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Au-Te Mineralisation of Sentyabr'sky Gold Deposit, Northeastern Russia

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1 Introduction

Epithermal gold deposits, where significant gold is chemically bonded to tellurium, rather than occurs as native species are frequently referred to the special Au-Te type (Head *et al*., 1987). Owing to high grade of gold in the ores, such deposits are of great interest.

In the northeastern Russia, the Au-Te epithermal deposits are known only from the Cenozoic volcanic belts of the Kamchatka Peninsula. This type deposits were not identified in the Cretaceous Okhotsk-Chukchi volcanic belt (OCVB) until recently, where the largest low-sulphidation Au-Ag deposits (Kupol and Dvoinoi) were discovered. Therefore, the Au-Te mineralization found at the explored Sentyabr'sky deposit, Ilirnei ore district is economically important.

2 Geological Setting

The Sentyabr'sky depositt is located in the Ilirnei ore district on the Upper Rauchua and Ilirneiveem.

The Vodorazdel'nyi gold cluster comprising the Dvoinoi and Sentyabr'sky deposits is spatially related to the volcano-tectonic structures of the Central Chukchi Zone of OCVB. The Sentyabr'sky deposit is located in the intrusive dome structure of the same name superimposed on the Ilirnei collapsed volcanic structure (caldera). The geological scheme of the deposit is shown in Fig 1. The area comprises the Early Cretaceous volcanic rocks of the Tytyl'veem Formation (K_1*tt*). In the central part, volcanic sequence is intruded by quartz monzonite ($q\mu_1K_2$*il*) and granodiorite ($\gamma\delta K_2$*il*) referred to the Late Cretaceous Ilirnei Complex of subalkaline granites. Volcanic rocks are also intruded by numerous dykes of the Ilirnei syenite (ξ_2K_2*il*) and porphyry granite (γ K_2*il*), and rhyolite bodies of the Early Cretaceous Tytyl'veem Complex (K_1*t*).

Wall-rock alteration is propylitic, silicific, sericitic, and argillic. Hydrothermally altered rocks occur as isometric or extended alteration zones 0.5 to 5.0 sq. km.

The mineralization is controlled by steep north-west and near-meridional striking faults. The orebodies at the prospect are veins, and veinlet and vein zones, which cut the Ilirnei quartz monzonite, andesite and basaltic andesite of the Tytyl'veem Formation. The veins are composed of quartz, sericite, adularia and chlorite.

3 Mineralogy of Gold Ores

Two economic ore types are recognized at the Sentyabr'sky deposit: (1) Au-Ag-As impregnation, veinlet, and vein; and (2) Au-Ag-Te vein.

Three major successive mineral assemblages were identified in the ores of the Sentyabr'sky deposit (from early to late): pyrite-arsenopyrite, base-metal, and gold-silver-telluride.

The minerals of the gold-silver-telluride assemblage (Fig. 2) that is dominated by petzite, hessite, altaite, and coloradoite overgrow or replace minerals of the base-metal assemblage. Gangue minerals are quartz, ankerite, Fe-rich dolomite, calcite, muscovite-phengite, and chamosite.

Petzite replaces minerals of hessite + native gold assemblage (Fig. 2a). In these clusters, the proportion of petzite reaches 20-50%. Native gold was found in aggregates of telluride minerals. The gold fineness is 832-853.

4 Fluid Inclusions

At room temperature, the fluid inclusions from quartz and sphalerite at the Sentyabr'sky deposit are divided into

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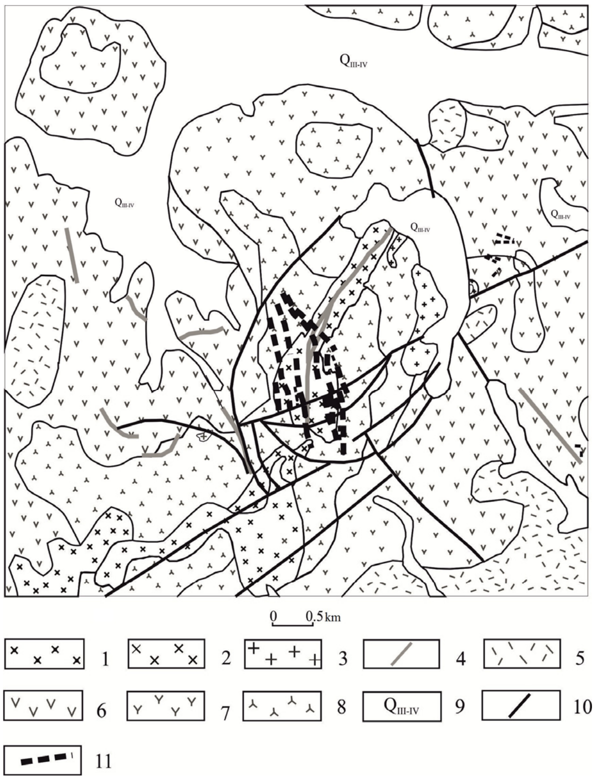

Fig. 1. Geological scheme of the Sentyabr'sky deposit.
(1-4) Intrusive rocks of the Late Cretaceous Ilirney Complex: (1) quartz monzonite, (2) granodiorite, (3) porphyry granite, (4) dykes of porphyry granosyenite; (5) rhyolite subvolcanic bodies of the Tytyl'veem Complex; (6-8) Tytyl'veem Formation: (6) lower subformation, andesite and basaltic andesite, (7) middle subformation, rhyolite, dacite, and their tuff, (8) upper subformation, andesite, its clastic lava and tuff; (9) Quaternary; (10) faults; (11) quartz veins and zones of quartz veinlets.

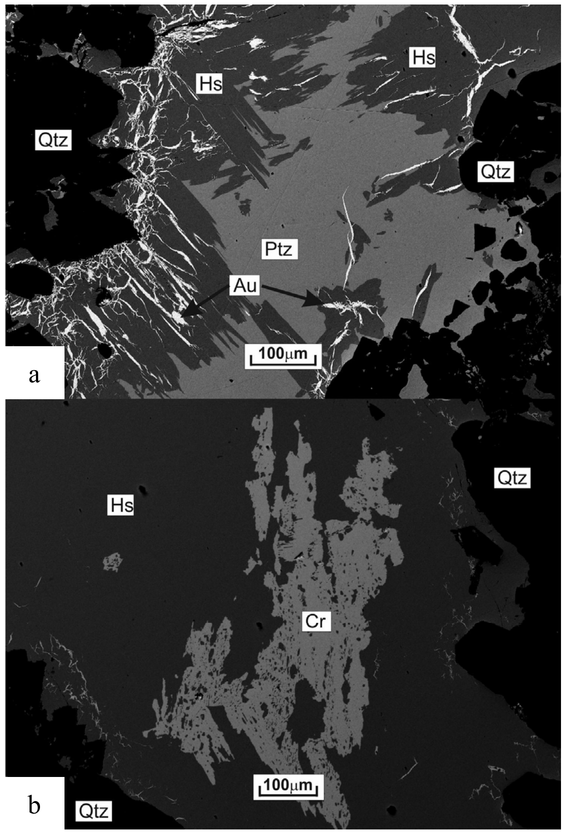

Fig. 2. BSE images of Au, Ag, and Te minerals of the Sentyabr'sky ores: (a) petzite is replacement of minerals association hessite+native gold, (b) coloradoite and hessite.
Ptz – petzite, Hs – hessite, Cr – coloradoite, Ag – native gold, Qtz – quartz. Scale bar 100 mkm.

two types: (1) gas-dominated with occasional CO_2 upon freezing and (2) two phase fluid inclusions, which are both primary and secondary. The second- and first-type inclusions are frequently syngenetic testifying to immiscible initial fluid.

Fluid inclusions have been studied in double polished plates with a THMSG-600 'Linkam' freezing/heating stage at IGEM RAS. Precision at low temperature (cooling) was about 0.1°C and about 1°C at high temperature (heating). Salinity was estimated from final ice melting temperature. A pressure was determined using the syngenetic gas-dominated and aqueous inclusions trapped from immiscible fluid.

The primary and pseudosecondary two-phase inclusions of the second type from quartz and sphalerite homogenize into liquid at 360-213°C and contain aqueous solution with salinity 8.1-0.9 wt.% NaCl equiv. The density of the fluid is 0.58-0.90 g/cm^3.

The primary gas-dominated inclusions of the first type syngenetic to the second-type aqueous inclusions and occasionally containing CO_2 (density 0.32-0.23 g/cm^3) homogenize into gas at +23.6 to +29.3°C. The homogenization temperature 295°C is identical to that of the second-type syngenetic primary inclusions. The pressure during fluid immiscibility was 270-180 bar.

5 Discussion

Geological structure, metasomatic rocks, and ore mineralogy indicate that the Sentyabr'sky deposit is related to the porphyry-epithermal system (Simmons *et al.*, 2005). The ore mineralogy corresponds to the IS type of Silitoe and Hedenquist (2003).

The assemblage of Te minerals identified in the Sentyabr'sky ores is typical of many Au-Te epithermal deposits. However, various Au tellurides are characteristic of the ores from these deposits, whereas only one Au telluride petzite was found in the ores of the Sentyabr'sky deposit. At the same time, according to computation, 40-70% Au in the Au-Ag-Te ores at the Sentyabr'sky deposit occur as petzite. It is probable the new type of the Au-Te mineralization transitional from shallow- to deep-seated ores.

According to fluid inclusion data, the Sentyabr'sky ores started to precipitate at higher temperature (about 300^{o}C) than low-sulphidation Au-Ag mineralization of the Dvoinoi deposit (257^{o}C, after Prokofiev et al., 2012). Based on mean gradient of hydrostatic pressure (100 bar/km), the Sentyabr'sky ores can be formed at the depth ca. 1 km.

The salinity of mineralizing fluids of the Sentyabr'sky and Dvoinoi deposits is dramatically different. A similar picture is seen at the Au-Ag and Au-Te epithermal deposits (Simmons *et al*., 2005).

The Au-Ag-Te mineralization of the Sentyabr'sky deposit and low-sulfidation Au-Ag mineralization of the Dvoinoi deposit are resulted from different hydrothermal fluids, which are related to the different phase of magmatic activity. The Sentyabr'sky deposit was formed as a part of multistage porphyry-epithermal system with different types of mineralization and the transition of epithermal to porphyry mineralization with depth is suggested. According to classification of Silitoe (2010), the Sentyabr'sky deposit may be referred to the subepithermal type.

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