Rare metallic Pegmatite belts of the Hindukush, Eastern Afghanistan

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Zusammenfassung

Die Pegmatitreviere mit seltenen Metallen liegen im Zentralmassiv des Pamir, das von archäischen kristallinen Schiefern aufgebaut ist; das Alter der Pegmatite ist End-Kreide bis Eozän. Sie sind an Zweiglimmergranite gebunden. Ihre tektonische Stellung ist durch die Ränder von Mulden und Gräben bestimmt, die mit Sedimenten von Perm-Jura gefüllt sind. Die Mächtigkeit der mineralisierten Pegmatite liegt zwischen 5 und 60 m, ihre Länge zwischen einigen hundert bis 2000 m, die vertikale Tiefe ist bis 1000 m aufgeschlossen. Der Gehalt an Spodumen beträgt zwischen 15 und 25 %, der Li-Gehalt 1—2 %. Die Vorräte werden auf 3 Millionen Tonnen Li_2O geschätzt. Diese Li-Konzentration wird auf eine Spätkristallisation in der anatektischen Granitschmelze zurückgeführt. — Die Edelstein-Pegmatite führen Kunzit, Beryll und edlen Turmalin; sie sind durch große und reichliche miarolithische Hohlräume ausgezeichnet.

Introduction

The numerous ore fields of rare metallic granite pegmatites were discovered in Afghanistan by Soviet geologists during 1971—1976. These deposits are located in the alpine region of the Hindukush in the valleys of Kabul, Alingar, Kunar and Daray-Pich. The ore fields in this part of Afghanistan are occuring in the absolute altitudes ranging from between 800 m to 6000 m above sea level. The revealed pegmatites are characterized by huge reserves, diverse associations of elements and minerals, including gem stones. From the economic point of view these deposits, or at least some of them, are evaluated as being economically valuable.

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Rare metal pegmatite fields are distributed in the Nuristan-Pamir middle massif, composed of the three main formations. The lower Archaean formation is composed of various crystalline schists, gneisses, migmatites, marbles metamorphised in conditions of granulate and amphibolite metamorphic facies (Saunglich series). The middle Proterozoic series consists of strongly displaced crystalline schists of amphibolite metamorphic facies (Nuristan series). The Upper Permian-Triassic sequence is represented by quarzzmica and granatstaurolite schists along with small quantities of limestone and quarzites; the state of metamorphism of the above corresponds to epidote-amphibolite and green schists facies (Kashmund series). This middle massif is broken into a number of large blocks. The granitoids, both ancient early Proterozoic and Cretaceous-Palaeogene, are widespread. The largest granite massifs (Lagman complex) have been formed by the process of Alpine activization (1).

Rare-metall pegmatites on the territory of Nuristan and Badakhshan are spatially and genetically associated with granites of the Lagman complex. Granite bodies of the Lagman complex are emplaced between sediments of the lower and upper structural sequences. At the foot of the granite massifs lies Precambrian gneiss, at the roof quarz – mica-granat – stawrolite schists of Permian-Triassic age.

The largest and most complicated among Lagman complex massifs is Alingar granite pluton. This intrusive is stretching from the area of the town Jalalabad northeastwards at a distance of about 400 km in the river valley of the Pyanj up to the confluence of the Pamir-Daryá with the Vakhan-Darya. The width of a compact granite field of the Alingar intrusive at the level of present erosion varies from 10 to 50 km.

The Lagman complex massifs have been formed during three main phases: 1. granodiorites, plagiogranites, quarz diorites; 2. strongly porphyrie biotite granites; 3. biotite and bimicaceus granite and sillimanite granite, with which rare-metall pegmatites are spatially and genetically associated. The age of Lagman complex granites is considered to be of the Upper Cretaceous-Paleogene. The Lagman complex granites and their rare-metall pegmatites are believed to be associated with Alpine activization (8).

The main features of pegmatites

The pegmatites genetically associated with the third phase of the Lagman complex (bimicaceous granites) occur as 1. syngenetic (schlieren) deposits in granites; 2. epigenetic deposits at the roof of the granite massifs. Gradual transitions have been established: bimicaceous granite – syngenetic (schlieren) pegmatite – epigenetic pegmatite. Rare-metal mineralization, as well as precious stones only occur in the epigenetic pegmatites.

The majority of rare-metal pegmatite veins are located near the exocontact of intrusive bodies, where only small (from 1×2 to 3×10 km) granite massifs of the

third phase are exposed; they are regarded as satellites or large apophysis of the main intrusive.

Wallrocks of rare-metal pegmatites are mostly quarz-micaschists containing andalusite, cordierite, granate, staurolite. A certain correlation of the degree of metamorphism of wall rocks and the localization of rare-metal pegmatite bodies is observed: the rare-metal pegmatite ore bodies are associated with the rocks mainly metamorphised in the condition of epidote-amphibolite facies.

The morphology of rare-metal bodies of Eastern Afghanistan is diverse, but as a whole veins and lenses are prevailing. The dimensions of pegmatite bodies range from 1 to 60 m wide and from 10 meters up to 2–5 km long. Certain rare-metal pegmatite bodies are of very large dimensions, so for example vein Nr. 8 from the Nilan-Kulam field is 4000 m long with an average thickness of 7 m; the spodumene-albite vein of the Drumgal is over 1500 m long and 30 m wide; the "Kulam" vein, composed of albitized microline, with lepidolite and spodumene is 5 to 40 m thick and over 3000 m long.

The inner structure of the pegmatite bodies is massive, stripy or weakly zoned.

Rare-metal pegmatites of Afghanistan have been subdivided with respect to their composition and tipomorphic minerals, as well as to their practical importance into the following types: 1. oligoclase–microline biotite–muscovite with rare beryl; 2. albitized microline with scherle, muscovite and beryl; ores of crystalline beryl; 3. albitized microline ores with nests of blue clevelendite, lepidolite, spodumene, polychromium tourmaline-deposits of precious stones like kunzite, vorobyevite, tourmaline; 4. albite ores with nests of lepidolite, tantalite, spodumene, pollucite, tantal ores; 5. spodumene–microline–albite and spodumene–albite (spodumene pegmatites): lithium ores; 6. lepidolite–spodumene–albite with polychromium tourmaline, tantaline, pollucite: caesium and tantal-caesium ores.

Pegmatite fields and belts

Rare-metal pegmatite veins in the territory of Nuristan and Badakhshan are forming ore fields over an area of 10 to 800 square km. All together 21 fields have been discovered. The number of individual rare-metal bodies within the fields usually are tens and rarely hundreds. Three structural types of ore fields are being distinguished: 1. the fields of veins, dipping at low angles, are the most typical ones for the gabbro diorite massifs. They are mainly confined to contraction joints in the endocontact area. 2. ore fields of subvertical veins are confined to schists in the contact zones. 3. The ore fields composed of lenses are occuring in the cuppolas of granite massifs.

The pegmatite fields in the territory of Eastern Afghanistan are grouped into three clearly defined zones: Badakhshan, Hindukush and Nuristan. These pegmatite belts are related to linear graben–syncline structures, composed of Permian Triassic and locally Jurassic sediments. The presence of pegmatite-granite is often being observed.

The formation of pegmatite-granites and pegmatits is linked with the period of a powerful and dynamic tension, which took place in the conditions of stress, thus causing cataclasm and mylonitization of both granites and pegmatites (Rushan belt of the Southern Pamirs). In other folding zones pegmatite-bearing granites are formed by the activization process, when folding zones have already been constituted by relatively hard tectonic blocks (Yasgulem belt of the Central Pamir).

The rare-metal pegmatite belts of Eastern Afghanistan and the Pamirs are regarded to be the largest in the world (3). Based on our studies, this province is characterized by its clearly defined Li, Be, Ta and Sn specialization which leaves an imprint on geochemical features of certain belts and ore fields of the region.

The study of ore-bearing belts and ore fields of rare-metal pegmatites of the Hindukush has shown that they are characterized by many specific metallogenic features, due to the influence of the following factors: 1. geochemical composition of the province as a whole; 2. geochemical peculiarities of pegmatite bearing granites in various tectonic zones; 3. tectonic regime of the formation of pegmatites; 4. structural and morphological type of pegmatite veins.

Depending upon the intensity of the ore forming factors, some pegmatite belts turn out to be specialized for lithium, others for tantalium, beryl and precious stones.

Mineral Resources of Pegmatite belts

Of the numerous metals and minerals so far discovered in the pegmatites of Eastern Afghanistan, lithium and precious stones are the most interesting ones. Lithium deposits are represented by large and numerous veins of spodumene pegmatites in the roof of granite massifs. Mainly quarz-muscovite-biotite schists with garnet and staurolite are the wall-rocks of the deposits. The spodumene pegmatites are located in various structural environments of pegmatite-bearing granites, but the largest deposits are related to Permian-Triassic graben-synclines in the area of Precambrian bed exposures, as mentioned above.

As far as the structure and morphology are concerned, the deposits under consideration constitute a specific type of vein series, which is characterized by a linear-extended form and steep-dipping. In this series spodumene pegmatites are deposited echelon-like, in the form of extended plates or lenses. The thickness of large bodies varies from 5 to 60 m, and the length from several hundred to 2000 m. The thickness of the veins varies from 20 to 500 m. The vertical extension of spodumene pegmatites varies from 100 to 1000 m. Certain large deposits, containing commercial lithium ore (Jamanak, Drumgal, Tsamgal), are exposed by the relief along their dip for 400–800 m. Spodumene pegmatites which are forming the lithium deposits in the Hindukush, belong to the lithium subtype of sodium-lithium pegmatites according to A. E. FERSMAN's classification (9), in which mean spodumen content varies between 15–25 %. The lithium deposits of Afghanistan are similar to spodumene deposits of other regions, but they have very close similarity with the deposits of tin-spodumene belts of North Carolina in the U.S.A.

Spodumene deposits of Afghanistan are characterized by their high content of lithium oxide (1–2 %). Six of the deposits only (Drumgal, Pasgushta, Tsamgal,

Jamanak, Paski and Jarigul) are estimated to contain reserves of 3 million tons of lithium oxide to a depth of 100 m. They belong to the largest deposits of the world. The formation of spodumene pegmatite deposits of the Hindukush should be explained by some specific features of the parent magmas and concentration of lithium.

The high-alumine granites are characterized by 2–3 times increased lithium content against clark (z); the sharpest incerease (30–50 times) of lithium content in comparison with granites and plagioclase-microline (ore-barren) pegmatites is observed in spodumene pegmatites. The spodumene pegmatites and their parent granites are regarded as differentiators of a granite magma, highly enriched with lithium.

Special studies of lithium geochemistry have led to the conclusion that granite magmas which are forming pegmatite-bearing massifs, are enriched with lithium by the anatexis process of sedimentary-metamorphic series. Further concentration of lithium in residual granite melts, is conditioned by differentation of magma and redistribution of lithium by the magmatic alteration, particularly by replacement of biotite by muscovite.

Deposits of Precious Stones

Deposits of kunzite, jewellery tourmaline, beryl, are associated with the rare-metal pegmatite ore fields, where they occupy a specific geological position: 1. they are located in the zones of tension only; they are however absent in the zones of compression; 2. the most productive pegmatites occur either in gneiss series around graben-synclinal structure, or in gabbroid massifs within these structures; 3. the largest deposits are always occuring in subhorizontal or gentle-sloping bodies, but the small ones are connected with bodies of any morphology and any steepness of dipping.

Most productive for gemstones are albitized microline pegmatites with lepidolite, spodumene, polychrome tourmaline. These pegmatites form the unique kunzite deposit of Kulam. Pegmatite bodies containing gemstones are characterized by inhomogeneous inner structure, by slightly expressed differentation, by large minerals and mineral aggregates, by abundance of minerals containing volatile components, and by extensive development of miarols, etc.

The gemstones are occuring in the miarols and near them among mineralized zones, consisting of blue clevelandite, lepidolite, white spodumene, pollucite. The size of a miarol varies from 10 cm to 3 m in diameter. The largest of them are located under the hanging contact of gentle-sloping bodies. Miarols with gemstones only occur in pegmatites formed under the condition of crystallization. The formation of the minerals took place at the end of differentation. Along with free crystallization there are widespread products of regeneration of spodumene and pollucite, as well as tourmaline, beryl, topaz, quarz around the miarols and partially within the miarols itself. Regeneration has an important practical significance: the majority of jewellery kunzite was formed just by the process of regeneration of primary spodumene.

Temperature of mineral formation in miarols, determined by homogenization of gas–liquid inclusions, range mainly within 120–280° C. Regeneration of kunzite took place within the temperature of 160–270° C.

In general, rare-metal pegmatites of the Hindukush containing gemstones, exhibit a wonderful similarity with the pegmatites of Pala and San-Diego in California as to their character of mineralization and geological position.

Conclusion

1. Eastern Afghanistan is a part of the global Himalayan pegmatite belt, stretching 3000 km from Iran in the West to Birma in the Southeast.

2. Rare-metal pegmatites of Eastern Afghanistan are spatially and genetically associated with bimica highly-alumina granites of Upper Cretaceous-Paleogene age. The formation of granites and pegmatites is conditioned by the Alpine activization.

3. The rare-metal pegmatite belts extending from 200 to 400 km in the territory of Nuristan–Pamir, are related to young Permian-Jura graben-synclines.

4. The pegmatite deposits of Eastern Afghanistan are characterized by a remarkably expressed Li, Be, Ta and Sn anomaly. The huge spodumene deposits, the deposits of tantalium and beryl, as well as unique deposits of gemstones-kunzite and jewellery tourmaline, have recently been discovered within this regional metallogenic unit.

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