composition is close, to a first approximation, to those described for the Aetykinsky massif. So, the specimens of Col-Ta from the later rare metal granite facies (small-grained structure, lepidolite – amazonite – albite composition) are enriched with tantalum and manganese in comparison with those from the earlier facies (middle-grained structure, cryophyllite – amazonite – albite composition): values of tantalic characteristic relation Ta/(Ta + Nb) equal to 0.45 and 0.23, and values of manganiferous relation Mn/(Mn + Fe) equal to 0.94 and 0.73, respectively in the first and second cases. However, the most tantalic Col-Ta specimens do not occur immediately close to the endocontact, but in a 30 – 40 (up to 60) meter distance from it. They are characterized by tantalic relation value Ta/(Ta + Nb) = 0.7 and rather decreased value of manganiferous characteristic relation Mn/(Mn + Fe) = 0.78. Presence of such specific zone of tantalic "secondary enrichment" of Col-Ta specimens in the Orlovsky massif may be explained, in our opinion, by the action of the following two factors: 1) redistribution of tantalum between its two main tantalum-bearing minerals Prch-Mcr and Col-Ta (their simultaneous occurrence is observed only at the mentioned distances from endocontact where tantalum is spent for Prch-Mcr formation with synchronous depletion of Col-Ta in this element), 2) wave-like character of acidity – basicity conditions evolution of mineral formation during the post-magmatic high-temperature autometasomatical alteration of granite by albitization and greisenization processes.

Specimens of Col-Ta from the Maykul`sky massif belonging to the same phase of rare metal granite (small-middle-grained structure, amazonite – albite with protolithionite – zinnwaldite) become more and more tantalic and manganiferous with approaching to the endocontact with quartzite of the Maykulian suite O_2mk (Ta/(Ta + Nb) = 0.048 – 0.172 and Mn/(Mn + Fe) = 0.284 – 0.367). Col-Ta specimens from the small-grained albite granites of additional intrusions occurring within the amazonite – albite granites in the form of narrow lenticular xenolith-like bodies are distinguished by decreased values of tantalic characteristic relation (Ta/(Ta + Nb) = 0.07). They also contain lesser amounts of the following elements (in mas. %,): tin (SnO_2 0.06 and 0.19), titanium (TiO_2 0.4 and 1.01), scandium (Sc_2O_3 0.15 and 0.33), and tungsten (WO_3 0.26 and 0.44) (greater concentrations correspond to Col-Ta from the main phase granite).

Trends of Col-Ta chemical composition variations in the investigated Transbaikalian massifs in comparison with those from several other amazonite – albite massifs of the Urals – Mongol – Okhotsk belt are shown on Fig. 1. These trends coincide in directivity with the geochemical ones revealed by G.P. Zaraysky for these massifs according to Zr – Hf relation (Zaraysky, 2004) and mineragenic established by S.M. Beskin (Beskin, 2007). Distinct discreteness of figurative spot fields of Col-Ta group minerals in the investigated amazonite – albite Transbaikalian massifs with the presence of the unified trend may be interpreted as an indication of the following two great Col-Ta generations occurrence: earlier primary magmatic (ongonitic), and later high-temperature, hydrothermal – autometasomatical genetically connected

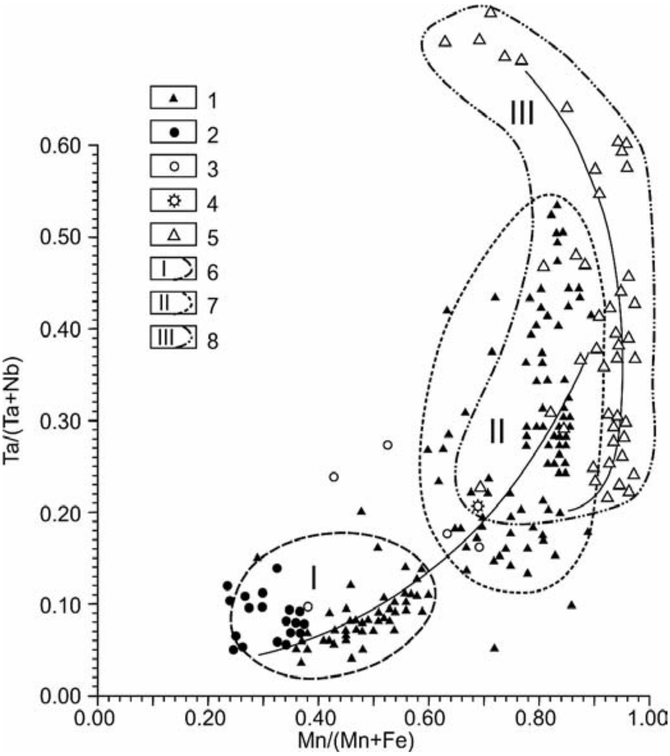


Fig. 1. Distribution of the composition figurative spots of the columbite—tantalite (Col-Ta) group minerals from different age phases and facial varieties of the subalkalic type rare metal amazonite—albite granites (according to 339 microprobe and 6 microchemical analyses data) at the diagram Ta/(Ta + Nb)—Mn/(Mn + Fe): 1 — specimens from the Aetykinsky massif (Eastern Transbaikalia); 2 — specimens from the Maykul`sky massif (Southern Kazakhstan); 3 — specimens by A.A. Sitnin (Aetykinsky massif, 1962); 4 — specimen by V.V. Matias (Aetykinsky massif, 1964); 5 — specimens from the Orlovsky massif (Eastern Transbaikalia); 6(I) — area of distribution of the Col-Ta composition figurative spots of the Maykul`sky massif and early phases and facial varieties of the Aetykinsky massif; 7(II) — the same from the later facial varieties of the Aetykinsky massif; 8(III) — the same from the later facial varieties of the Orlovsky massif. Trends of the Col-Ta composition changes in the investigated massifs are shown by solid lines.

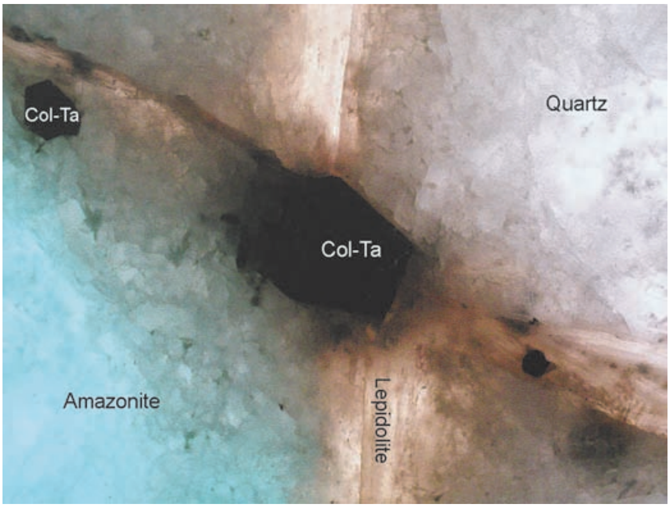


Fig. 2. Formation of manganocolumbite (Col-Ta) within the flakes of lithium mica (zinnwaldite—lepidolite) during the autometasomatical alteration of the subalkalic type rare metal amazonite—albite granite. Aetykinsky massif (Eastern Transbaikalia). Middle-grained amazonite—albite granite of the homogenous and taxitic texture (γ_3^5) of the apical parts of the massif. Thick polished section. Transparent light. Magnification 15.

with the ore—magmatic system development from the unified magmatic chamber without external matter introduction.

Typomorphism of morphology (properly typomorphism)

Morphology of crystals of the Col-Ta group minerals varies greatly in deposits of different genetic types. The simplest morphology is observed in Col-Ta crystals from the granitic pegmatites (12—15 simple forms). The most complicated morphology is observed in ferrocolumbite crystals from carbonatites (40—50 simple forms). According to our data and other informaion from the literature, including the data for the Ukrainian Priazov granitic massifs, Col-Ta specimens from the rare metal granites occupy an intermediate position: maximal amount of simple forms identified by us with the help of two-circle reflecting goniometer GD – 1 on manganocolumbite crystals from the Orlovsky massif reaches 19 (Povarennykh, 1988, 1991, 1994; Matias *et al.*, 1984).

Col-Ta specimens from carbonatites are distinguished by the often presence of complication simple forms such as {321}, {211}, {342}, {121}, {151}, {161}, and other as well as roundness of edges and tops (Povarennykh, 1990). Crystals of Col-Ta from rare metal alkaline granites are characterized by the presence of the following simple forms facets: {010}, {111}, {130}, {110}, {150}, and other. Along with the presence of simple forms common to the Col-Ta crystals from the rare metal alkaline granites, the specimens from the rare metal amazonite – albite subalkalic (the so called persilic) granite massifs investigated by the author, Orlovsky and Aetykinsky, also contain the following habitus simple forms: {021}, {031}, {051}, {230}, and {170}. For crystal face indexing, we have used goniometer GD – 1 as well as modified for this purpose Fedorov`s stage and photogoniometer with laser exposer (Institute of Geochemistry and Physics of Minerals, Kiev, V.M. Krochuk). Drawing of crystals has been conducted manually by the known method or with the help of computer ES-1033 and adopted japanese program of crystal drawing KRISTAL.

The widest variation of Col-Ta crystal habitus types has been observed in the specimens from the Orlovsky massif. According to their occurrence in different age phase and facial varieties of the amazonite – albite granites, evolution row of Col-Ta crystal habitus forms has been constructed (Fig. 3). Col-Ta crystals in this massif vary in morphology from columnar – needle-shaped elongated by [001], plate-like flattened by [010] and elongated by [001] through tabular and thick tabular, tabular – columnar flattened by [010] and elongated by [001] to isometric and short columnar shortened by [001].

Simple forms and habitus types' spectrum of Col-Ta crystals from the Aetykinsky massif is not so wide in comparison with those from the Orlovsky massif: a) amount of simple forms does not exceed 15, b) crystals distinct elongation by [001] has not been observed, and c) share of columnar – needle-shaped and thick tabular crystals is significantly lower.

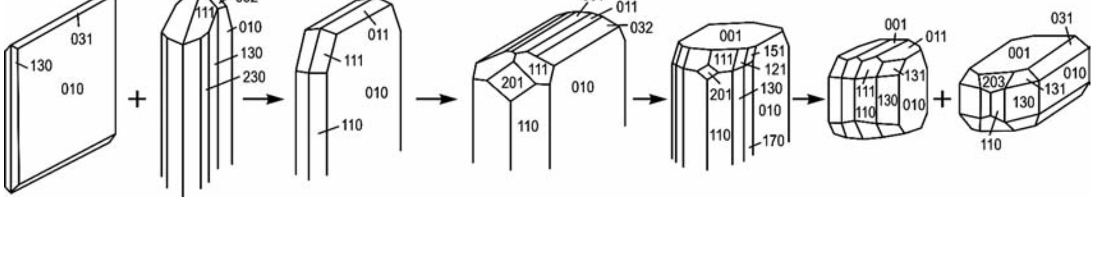
Spectrum of simple forms (up to 11) and habitus types of Col-Ta crystals observed in specimens from the Maykyl`sky massif is much more poor. Tabular, plate-like, and thick tabular flattened by [010] Col-Ta individes are the most abundant in this massif. Columnar – needle-shaped and thick tabular crystals occur rarely with minor occurrence of more isometric crystal forms.

The following regularities of Col-Ta crystal morphology has been observed for the investigated rare metal granites: 1) more isometric form crystals are connected with apical parts of massifs or their endocontacts, and anisometric form crystals are connected with more deep massif parts; 2) more late facial varieties of granites contain, as a rule, more isometric form crystals; 3) for the same facial variety of granites, more isometric form crystals occur in the upper horizons, and anisometric ones for lower horizons.

Typomorphism of inner structure (structure typomorphism)

According to the structure degree of ordering of the Col-Ta group minerals, very wide variation occurs for the specimens belonging to different genetic type's deposits. Ferrocolumbites from carbonatites are commonly most ordered, normally rhombic. Most unordered up to ixio-

Fig. 3. Schematical evolution row of habitus forms of the Col-Ta group minerals of the Orlovsky rare metal granite massif (Transbaikalia) (Povarennykh, 1991, 1994). Habitus types: I (columnar–needle-shaped and lamellar crystals) {010}+{031}+{130}+{hk0}; II (tabular crystals) {010}+{110}+{011}; III (thick tabular crystals) {010}+{110}+{0kl}+{111}; IV (tabular–columnar crystals) {010}+{001}+{hk0}+{hkl}; V (isometric and short columnar crystals) {001}+{010}+{0kl}+{hk0}+{h0l}.



lites (rhombic) and wodgenites (monoclinic), in contrast, are the Col-Ta specimens from granitic pegmatites (Nickel *et al.*, 1963, Giese, 1975). According to the degree of structure ordering, Col-Ta from the rare metal granites of subalkalic type investigated by the author occupies the intermediate position between the mentioned extreme values.

X-ray diffraction investigations has been conducted with the help of the monocrystal autodiffractometer Syntex, diffractometer DRON-3.0, and RKU chamber with D = 114 mm (Lomonosov Moscow State University, Geological Faculty, Crystallography Department).

Ferrocolumbites from the Maykul`sky massif are the most ordered (relation of the unit cell parameters b_0/c_0 varies from 2.817 to 2.818). Col-Ta specimens from the Aetykinsky massif are disordered in different degree (b_0/c_0 varies from 2.780 to 2.827). Manganocolumbites from the Orlovsky massif are the most variable in degree of ordering: from the ordered normal rhombic to completely disordered rhombic ixiolites and more rare monoclinic wodgenites.

Col-Ta specimens from the investigated massifs differ greatly in their anatomy. This feature has been studied on the crystallograpfically oriented and powdered with gold sections of crystals. Ferrocolumbites from the Maykul`sky massif do not reveal visual zonal – sectorial picture of inner structure: its crystals are evenly well polished without crumbling and evenly powdered. Three different types of zonal-sectorial picture are distinduished for the Col-Ta from the Aetykinsky massif: 1) nonvizualized zonality (could be revealed only during point-to-point microprobe analysing), 2) coarse zonality of the "center – margin" type characteristic, as a rule, to the specimens from the early phases and facia of the massif, and 3) complicated picture of oscillating or hourglass type structure revealed by the presence of different oriented trends of chemical composition change in different sectors of Col-Ta monocrystal characteristic to the later granite massif facia. First type zonal – sectorial picture does not practically occur in the Col-Ta specimens from the Orlovsky massif; crystals with second and more often third type of zonal – sectorial anatomy structure predominate.

In the investigated massifs of rare metal granites, Col-Ta group minerals are paragenetically associated* with the following rock-forming minerals: 1) albite (no. 0 – 5 polysynthetically twinned or rarely "chess-like"), 2) lithium micas belonging to the zinnwaldite – lepidolite row (Fig. 2, 3) smoky-gray small-grained quartz or outer zones of coarse-grained "pea-shaped" quartz containing oriented intergrowths of albite (the so called quartz with a structure of a snowball), 4) poikiloblastic topaz*, 5) pale violet fluorite, and 6) intensively colored blue-green small-grained idiomorphic microcline (amazonite).

For less autometasomatically altered granites of the Orlovsky massif, the following association of accessory minerals is common: ilmenite, monazite, zircon, titanium oxides, and apatite. Within the albitized granites, this association is replaced by the association of ferrocolumbite with cassiterite and monazite. With increase of the albitization intensity, more tantalic members of the Col-Ta mineral group occur, and monazite escapes. Zone of amazonite containing significantly albitized granites with lepidolite is characterized by the presence of substantial amounts of microlite and topaz in association with Col-Ta. According to the data of the researchers of this massif (Zalashkova *et al.*, 1969), the relationship between the amounts of Col-Ta group minerals and microlite accounts there for about 3:1, and reach 7:1 for the underlying muscovite-containing intensively albitized granites with amazonite and lithium mica. Investigations on mineralogical mapping of the Orlovsky massif showed (Matias *et al.*, 1984, Povarennykh, 1988) that the distribution of the Col-Ta group minerals is uneven (lens-shaped and banded) and does not correspond with the known before strict vertical zonality described by the other investigators (Lugovskoy *et al.*, 1972, Alexandrov, 1989).

In the rocks of the Aetykinsky massif, Col-Ta group minerals occur everywhere in contrast to the other ore tantaloniobates. Due to the association with different age facial granite varieties (subphases), they are present here in the form of several generations. Two widespread generations are distinctly determined: early, pre-microlite, and later, post-microlite. First generation Col-Ta is presented by small grains (0.05 – 0.15 mm along elongation) with composition corresponding to manganiferous ferrocolumbite (Ta_2O_5 5.88 – 8.78%, FeO 7.89 – 11.16%, MnO 8.4 – 10.9%). In quantitative sense, it strongly predominates, and in granites it is distinctly replaced by pyrochlore-microlite containing 8.5 – 35 mas. % Ta_2O_5 and 41 – 69 mas. % Nb_2O_5. Second generation Col-Ta is more coarse-grained (0.25 – 1.0 mm along elongation), more tantalic

* Paragenetic association was determined visually with a binocular microscope due to the presence of induction surfaces of cooperative growth as well as with the help of a raster electron microscope JSMT-20 under 1000 – 2000 magnifications.

and manganiferous (can be classified as manganocolumbite), and contains more high concentrations of such admixture elements as titanium, tungsten, tin, and scandium. Col-Ta group minerals are distinctly connected with different age subphases of granites (facia on degree of albitization and greisenization): ferrocolumbite is connected with the early rocks, and manganocolumbite to the later rocks. Coarse-grained Col-Ta crystals (0.5 – 1.5 cm) of isometric or tabular – columnar habitus close in composition to the second generation Col-Ta occur in pegmatoid quartz – amazonite and Li-mica quartz – amazonite veins intersecting middle-grained and fine-grained amazonite – albite with light Li-mica granites. Within the middle-grained amazonite – albite apical massif part granites of homogeneous and taxitic texture γ_3^5), incomplete apomanganocolumbite pseudomorphosises of wolframite (huebnerite) occur (Povarennykh, 1991, 1994, Povarennykh *et al.*, 1990). Mutual overgrowths of manganocolumbite and pyrochlore – microlite occur in the later facia.

The Maykyl`sky massif is characterized by the occurrence of regular intergrowths of ferrocolumbite with fersmite and samarskite as well as its apopyrochlore pseudomorphosises. Presence of induction surfaces of cooperative growth between ferrocolumbite, amazonite, and lithium-containing biotite (raster electron microscope JSMT-20 under 200-fold magnification) indicates close synchronism of their formation in the granite. According to the presence of replacement products correlation, the following row of the occurrence succession of the main ore tantalum-bearing minerals of the Maykul`sky massif has been established: fersmite – samarskite – ferrocolumbite (Povarennykh, 1994).

Resistant characteristics of Col-Ta have been investigated with the help of PMT – 3 device with indenter loading varying from 20 to 100 g. Microhardness of the Col-Ta specimens from the investigated granite massifs varies within the limits 320 – 970 kg/mm^2. Relation between the microhardness and Ta content is nonlinear and represents a broken line. Col-Ta specimens with 5 – 15% Ta_2O_5 content occupy the part of this broken line with a steep incline, and Col-Ta specimens with 15 – 60% Ta_2O_5 occupy its part with a gentle incline. We have found the inverse proportion between the values of microhardness and microbrittleness of the investigated Col-Ta specimens. Col-Ta from the later granite subphases rather often shows microhardness anisotropy of the I and II types (Povarennykh, 1991, 2008).

Crystal morphology mapping of the Col-Ta group minerals has been conducted at the rare metal granite massifs Orlovsky and Aetykinsky (Transbaikalia). Tantalum deposits are connected with these massifs, and the Col-Ta role in the balance of tantalum in these deposits is predominant in comparison with the pyrochlore-microlite. Col-Ta crystals shape and habitus have been used as elements of mapping (Povarennykh, 1988). We construct histograms of distribution of different habitus type crystals of Col-Ta in series of samples in every borehole and in surface mining workings (quarries, open pits, trenches), series of boreholes in profiles, series of profiles in the block, and in the massif as a whole. With the help of the data of the preceding researchers, we construct block-diagrams showing the correlation between the Col-Ta concentration in the granites and peculiarities of its crystal morphology.

For explanation of the established crystal morphology regularities, the author has used morphogenetic hypothesis (A. Povarennykh, 1966) in addition with the universal principle of Curie on the influence of the environment symmetry onto the individual symmetry. As a result, we could gain an impression of the crystal genesis conditions (if for no other reason than the symmetry of feeding environment) due to the observed natural distribution of the Col-Ta individuals of different habitus type. It also allows reconstructing the former geological conditions and estimating respectively the modern level of erosion shear of granite massif. Thus, according to the distribution in the granite samples of Col-Ta crystals belonging to the different habitus types and members of the evolution row of habitus forms, the minimal erosion shear level occurred in the western apical nose of the Aetykinsky massif roof (in reality does not day outcropping). The values of the erosion shear level have been respectively estimated as negligible (0 – 50 m) for the Orlovsky massif, moderate (100 – 200 m) for the main cupola of the Aetykinsky massif, and significant (300 m and more) for the Maykul`sky massif. These estimates of the erosion shear level are in well correspondence with those made in accordance with the geological data by Yu.I. Temnikov for the Orlovsky massif, A.A. Sitnin and V.V. Sunkinzian for the Aetykinsky massif, and P.V. Koval` for the Maykul`sky massif (Beskin, 2007).

Thus, along with the other typomorphic signs, crystal morphology of the Col-Ta group minerals can be successfully used during the geological prospecting for the survey and estimation of the tantalum ore occurrences in the massifs of the subalkalic type rare metal amazonite – albite granites. It can be also used at the stage of the detailed and exploitation exploration during conduction of the mineralogical – technological mapping of tantalum deposits in such massifs.

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