Veined Bodies of Kharbey Area in Polar Urals

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Abstract. The steady increase in the price of gold in the world market causes increased interest of domestic and foreign investors not only in the traditional and long-known gold-bearing regions of Russia, but also in new territories where valuation works for gold have been actively carried out recently. One of such territories in the Polar Urals is the Riphean-Ordovician folded frame of the Precambrian Kharbey crystalline massif located in the Sakmar-Lemvinsky structural and faci zone within the river basins Grand Paypudyna river and Kharbey river. The gold mineralisation of Kharbey area and its ampelshorskaya zone is associated with the development of the black shists formation, with the stratiform type of gold mineralization characteristic. Another important feature of this area is the massive development of heterogeneous mineral veins, some of which may be gold-bearing.

1. Introduction
The aim of this work was to study vein formations of Kharbey area and to find potentially gold bearing veins among them. The geology aspects of the the region is extremely complex and is interpreted ambiguously by geologists [1, 2, 3, 4, 5]. According to the latest ideas, it is explained from the standpoint of plate tectonics and represent four-phases tectonic blocks of Riphean, Lower - and Upper Paleozoic strata overthrusting each other and undercovered by Mesozoic sediments [2, 3, 5, 6, 7, 8, 9, 10]. Igneous rock formations are diverse and represented by boss and dyke bodies of rock from ultrabasitic to acidic, formed in the age range from Riphean to Late Permian [5]. The Polar-Ural granitoid complex of the Late Carboniferous age, formed after the accumulation of deposits of the oran stratigraphy assise, deserves special attention. The assise belongs to the early Ordovician and has a gold mineralization [11]. In the east, in a possible large thrust, it contacts the Riphean shales of the hard Harbey block, which, by petrographic features, are hardly distinguishable from the rocks of the ore-bearing assise [12].

2. Material and methods
The actual material for the research was the mapping data, as well as the results of documentation and geochemical sampling of mines and rock outcrops. Samples were studied by microscopy (polarized microscope POLAM L213M), X-ray diffraction (DRON-4 diffractometer) and atomic emission spectral analysis (AESA spectrometer). Analyzes were performed in the laboratories of RUDN, RGGRU, TSNIGRI and the Alexandrovskaya Experimental Methodical Expedition (RUSGEOLOGY).
3. Results and discussion

The assise combines clay, siliceous, and silty-clay rock altered under the greenish metamorphic facies. According to the data of microscopy and X-ray phase analysis, the rock consists of randomly alternating thin chlorite-sericite, albite-quartz, quartz and a mixed composition of the layers. Their texture is lepidoblastic, granoblastic and lepidogranoblastic. Various combinations of these elements determine a diverse mineralogical-petrographic composition of the shists. Plicature and schistosity, subparallel to rock stratification are developed in the rock, as well as cleavage in two directions: parallel to the apical plane of the folds and oriented at an angle of 45° to shistosity. In geological surveying, shists are traditionally divided, depending on the presence of carbonaceous matter, into black and light green species. Mapping along watercourses showed that black and green shists are in close interlayering, but at the same time, separate intervals are distinguished, where various rock species dominate. Pyrite impregnation is established in the shists in the form of scattered layer-by-layer small cubic crystals, as well as globular lenses. The maximum amount of pyrite associates with black shists and is about 5%.

Geochemical sampling of bedding rock and quaternary sediments, followed by computer processing of the results using component analysis, shows the existence of the following successively linked four groups of elements: 1) Cu, Zn, Pb, Bi, Ni, Cr, Sr; 2) Co, Mn, Ti, Sn, Li, Y; 3) B, Nb, Sc, As; 4) Hg, Ag, Mo, P, V. Gold is more inclined to the fourth group. The prospect ampelshorskaya zone of gold ore mineralization is a pod-like ore body with southeastern rock fall at an angle of 50°. The distribution of gold within it and in other neighboring areas is chaotic and so far does not lend itself to a logical explanation. The maximum gold contents set here is 4.5 g/t. Also, the form of gold emissions remains not fully understood. According to the TSNIGRI, it is undoubtedly dispersed, and sulfide minerals or gold-organo-carbon compounds are considered as possible metal carriers.

Since the ampelshorskaya zone of gold ore mineralization is genetically associated with the black shists formation, it is obvious that attention should be paid to the industrial “model” objects of this formation in the Bodaibo region, and, above all, to the largest Sukhoi Log deposit. As is known, in addition to the main stratiform mineralization, a significant part of gold here is associated with quartz vein formations [8,13,14]. According to the mapping data, in the Polar Urals in the ampelshorskaya zone, quartz veins are also widely developed, accounting for up to 40% of the section in separate intervals. However, an assessment of their role in the localization of gold was not carried out. However, the existence of such a connection is quite real and, therefore, the authors attempted to consider some aspects of this problem. Performed full-scale and microscopic observations show that vein bodies are heterogeneous and of different age structures that formed at different stages of change in the host rocks. This is clearly seen in the outcrops, where at least three systems of vein bodies with a capacity from the first centimeters to several meters are recorded. The following is a description of the vein formations, according to the principles of their separation adopted in world practice [10, 15, 16, 17, 18, 19, 20, 21, 22, 23]

3.1. Varieties of veins formations of the ampelshorskaya gold ore zone

1. In relation to the host rock, the veins are divided into concordant (strata) body and cross-cutting ore body. 2. According to morphology, they are simple (tabular) and complex (ladder, branching, knee-curved, lenticular and saddle-shaped). Among those and others, extended and discontinuous (lenticular, clear-shaped), as well as single and close, consisting of a series of subparallel closely spaced bodies are distinguished. 3. According to structural and controlling signs, the vein bodies can be oriented: a) by layering; b) by shistosity, developed subparallel to layering; c) along cracks parallel to the axial surfaces of the folds (main cleavage); d) along cracks diagonal to the axial surfaces of the folds (fan-shaped cleavage); e) along the delamination cracks in the folds (hinges) of the folds (saddle veins). 4. Monomineral-quartz, carbonate-quartz, and polymineral are distinguished by mineral composition. 5. According to the mechanism and staging of the substance deposition, the veins of cavity fulfillment (single-stage quartz, carbonate-quartz) and substitution veins (multi-stage
polyminal) are established. 6) According to the formation time, they are distinguished: a) premetamorphic (concordant); b) metamorphic "alpine type (?)" (Subsynchronous to the occurrence of shists, folding and cleavage processes); c) veins of substitution of a multi-stage long formation. From the point of view of the problem under consideration, polyminal veins of substitution of multistage formation are of most interest. According to morphology, they belong to complex, lensing, often close together bodies, which are characterized by multiple swelling and pinching. According to microscopy, the following stages of their formation are established. Stage 1. Metasomatic chloritization of shists along fracture zones. (Figure 1). Stage 2. Feldspathisation with the development of albite-andesine—labrador association of plagioclases No. 7-55 (Figure 2). Stage 3. The silicification of the previous phases. (Figures 3,4,5). Stage 4. The development of compression deformations with the appearance in

![Figure 1. Chloritization of shists along fracture zones. Thin section, polars crossed, width of view 2 mm.](image1)

![Figure 2. The feldspathic zone of shists in the frontal part of the advancing quartz metasomatism. Deoxidation of plagioclase from andesine labrador to albite is observed as it approaches the sites of silicification. Thin section, polars crossed, width of view 2 mm.](image2)

![Figure 3. Quartz with shadow (relict) textures of shists. Thin section, Plane-polarised light, width of view 2 mm.](image3)

![Figure 4. The same with the shadow structures of plagioclase twins. Thin section, polars crossed, width of view 2 mm.](image4)

![Figure 5. The silicification of chlorite mineralization sites. Thin section, plane-polarised light, width of view 2 mm.](image5)

the vein bodies of cleavage cracks, zones of stylolites, cataclase and slacking. (Figures 6,7,8). Stage 5. The development of tensile deformations, accompanied by crushing of the vein mass with the possible appearance of open cavities. (Figures 9,10). Step 6. Filling the cavities with a sulfide-containing quartz aggregate. The amount and composition of sulfide minerals cannot be accurately estimated, because, due to weathering, they are mainly leached, and their presence in the rocks is evidenced by pore openings of a characteristic shape, as well as rare relict deposits (Figures 11, 12).
Figure 6. Traces of deformations (bending twins) in plagioclases. Thin section, polars crossed, width of view 2 mm.

Figure 7. Stilolitic structures in quartz grains. Thin section, polars crossed, width of view 2 mm.

Figure 8. Traces of dislocations in quartz grains with the development of slitting and cataclase. Thin section, polars crossed, width of view 2 mm.

Figure 9. The fragments of shist and feldspar rock enclosed in the quartz vein body. Thin section, plane-polarised light, width of view 2 mm.

Figure 10. Small fractures in quartz, sometimes partially filled with siliceous material. Thin section, polars crossed, width of view 2 mm.

Figure 11. Tensile structures in the veinlet’s contours with a subparallel orientation of plagioclase-quartz mineral aggregates. In the center, the cross-cutting, filling the newly formed crack, the more “later” quartz vein of the next (sixth) stage of mineral formation, is clearly visible. Thin section, polars crossed, width of view 2 mm.

Figure 12. Relic secretions of copper pyrite. Polar section, 180x.
Given the known patterns of localization of "veined" gold, it is logical to assume that this stage could be accompanied by gold ore mineralization [13, 16, 17, 18, 24]

4. Conclusions
When assessing the gold content of the Kharbei area, the possibility of developing two types of mineralization should be taken into account. One of them (known) is associated with sediments of the black shists formation and belongs to stratiform mineralization. The second (predicted) - confined to the veins. The veins are diverse in mineral composition and formation time. From the point of view of gold content, the most promising are multiminerall veins of substitution of a complex (multi-stage) formation.

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