The Prospects of Expanding the Raw Materials Source of Gold-Silver Ore Occurrence in Sentyabrskoe SV (Chukotka Autonomous Area)

A A Grebennikova¹, G R Sayadyan¹

¹Far Eastern Geological Institute, Vladivostok

E-mail: anylotina@mail.ru

Abstract. The Chukotka autonomous area of Russia holds one of the leading positions in Russia in the gold mining. Various formational types’ deposits are known to this region. Among the most industrially interesting types are bonanza gold-silver sites in Kupol, Dvoinoye, Sentyabrskoe and many others. This article studies the prospects of extending the raw materials’ source of the gold-silver ore occurrence in Sentyabrskoe on the basis of its comparison with the known sites of this type.

1. Introduction

The Chukotka autonomous area of Russia holds one of the leading positions in Russia in the gold silver mining. Numerous gold and silver deposits and occurrences were found here in the volcano-plutonic belts [1, 6]. The increasing extraction of gold and silver is first of all related to the progress of the exploration of the volcano-plutonic belts which are proposedly rich in bonanza gold and silver ores. We are speaking of such sites as Kubaka, Kupol, Valunisty, Dvoinoye and many others [1, 6]. The extraction of metals from such deposits proves to be profitable even in the hard-to-reach areas of the Northeast of Russia.

One of the most significant epithermal and bonanza gold-silver sites is a world class deposit “Kupol” [1, 6] exploited by the Canadian company “Kinross”.

The ore occurrence Sentyabrskoe, one of the prospective gold-silver sites, is situated 70 km away from the Kupol deposit and 10 km away from the Dvoinoye deposit. Some researchers see this site as a great example of the “bonanza” type having an uneven distribution of the precious metals (Au и Ag) [2, 4]. These facts render this research as well as the determination of the typical mineral-geochemical particularities of the gold-silver ore occurrence Sentyabrskoe important and timely. This site’s comparison to the biggest deposits of Chukotka – Kupol and Dvoinoye – is also of great significance.

Within the Ilirneyskay ore area, at the upper reaches of the Rauchua and Ilirneyveem rivers an ore cluster Vodorazdelny was distinguished. It includes sites that were already contoured: the Dvoinoye deposit, ore occurrence Sentyabrskoe and many others [2, 4].

2. Research object

The ore occurrence Sentyabrskoe is located in the eastern margin of the volcanic dome which relates to the western part of the Ilirneyskay volcano-tectonic early collapse of the formation structure (texture) of the Central Chukotka zone’s Okhotsk-Chukotka volcanic belt. This region is composed of
the Upper Cretaceous volcanites of the Tytylveem suite that is a part of the andesite-rhyolite volcanic complex of the same name. The Tytylveem suite’s deposits consist of the alternating andesite flows, rhyolite tuffs, andesite-basalts, average composition tuff beds, dacite volcanic breccia, tuff sandstones, tuff argillites and conglomerates. Volcanites are erupted in the form of comagmatic extrusive andesites composed of explosive breccia (Figure 1) and, probably, of diorite dikes and subvolcanic rhyolites [4].

Figure 1. Schematic geological map of the September ore field (modified from Zhuravlev, 1999; Savva et all, 2016).

Ore bodies of the ore occurrence are present in the vein-veinlet zones, that cut the quartz monzonites of the Ilirney complex, andesites and andesite-basalts of the Tytylveem suite. The mineralization is controlled by the high-angle faults of the NW and submeridianal strike [2].

The Sentyabrskoe SV deposit’s ore bodies’ morphology is determined by laying the ore mineralization onto explosive and tectonic breccia containing clasts of various composition (andesite tuffs, andesite-basalts) [2, 4].

3. Results and discussion
The gold-quartz-polymetallic mineralization that we have studied develops mainly along the cement of the tectonic breccia. The vein minerals of the mineralized breccia matrix include quartz, calcite, sericite and carbonate. Galena, sphalerite, pyrite, chalcopyrite, hessite and native gold are among the main ore minerals (Table 1).

For our investigation we used such methods as: X-Ray micro-spectral analysis at the four-channel microanalyzer JXA 8100(the analyst: Molchanova G.B.), and microscopy at the Axioplan 2 microscope.

Galena – forms 2 to 600 μm single-crystal or monomineralic aggregate impregnation. Galena is found intergrown with sphalerite, chalcopyrite, hessite and pyrite. It forms different size inclusions inside the latter. Chalcopyrite’s rim in some cases is composed of galena. The native gold is most often fixated in galena in the crystallized rounded form.

Sphalerite – forms 50 to 800μm either erratic or idiomorphic crystals. It intergrows with galena, chalcopyrite and pyrite and contains inclusions of native gold intergrown with chalcopyrite and its emulsion insets. Common sphalerite impurities include Cd-0.67-1.19 mass %, Fe-0.56-1.95 mass % and Cu- 1-3.94 mass %.
Pyrite – forms differently shaped insets in the quartz mass. Three pyrite generations are distinguished. Generation I pyrite has a darker color and is segregated in the form of a solid cataclastic mass. No impurities were found in it. Generation II pyrite is represented by idiomorphic crystals without impurities and is observed intergrown with sphalerite, galena and chalcopyrite. Its common inclusions are native gold, hessite and galena. Generation III pyrite forms idiomorphic crystals of heterogeneous bright colouring compared to generations I and II pyrite. It contains an impurity of As -3.2 mass %.

Chalcopyrite – forms 5 to 200 μm allotriomorphic grains. It is found intergrown with pyrite, galena and petzite in sphalerite (Figure 2 b, d). Chalcopyrite sometimes forms aggregates and microveinlets in sphalerite. Thin rims of galena are also common around chalcopyrite’s grains.

Native gold – forms separate inclusions in quartz and is a widely spread mineral. Its grains have a crystalline, elongated, rounded form or a form of microveinlets. The grains’ size is 5 to 50 μm. Native gold’s inclusions in galena, sphalerite and pyrite were also observed (Figure 2 c, d). Generally native gold contains Au -79.07-79.72 mass % and Ag -20.68-20.15 mass %. With the impurities of Te it contains Au-53.66 mass % and Ag-31.31 mass %. It may also contain Te – 8.64 mass %.

Hessite Ag₂Te – a rare mineral that forms separate inclusions and is intergrown with galena in pyrite (Figure 2 a). Inclusions’ size is 1-6 μm. An impurity of gold - 3.56 mass % - was also found in it.

Consequently, we have the following model of crystallization of minerals: pyrite→sphalerite→galena→chalcopyrite→hessite→native gold.

4. Conclusion

To sum up, from our data it can be concluded that

1) Gold-silver epithermal ore occurrence Sentyabrskoe SV characterized by typical mineral composition (quartz, calcite, sericite, carbonate, native gold, petzite, hessite and other), large grains of native gold; geological structure and age of the rock.

2) All the studied gold-silver epithermal deposits (Sentyabrskoe SV, Kupol, Dvoynoy) characterized are typomorphic features (similar mineral composition, geological structure and age of mineralization) (Table 1).

3) From our data it can be concluded that the Sentyabrskoe SV ore occurrence is industrially promising for the gold mining and for exposing new ore zones at this site and can be advised for further exploration.

4) Finally, the obtained data can prove useful in forecasting and searching for new epithermal gold-silver sites both on Chukotka and in the whole of Russia.

Figure 2. The character of inclusions of gold, tellurides of Au and Ag with sulfides in the mineralized tectonic breccia. A. Hessite micrograins in pyrite. B. Petzite-chalcopyrite intergrowth in sphalerite. C. Gold micrograins in galena-sphalerite intergrowth. D. Gold and chalcopyrite micrograins in galena. Sp-sphalerite, Chal-chalcopyrite, Ga-galena, Py-pyrite Hs-hessite, Au-native gold.
Table 1. Type features’ comparison of the gold-silver epithermal deposits of the Okhotsk-Chukotka volcanic belt.

| Deposit            | Kupol                  | Dvoinoye               | Sentyabrsksoye SV     |
|--------------------|------------------------|------------------------|-----------------------|
| Belt               | Okhotsk-Chukotka       | Okhotsk-Chukotka       | Okhotsk-Chukotka      |
|                    | volcanic belt          | volcanic belt          | volcanic belt         |
| Mineral type       | Au-Ag epithermal       | Au-Ag epithermal       | Au-Ag epithermal      |
| Mineralized rocks  | Andesites, andesites-dacites, rhyolites and tuffs | Andesites, their tuffs and volcanic breccia | Andesites, andesite-basalts, tuff rhyolites and tuffs and volcanic breccia |
| Mineralization age (mln years) | 88 – 89                | 88 – 87               | 90–100                |
| Ore bodies’ morphology | Veins, explosive breccia | Vein-veinlet           | Veins, explosive breccia |
| Ore textures       | Collomorphic-banded, veinlet-vein, breccia, cocarde | Collomorphic-banded, spotted, unclear banded, breccia | Collomorphic-banded, vein, breccia, cocarde  |
| Vein minerals      | Quartz, chalcedony, moonstone, carbonate | Quartz, moonstone, calcite | Quartz, moonstone, chlorite, sericite, carbonate, native gold |
| Ore minerals       | Sulfide (pyrrhotite, arsenopyrite, pyrite, galena, sphalerite, chalcopyrite), acanthite, Ag-Sb and Fe-Sb sulfosalts, intermetallics, Au-Ag sulfide and native gold. | Sulfide (pyrite, pyrrhotite, sphalerite, galena, chalcopyrite), pyrargyrite, acanthite, fahlorea, hessite, pearceite, japaite, electrum and native gold. | Sulfide (sphalerite, galena, pyrite, chalcopyrite, hessite, petzite, acanthite, fahlore and native gold. |
| Fineness of gold, %| 700–1000, 250–700, 100–250, 0–100 | 670–820               | 620–820, 830–850, 860–870 |

NB: Kupol data – Savva and others [3], Sakhno and others [5]; Dvoinoye data – Volkov and others [6], Sakhno and others [5]; Sentyabrsksoye data – Savva and others [4], our dates, Sakhno and others [5]

References
[1] Goryachev N A, Volkov A V, Sidorov A A, Gamyznin G N, Savva N E and Okrugin V M 2010 Au-Ag mineralization of volcanic belts of North-East Asia Lithosphere 36–50
[2] Nikolaev Iu N, Prokofiev V Iu, Apletalin A V, Vlasov E A, Baksheev I A, Kalko I A, Komarova Ia S 2013 Gold-Tellurium mineralization of the western Chukotka: mineralogy, geochemistry and formation conditions Geology of ore deposits 55 114-144
[3] Savva N E, Palianova G A, Byankin M A 2012 To the problem of sulfide and selenide genesis of gold and silver at the Kupol deposit (Chukotka, Russia) Geology and geophysics 53 597-609
[4] Savva N E, Kolova E E, Fomina M. I, Kurashko V V, Volkov A V 2016 Gold-polymetallic mineralization in explosive breccia: mineral and genetic aspects (Sentyabrskoe SV deposit, Chukotka) Herald of NESC FEB RAS 16-36

[5] Sakhno V G, Grigoriev N V, Kurashko V V 2016 Geochronology and isotopic geochemical features of magma complexes of the gold-silver ore magmatic structures of the Chukotka sector of the Arctic coast of Russia Proceedings of RAS 468 297-303

[6] Volkov A A, Goncharov V I, Sidorov A A 2006 Chukotka’s gold and silver deposits (M.: IGOD RAS; MAGADAN: NECRI FEB RAS) p 221

Acknowledgements
The authors would like to thank V.V. Kurashko and N.V. Grigoriev for the samples and factual materials. This research was carried out with the partial support from Russian Foundation for Basic Research by grant № 16-05-00283 and the project of FEB RAS 18-2-001.