Typomorphism of Placer Gold and Prerequisites for the Discovery of Gold Ore Occurrences in the Southern Part of the Lena-Anabar Trough (North-East of The Siberian Platform)

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Abstract. The article examines the results of exploratory work carried out in the southern part of the Lena-Anabar trough in the north-eastern part of the Siberian platform. Alluvial deposits of the Polovinnaya river, which belongs to the Uele-Udzhinsky placer cluster, were sampled for predictive assessment of commercial prospects for placer occurrences of gold. The mineralogical-geochemical features of the placer gold were studied in order to identify potential primary sources. It is proved that the Mesozoic and Cenozoic deposits are the main sources of gold. Its typomorphic features are small size (~0.5 mm), toroidal and flake shape, shagreen surface with casts of pressing of the minerals, and high fineness (950-999 ‰). The internal structures of gold particles are represented by thick high-grade shells, translation lines and high-grade intergranular veinlets. Along with this, the discovery of the autochthonous gold of ore habit in the studied gold area suggested the presence of an additional primary source. Very small size (~0.2 mm) and angular-lumpy shapes of the individuals, almost unrounded surface and low fineness are typical features of slightly altered gold. The discovery of small (3-4 mm) fragments of hydrothermal-metasomatic rocks in the alluvium of the Polovinnaya river confirms the above assumption. The epigenetic mineral composition of these fragments is represented by pyrite, potassium feldspar, fluorapatite, and quartz. Micro-X-ray spectral analysis determined the smallest (first microns) mineral phases of native gold, argentite, galena, sphalerite and greenockite in them. It is worth noting that the described fragments are quite fragile, and they are destroyed with a slight impact with a steel needle. The fragility of these fragments indicates the close proximity of the rewashed ore occurrences. In addition, increased gold content in small classes of heavy concentrate material of small-volume samples was determined according to atomic absorption analysis. All this together is a prerequisite for the discovery of ore occurrences with finely-dispersed and fine gold. It is assumed that the ore occurrences can be localized in the Anabar-Eekit fault zone, which extends parallel to the Pronchishchev ridge, through the Anabar-Olenek trough, to the Sololiy uplift of the Olenek arch. In the area of the Olenek arch, this zone is associated with superimposed gold-bearing low-temperature hydrothermal mineralization, expressed by K-feldspathization and sulfidization of the Permian deposits.

1. Introduction

In the north-east of the Siberian platform, the Quaternary complex platinum-gold-diamond-bearing placer occurrences (Uele-Udzhinsky placer cluster) are known within the outcrops of the of the Mesozo-Cenozoic sediments of the Lena-Anabar trough. At the same time, to date, the placer occurrences of
gold have not been studied in detail in this territory and the primary sources that served to form the gold content of modern alluvial deposits have not been identified. We conducted prospecting and revisionary work in the Polovinnaya river basin in order to forecast the commercial prospects of placer gold occurrences.

Изучены минералого-геохимические особенности золота с целью выявления потенциальных коренных источников. The reasonability of the conducted studies is also determined by the localization of placer occurrences with an increased gold content in the zone of influence of the Anabar-Eekit system of deep faults, which, in general, increases the region's prospects for identifying primary sources.

2. Factual material and research methodology
Field work included prospecting geological-geomorphological traverses, heavy mineral concentrate and small-volume sampling of producing facies of modern stream bed alluvium. Samples with a volume of 0.5-3.0 m³, taken from the alluvium of the modern riverbed and the head parts of the Polovinnaya river spit and its tributaries, were washed using a manual screen - "shaker". After washing in "shaker", the material, divided by size classes, was subjected to manual jigging in fine-mesh sieves. The fine fraction of each sample (~1 mm) that accumulated in the shaker tray was completely washed on the wooden pans in order to extract the gold. The chemical composition of gold was determined using the «Cameca» CamebaxMicro microanalyzer, as well as using the «JEOL» OXFORD INCA-sight energy spectrometer. The content of the finely-dispersed gold in the small fractions of the samples was detected by atomic absorption method with the spectrometer iCE 3000 SeriesAAS. Structural etching of gold was carried out according to the well-known method [1] using a reagent: HCl+HNO3+FeCl3+CrO3+ thiourea+water. The revealed internal structures were studied in detail using the NEOPHOT 32 ore microscope and the JEOLJSM-6480LV scanning electron microscope.

3. Geological-structural position
The Uele-Udzhinsky cluster of complex alluvial placers of gold and diamonds of the Quaternary age, which includes the Polovinnaya river basin, covers the interfluve of the same name and is located within the Lena-Anabar trough. As a modern morphostructure, the Uele-Udzhinsky interfluve is a ridge-like sublatitudinal uplift with absolute elevations of 131-172 m above sea level, formed in the neotectonic stage. [2]. It should be noted that according to B. R. Shpunt (1971), the Polovinnaya river basin is located in the zone of influence of the Anabar-Eekit system of deep faults of the Late Paleozoic formation, which can be traced in the north-west direction from the Olenek arch to the Lena-Anabar trough. [3].

Within the studied area, the Jurassic and Lower Cretaceous terrigenous rocks, represented by conglomerates, gritstones, sandstones, siltstones and claystones, are exposed on the day surface. They are overlain by a complex of gravel-sand and loamy rocks of the Pleistocene (Figure 1).

4. Results and discussion
According to 14 small-volume (1-3 m³) samples, the gold content in the streambed alluvium of the Polovinnaya river varies from 0.02 to 1.2 g/m³. The average content of alluvial gold was 0.5 g/m³. It should be noted that in almost all samples in a small amount (3-5 mg/m³), platinum group minerals were found, as well as diamonds with an average content 1,1 carat/m³.

The granulometric composition of gold is: 0.25-0.5 mm-2.5%; 0.1-0.25 mm-65% and -0.1 mm-32.5%. Gold is mainly represented by toroidal (60%), spherical (30%) (Figure 2, a, b) and flake (10%) forms. The surface of the gold particle is shagreen, often with casts of pressing of minerals. In the fraction of -0.1 mm, gold particles of ore habit up to 5% were found (Figure 2, c). Gold fineness is mainly high (900-1000‰)-80%, average (800-899‰)– 8% and relatively low (700-799‰) – 12%. Cu-up to 0.3% and Hg – up to 0.3% were found as impurity elements. The internal structures of the gold
particles are characterized by thick high-grade shells, translation lines and high-grade intergranular veinlets.

**Figure 1.** Diagram of the geological structure of the Polovinnaya river basin: 1-7 deposits: 1 – Bajocian-Bathonian of the Middle Jurassic; 2 – Oxfordian, 3 – Volgian of the Upper Jurassic; 4 – Berriasian, 5 – Valanginian of the Lower cretaceous; 6 – Mid–Upper Quaternary; 7 – modern; 8 – sampling points.

In general, the set of typomorphic features of the main part of the studied gold indicates the distance of its transfer and redeposition from intermediate gold deposits. The latter could be the Jurassic and Cretaceous giotstone and conglomerates, as well as relict watershed pebbles of the Pleistocene age. It should be noted that according to the literature data [3,4,5,6,7], similar gold is widely distributed throughout the Lena-Anabar trough in the basins of the rivers Uele, Buolkalakh, Srednaya, Bilir, etc.

**Figure 2.** The morphology of gold in the Polovinnaya river basin: a – toroidal, b–spherical, c-ore habit.
Meanwhile, B. R. Shpunt and co-authors [3] based on the results of the assay analysis found that the gold content is 15-20 times higher than the results of the heavy mineral concentrate sampling. Based on this, they concluded that a significant part of the gold in the alluvial deposits of the rivers of the Leno-Anabar trough is in a finely dispersed state and is not captured by wooden pan sampling. This conclusion was confirmed. The department of physical-chemical methods of analysis of the DPMGI SB RAS performed 10 determinations of the gold content by atomic absorption method in small-volume samples taken from the channel deposits of the Polovinnaya river. The material for analysis was a heavy fraction of these samples with a size of less than 0.2 mm after the separation of visible gold. As a result of the performed analyses, the maximum gold content was 79.2 g/t. Thus, we have obtained evidence of an increased content of finely-dispersed gold in modern alluvial deposits.

The analysis of archive materials and literature data showed that in the southern part of the Lena-Anabar trough, a zone of tectonic fracturing (crush zone) is localized, which is confined to low-temperature hydrothermal mineralization, expressed by silicification, calcitization and pyritization of unconsolidated Mesozoic strata. [3, 7]. According to the researchers, this zone belongs to the Anabar-Eekit fault system, which extends parallel to the Pronchishchev ridge, through the Anabar-Olenek trough, to the Sololiy uplift of the Oleneck Arch, capturing the basins of the Buolkalakh, Khatygyn-Yuelelete, Kangalas-Yuelelete and Sodiemykha rivers. In the area of the Oleneck arch, a gold-sulfide ore occurrence of the disseminated type, superimposed on the Permian quartz conglomerates is related to this zone [8].

In the light of the above, it is noteworthy that we found small fragments (3-4 mm) of hydrothermal-metasomatic formations with disseminated gold-sulfide mineralization in the alluvium of the middle course of the Polovinnaya river (Figure 3, a). The epigenetic mineral association is represented by pyrite, potassium feldspar, fluorapatite, and quartz (Figure 3, b). In these rocks, micro-X-ray spectral analysis revealed the smallest (first microns) mineral phases of native gold (Figure 3, c), acanthite, galena, sphalerite, and greenockite, that directly proves the presence of ore occurrences (mineralization zones) with finely-dispersed gold in the area. It is reasonable to assume that the increased content of fine gold in the alluvium is due to the washing up of the predicted mineralization zones. It is worth noting that the described fragments are quite fragile, and they are destroyed with a slight impact with a steel needle. Their fragility indicates the close proximity of the washed ore occurrences. Thus, this finding indicates the presence of nearby ore occurrences with finely-dispersed gold, probably associated with the Anabar-Eekite fault zone.

Figure 3. Fragment of a hydrothermal-metasomatic formation: a – general view; b– epigenetic mineral association: Qtz–quartz, Py–pyrite, Fs–potassium feldspar, Fap– fluurapatite; c– very fine gold particle (Au) in association with pyrite (Py) and quartz (Qtz).

5. Brief conclusions
1. The Jurassic, Cretaceous, and Cenozoic deposits were the main sources of placer gold from the Polovinnaya river occurrence and probably most of the modern placer occurrences of the Lena-Anabar trough.
2. Discovery of fragments of hydrothermal-metasomatic formations in the alluvium of the Polovinnaya river and gold particles of ore habit (fraction -0.1 mm), as well as the identification of increased gold content in small classes of heavy concentrate material of small-volume samples according to atomic absorption analysis, it is a prerequisite for the discovery of ore occurrences with finely-dispersed and fine gold, confined to the Anabar-Eekite fault zone. The main conclusions of the study may be presented in a short Conclusions section, which may stand alone or form a subsection of a Discussion or Results and Discussion section.

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