

Au-Ag-Te-Se deposits

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Gold-polymetallic mineralisation of the Il'inskoe ore field, South Urals

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Abstract. The study characterises two gold-polymetallic mineralisation within the Il'inskoe orefield in the South Urals. The Murtykty and Ik-Davlyat deposits are representative of the type and consist of gold-polymetallic sulphide veins, mineralised zones in quartz-sericite-chlorite metasomatic rocks, and linear weathering crusts. Ore formation occurred in several stages as result of orogenic belt development.

Key words: Urals, Il'inskoe ore field, Murtykty, Ik-Davlyat, gold

Introduction

The Urals is the birthplace of the Russian gold mining industry. Gold extraction has been carried out since the 18th Century. Gold-quartz deposits relating to the collisional stage have, for a long time, been the traditional source of gold. Subsequent development of extractive and metallurgical technologies created the prerequisites for the exploitation of a number of less traditional types of gold deposits, including, for example, the iron-rich gossans of gold-rich massive sulphide deposits related to the island-arc stage of Urals evolution.

The Magnitogorsk-Mugodzhary paleo-island arc was active from the Ordovician up until the Carboniferous, and contains different types of gold mineralisation. One of these is the class of gold-polymetallic deposits associated with tholeiitic basalt formations of the island arc stage (Sazonov and Murzin, 1995). The Il'inskoe orefield is both typical

and representative of this type. Numerous small gold-sulphide and gold-quartz-sulphide ore deposits are known here. Prospecting and exploitation in the orefield have continued from the 19th Century. At the present day, exploitation of the deposits is realized by the Bashkirian gold mining company. Hydro-metallurgy processing (cyanidation) is used for extraction of precious metals from mostly oxidized ores.

Geological setting

The Il'inskoe orefield is located in the northern part of the Uchaly ore district, within the area dominated by a broad outcrop of Palaeozoic volcanogenic and sedimentary-volcanogenic rocks (Fig. 1).

The geological sequence includes sodic siliceous-basaltic rocks of the Polyakovskaya Formation (S_1ln_{2-3}), which reflect the oceanic stage of volcanism, the sodic rhyolite-basaltic Karamalytash (D_2e) and Ulutau D_{2gv}

Formations, and the andesite-basaltic Irendyk Formation (D_{1-2e}) which belong to the island-arc stage. Diminishment of volcanic activity is accompanied by formation of volcanogenic sedimentary rocks (Koltuban and Zilair D_{3fr} Formations). The sequence, therefore, shows a coupling of different volcanogenic formations in the local vicinity of the orefield. This is explained by the proximity of the so-called "Ufimsky" Ledge, where paleoceanic structures of the Urals are crushed during collision of East-European and West-Siberian platforms.

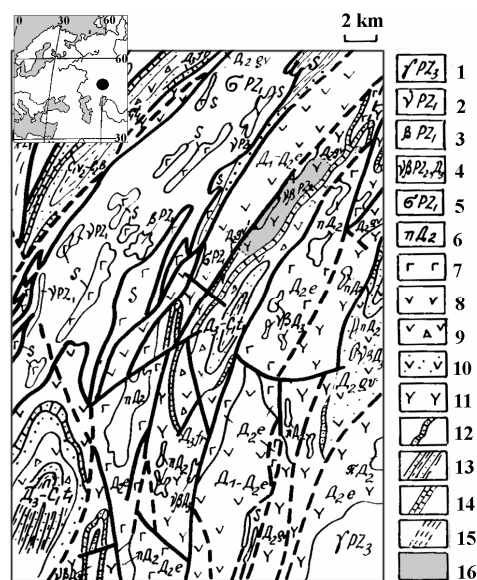


Fig. 1. Geological map of the Uchaly ore district. 1 – granites Pz_1 ; 2 – gabbro Pz_1 ; 3 – diabases Pz_1 ; 4 – gabbro-diabases Pz_2 ; 5 – ultrabasites Pz_1 ; 6 – dacites and rhyolite-dacites D_2 ; 7 – basalts; 8 – andesites; 9 – volcanic breccia; 10 – volcanomict sandstones; 11 – volcanic rocks basalt-andesite-rhyolite-dacite series; 12 – jaspers; 13 – sandstones, aleurolites, shales; 14 – limestones; 15 – metamorphosed sedimentary rocks; 16 – Il'inskoe orefield

The structure of the orefield is characterised as an alternation of a series of narrow tectonical zones divided by faults. The volcanic rocks feature high-angle dips; linear folds are widespread. Within the orefield, there

are a number of gold deposits, such as Murtykty and Ik-Davlyat, as well as numerous lesser occurrences.

The Murtykty deposit

The Murtykty deposit consists of three zones: Intermediate, West, and East. The geological section in the Intermediate zone of the Murtykty deposit includes metabasalts and volcanomictic sandstones, usually transformed to schists and metasomatic rocks with carbonate-quartz-chlorite-sericite and quartz-sericite compositions (Fig. 2). The relationships between the different rock types are complicated, with gradual contacts and facies transitions.

Alteration styles recognised in the rocks include pyritisation, silicification, sericitisation, carbonatisation and chloritisation. Tourmalinisation of the rocks is observed sporadically, but it is of considerable importance in the East zone, where massive tourmalinite bodies and quartz-tourmaline veins are known. The vein complex is represented by 3 types of veins and veinlets: (1) quartz-(carbonate)-sulphide (2), quartz, and (3), carbonate-quartz.

The orebodies consist of narrow mineralised zones; borders of the orebodies are determined by sampling. Average contents are 5.1 g/t Au and 17.1 g/t Ag. Gold-bearing sulphide ores can be subdivided into 3 types:

- 1) Disseminated pyrite, sphalerite-pyrite fine- to medium-grained ores in the chloritized basalts.
- 2) Banded polymetallic (sphalerite-chalcoppyrite) sulphide ores in chloritized volcanomictic sandstones.
- 3) Sulphide-bearing quartz-carbonate veins.

In addition, small lenses of massive pyrite are also found.

The main ore minerals are pyrite and sphalerite; chalcoppyrite and galena are only of minor importance. Covellite, chalcocite, tennantite, altaite, arsenopyrite, Au-Ag tellurides, native gold and Pb-sulphosalts have been determined as scarce components of the ore. 'Schirmerite' has been mentioned in isolated

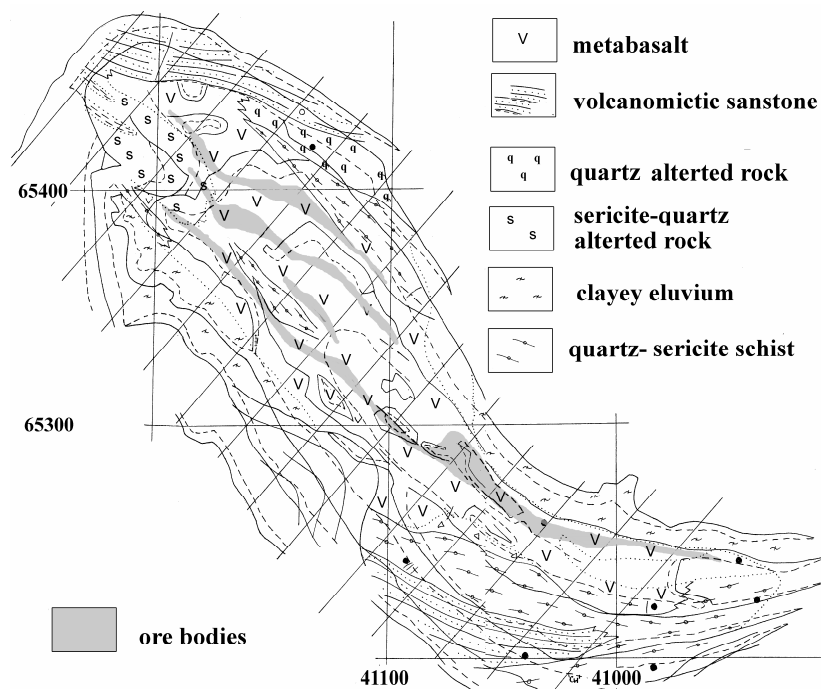


Fig. 2. Intermediate zone of Murtykty deposit (within open-pit frame)

instances (Bachtina, 1985), as impregnations within native gold.

The greater part of the precious mineralisation is associated with the late polymetallic stage. Native gold and electrum form anhedral and interstitial impregnations, rims and tabular-shaped inclusions within sulphide minerals. Rarely, they form secant veinlets.

Altaite is most widespread telluride in the ore. It forms anhedral inclusions in pyrite, rims on the chalcopyrite-sphalerite borders, intergrowths with Au/Ag tellurides and anhedral to subhedral spots in galena (Fig. 3). Gold-(silver) tellurides form very finely intergrown structures and have been observed in galena and sphalerite (Bachtina, 1985). Frequently they outline zonation patterns within pyrite crystals. Intergrowths of different telluride phases are widespread. Only calaverite was identified with confidence; krennerite and petzite are probably also present.

The Ik-Davlyat deposit

Ore mineralization is related to (1) quartz-sericite-chlorite metasomatic rocks and (2) secant veins with different trends. Intersections of veins lead to the formation of bonanza ores with extremely high contents of gold (up to 1.5 kg/t). Typical vein ores consist of quartz-illite, feldspar-quartz-illite clayey rocks with fragments of vuggy quartz. Cerussite, a Pb-bearing mineral of the jarosite group, native gold and rutile were discovered in the heavy concentrates of the ores. Gold-bearing quartz-sericite-chlorite metasomatites contain considerable amounts of chalcophanite. Native gold forms plate-shaped particles, and dendrites (Fig. 4). Silver contents in the native gold are estimated as about 6-7 wt. %.

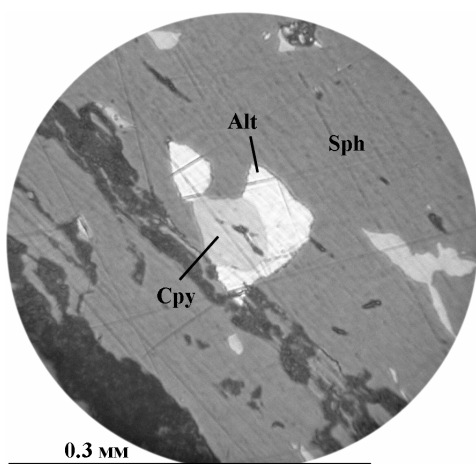


Fig. 3. Inclusion of altaite (Alt) in sphalerite (Sph). Cpy – chalcopyrite. Reflected light

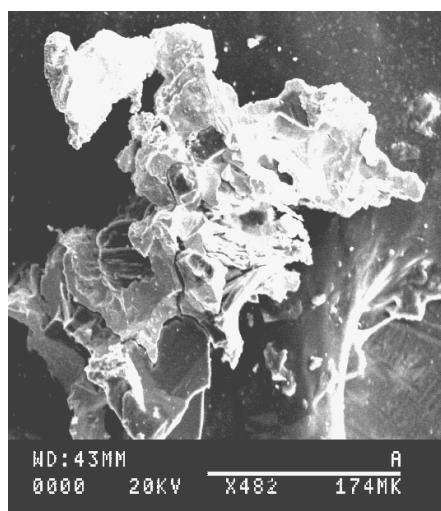


Fig. 4. SEM image of native gold from the Ik-Davlyat deposit

Conclusions

Rapid evolution of ore formation conditions is a distinct feature of deposits located in orogenic belts. Development of volcanism led to changes in the parameters of ore deposition. As a result superposition of different ore-forming situations observe in the frame one ore field.

In parts of the Il'inskoe ore field, for example the massive pyrite lenses of the Intermediate zone, ores were formed at conditions specific to deposition on the ocean floor. The polymetallic ores are related to the intrusion of subvolcanic bodies D₂gv (Bachtina, 1985). Temperatures of ore formation are estimated as beginning at 350-410°C, and 175-125°C towards the end (pyrite-sphalerite stage with deposition of Au-Ag mineralisation). Sulphur isotope ratios in galena-sphalerite pair was used as a geological thermometer (Bachtina, 1985); no fluid inclusion data are available. Thus, a transition from mesothermal to epithermal conditions is believed to have taken place. The influence of collisional granites occurs in the East zone where tourmalinisation is of importance.

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