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GENETIC FEATURES OF STRATIFORM TUNGSTEN MINERALIZATION

(Figs. 3)

A b s t r a c t: Stratiform tungsten occurrences are found in the Northern Kazakhstan province as thin layers with the primary tungsten accumulation (up to 10—40 clarks) within a block of Pre-Riphean metamorphic rocks. The epigenetic scheelite mineralization is controlled by layers of skarnoids that have replaced apovolcanic amphibolites at the front of Upper Paleozoic injectible-metasomatic granitization.
Ore formation is provided by the combination of the following factors: abundance of the primary tungsten in the host rocks; its magmatic and postmagmatic remobilization during formation of skarnoids.

Резюме: Вольфрамовые стратиформные рудопроявления недавно стали известны в провинции Северного Казахстана. Они локализованы в блоке дорифейских метаморфических пород в виде тонких залежей в горизонте первичного накопления вольфрама (до 10—40 кларков).
Эпигенетическая шеелитовая минерализация контролируется залежами скарноидов, заместивших аповулканические амфиболиты, на фронте инъекционно-метасоматической гранитизации верхнепалеозойского возраста.
В генезисе оруденения ведущими выступают два фактора: повышенное содержание вольфрама в субстрате и его последующая магматическая и послемагматическая мобилизация при формировании залежей скарноидов.

Economic tungsten deposits represented recently exclusively by plutogenic type are gradually giving way to stratiform deposits of different geological character. Besides the Eastern Alps deposits (Austria) that have represented a certain model of stratiform tungsten mineralization of late as well as the known ore deposits in Precambrian sequences of Scandinavia, South Africa and other countries such occurrences have been discovered in a number of regions of the Soviet Union.

The deposits in various regions being characterized by the main specific features common to such mineralization, sometimes show significant specific differences. Investigation of different stratiform tungsten mineralization gives the opportunity of a more detailed knowledge of similar deposits. New data obtained in the stratified tungsten deposits of the Northern Kazakhstan are of great interest. The deposits are located in Kokchetav median mass, in a block of deeply metamorphosed and intensively dislocated deposits of Lower Proterozic Zerendinsk formation. Tungsten occurrences studied in this region are characterized by many properties typical of the stratiform deposits. Here tungsteniferous rocks are localized in a sublatitudinal belt 6—12 km wide, in the Northern periphery part of Zerendinsk granite-gneiss dome. Scheelite occurrences can be traced along certain horizon in metamorphic sequence as a continuous chain up to several tens of kilometers (Fig. 1).

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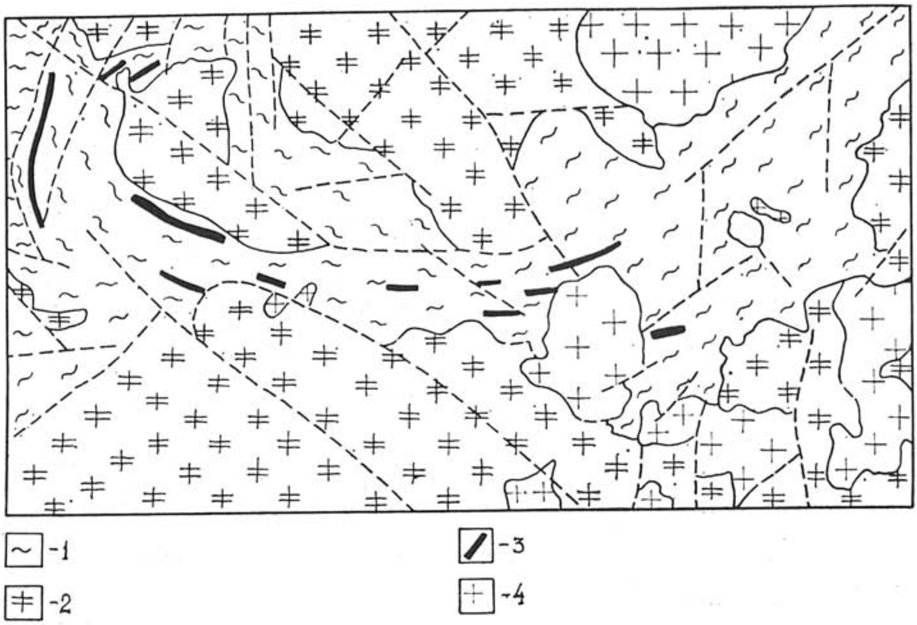

Fig. 1. Geologic map showing location of stratiform scheelite mineralization in the Northern Kazakhstan province.
Explanations: 1 — metamorphic rock; 2 — preore granite; 3 — tungsteniferous skarnoid and altered amphibolite; 4 — postore granite.

The prevailing rocks of such ore containing unit comprise, as a rule, aluminosilicates with a higher basicity (biotite-plagioclasic schist, amphibolites, low quartz gneisses, more seldom — graphite-mica-microclinic schist). Quartzites are of secondary importance, while marbles are extremely rare. Mineral parageneses of ore containing metamorphic correspond to amphibolite facies.

Reconstruction of original rock composition on the basis of the ore structures, their chemical composition and impurities-elements indicate its volcanogenic--terrigenic origin.

As compared to crustal abundance metamorphic rocks are distinguished by a higher tungsten content.

Its maximal median contents — with mode 34 g/t, are common for amphibolites; a lower mode — 15 g/t and 8—10 g/t, respectively, is typical of graphitic and other schists and gneisses.

The tungsten minerals were not found in these rocks and tungsten is supposed to be found in a dispersed form, mainly with different rock-forming minerals.

The tungsteniferous deposits under review are basically similar to those found in other regions of the world and described in the Early Precambrian of Kap Province by C u n n i n g h e m et al. (1973); in other Southern African countries (North of Rwanda, South-West of Uganda, a number of Zimbabwe areas) by R e e d m a n (1974); in the basic gneiss of Upper Archey in Colorado

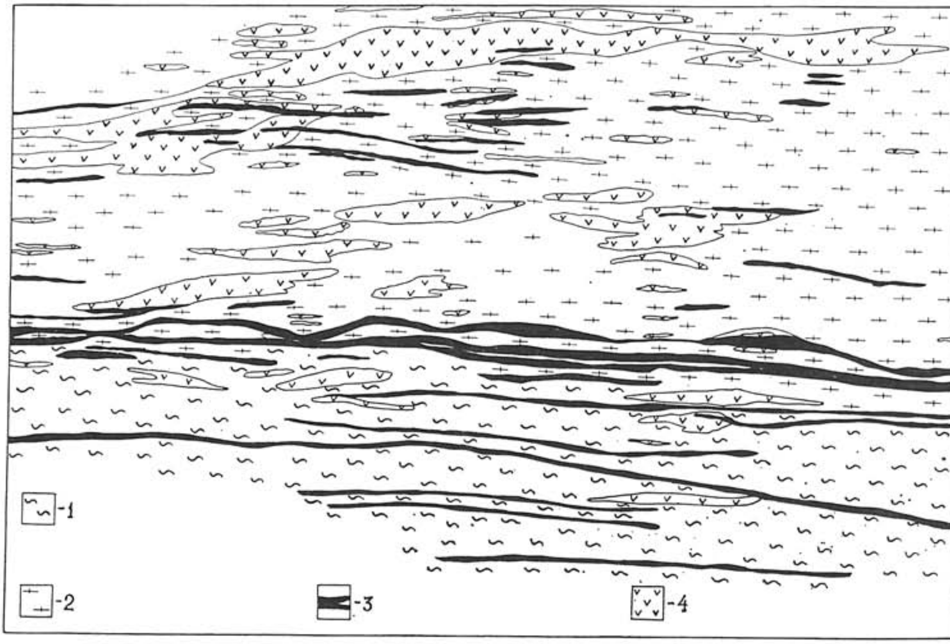

Fig. 2. Geologic map of stratiform tungsteniferous deposits.
Explanations: 1 — gneiss and schist; 2 — granite-gneiss; 3 — leucogranite; 4 — scheelite-bearing skarn and altered amphibolite.

Plato by Tweto (1960), including a horizont of scheelite-bearing gneiss of molybdenum-tungsten Tarrial-Springs deposits.

Such tungsten-bearing deposits, as many explorers have emphasised, can be characterized by constant graphite content of organic nature and significant manganese in ferro-magnesium silicates, as well as magnetite and sometimes sphalerite.

In the discussed area of Northern Kazakhstan tungsten mineralization can be found in a tungsten horizon under rewiev as impregnation of molybdoscheelite and scheelite with stratified lenticular and sheet-like bodies called skarnoids. There is no doubt as to the metasomatic nature of skarnoids formation replacing amphibolites and amphibole-plagioclase schist, more seldom — biotite-plagioclastic schist.

Thickness of skarnoids varies from a few centimeters to a few tens of meters. Biotite-bearing schist being replaced, it usually results in a number of subparallel skarnoid zones with insignificant thickness (first cm — fractions of cm), alternated with bands of unaltered schist.

Along the strike and dip the largest skarnoid bodies can be traced up to hundreds of meters. They are usually grouped into far stretching (up to several kilometers) zones, with series of autonomous bodies (Fig. 2) being parallel and echelon-like. In its turn the ore-bearing section of metamorphic rocks demonstrates a number of similar parallel zones, spaced here and there, coinciding with the horizons of prevailing amphibolite development.

Younger (post-metamorphic) granitoid bodies (or zones) can be regarded as an important element of geological structure in the area with stratiform tungsten mineralization and as a control of its attitude. The granitoids comprise two genetically related and simultaneously formed groups: allochtonic leucogranites and injectionally-metasomatic granito-gneisses. Leucogranites make up numerous sheet bodies 3—5 m thick, seldom thicker. They are often replaced by aplite-like and pegmatoid, and as a result of injection of thinnest magmatic matter into gneisses and schists, leucogranites form injection-metasomatic granitogneiss zones along contacts tens centimeters thick. Similar granitogneisses also occur as large layer zones, isolated from intrusive bodies, tens and hundreds meters thick. The similarity of petrographic composition and profuse saturation of thick granitogneiss zones with "dissolved" veins of large grain and pegmatoid quartz-feldspar indicate the similar conditions of formation both of thick zone granitogneisses and of their contact aureole around vein--shaped granite bodies.

Certain zoning in the complex granitoid rock development can be clearly seen: intensive spacious granitization of metamorphic rocks locates the area of maximal intensivity of magmatic replacement; in the upper and sideway direction from this area granite formation intensity is gradually attenuated, manifesting itself as a prevailing development of interlayer intrusive leucogranite bodies and weak granitization of adjoining sheets. All the granitoid rocks are two-feldspar, biotite, and with chemical composition similar to that of the normal series rocks. As compared to clarks of the elements, they can be characterized by a higher contents of F, W, Mo, Sn, Pb, Cr. Their tungsten median content is 6 g/t, i. e. the crustal abundance of tungsten is higher; however, this figure is significantly lower than that of indicating of tungsten contained in metamorphic rocks; in granitogneiss series this figure regularly decreases with the increase of rock granitization (leucoreduction).

Many geological, petrological and geochemical properties of granitoids make them typically ore-productive magmatic formations. This, in particular, is demonstrated by their significant "fluidosaturation" and geochemical specialization, but it can be more clearly seen in their close space association and age proximity of ore-bearing skarnoids and granitoids: this contributes to our regarding the ore-bearing skarnoids as postmagmatic.

Skarnoid space association with magmatic rocks is manifested both in the area skarnation position and in the position of the largest skarnoid bodies, showing tendency to frontal granitization (Fig. 3). Thin and little skarnoid zones very often form the pegmatoid quartz-feldspar rock vein trimmings; this contributes to skarnoid mineral parageneses being clearly put on granite associations.

The internal composition of all the skarnoid bodies shows a symmetrical zoning (in regard to the layer). It is manifested in the development of external--peripheral parts of the bodies (i.e. the frontal metasomatosis zones) in regard to low temperature actinolitic and epidote-actinolitic skarnoid facies, later being substituted by epidote-pyroxenic, and in internal (backside) parts of the bodies — by a higher temperature epidote-granite facies. Only gradient temperature field can contribute to such facial zoning with practically constant chemical composition. This state of art does not match regional metamorphism conditions, but it corresponds to hydrothermal formations.

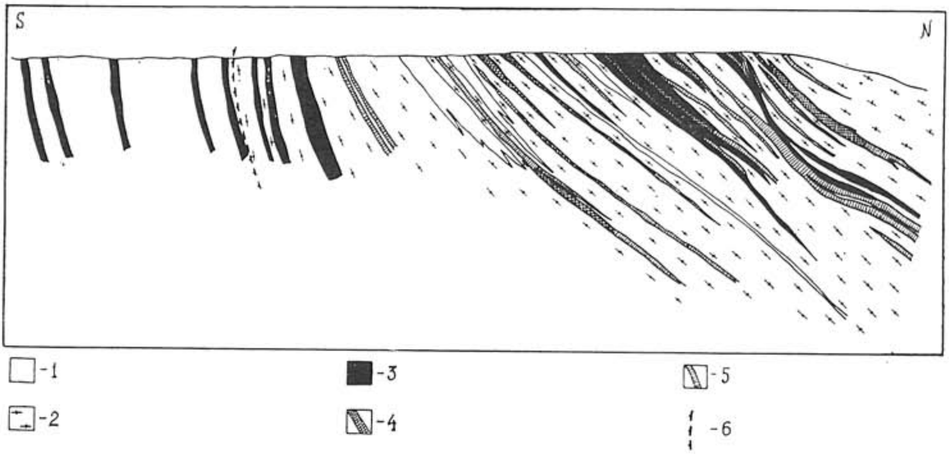

Fig. 3. Geologic section.
Explanations: 1 — gneiss and schist; 2 — granite-gneiss; 3 — leucogranite; 4 — scheelite-bearing skarn; 5 — altered amphibolite; 6 — granitization front.

Another specific feature of scheelite-bearing skarnoids stressing their relation with granitoids is the evolution of their mineral composition with the time, repeating normal ore development in plutonogenic skarnoid deposits. Skarnoid parageneses, including both granite, pyroxene, amphibole, epidote and sometimes feldspar, calcite, sphene, apatite are without ores. Scheelite appears in rocks in a kind of small dispersed inclusions only as a result of hysterogenic transformation of the above-mentioned skarnoid elements with acid leaching developing as an association and corresponding to aposkarnoid quartz-feldspar-amphibole--epidote metasomatites (Z h a r i k o v, 1982). The latter include recrystallized granite, pyroxene, epidote, amphibole and newly formed elements — quartz, feldspar, fluorite, calcite, pyrite and other sulphides as well bismuth minerals. This association also contains scheelite with significant molybdenum (up to 1.5 %).

The following ore association placed on (sometimes in autonomous veins) skarnoids corresponds to quartz-epidote-flogopite metasomatites. It includes nonmolybdenum scheelite, pyrite, pyrrhotite, chalcopyrite, molybdenite and other sulphides. Space distribution of this association shows a definite tendency to skarnoid areas, but it consists mainly of rocks containing alumosilicates (as a rule these are the remains of schist, gneisses and granites among skarnoids); the association is controlled by a crack system lateral to dip of skarnoid body.

The data stated testify to the fact that two groups of factors have played an important role in the genesis of the reviewed ore formations of Northern Kazakhstan. One of them determines the hydrothermal-metasomatic nature of mineralization formation and its close relation to leucogranites-granito--gneisses complex with lithological skarnation control by the amphibolite horizons, i.e. it corresponds to the formation conditions of the most of post-magmatic skarnoid deposits.

The second group of factors is responsible for "stratiform" mineralization. The most important one represents the primary impregnation of certain sequence horizons with tungsten. However, even maximum tungsten content dispersed in metamorphic rocks is far under the industrial concentration level. The industrial concentration level can only be achieved as a result of tungsten redistribution under the granitoid influence. Granitization actively influences tungsten thus decreasing its medium content in granitogneisses as compared to initial schists and amphibolites. Since the continuity of granitization columns to its full depth is not known, it is impossible to determine the complete balance of mobilized and deposed tungsten. Nevertheless, there is no doubt that tungsten present in ore bodies can be explained to a certain degree by primary accumulation of this metal in volcanogenic-sedimentary sequences whose rocks served as a source of ore matter. Significant tungsten concentration was only a result of late magmatic and, mainly, post-magmatic granitoid activity at the geochemical barriers of granitization fronts. Thus, it is granitoid magmatism development in a productive horizon in a peculiar injection-metasomatic replacement form that brought about mobilization, migration and finally tungsten deposition that resulted in deposit formation. Hence it is combination of these two groups of factors discussed above that predetermined the possibility of formation of these ore deposits. In the light of the data stated there a certain difficulty arises in defining such associations on the basis of the standard genetic classification. Nevertheless, since "material" granitoids beyond the stratified source of ore matter lose their ore productive properties, stratiform mineralization should be of primary importance both in classification and ore prospecting.

It is evident that the reviewed specificity of stratiform tungsten mineralization in Northern Kazakhstan is not exceptional. A number of similar deposits in Prebaikalje, Altai-Sayanskaya folded region, Middle Asia and other regions, and according to the literature elsewhere (L o b k o v et al., 1982), hydrothermal-metasomatic processes are also expressed in ore matter accumulation. They are related to granitoid magmatism, the latter being a necessary condition of ore formation in numerous stratiform tungsten deposits.

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