Ore Geology Reviews 85 (2017) 247–270

Contents lists available at ScienceDirect

Ore Geology Reviews

journal homepage: www.elsevier.com/locate/oregeorev

Listvenite-related gold deposits of the South Urals (Russia): A review

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ARTICLE INFO

Article history:
Received 9 September 2015
Received in revised form 31 October 2016
Accepted 11 November 2016
Available online 24 November 2016

Keywords:
Orogenic gold
South Urals
Oxygen isotopes
Listvenite
Fluid inclusions

ABSTRACT

The Urals is a complex fold belt, which underwent long geological evolution. The formation of most gold deposits in the Urals is related to the collision stage. In this paper, we review some relatively small listvenite-related gold deposits, which are confined to the large Main Uralian fault zone and some smaller faults within the Magnitogorsk zone. The Mechnikovskoe, Altyn-Tash, and Ganeevskoe deposits are studied in detail in this contribution. They comprise the ore clusters along with other numerous small gold deposits, and constituted the sources for the gold placers exploited in historical time. The gold is hosted by metasomatites (listvenites, beresites) and quartz veins with economic gold grades (up to 20 g/t Au). Listvenites are developed after serpentinites and composed of quartz, fuchsite, and carbonates (magnesite, dolomite) ± albite. Volcanic and volcanoclastic rocks are altered to beresites, consisting of sericite, carbonates (dolomite, ankerite), quartz and albite. Pyrite and chalcopyrite are major ore minerals associated with gold; pyrrhotite, Ni sulfides, galena, sphalerite, arsenopyrite and Au-Ag tellurides are subordinate and rare. Gold in these deposits is mostly high-fineness (>900‰). The lower fineness (~800‰) is typical of gold in assemblage with polymetallic sulfides and tellurides. The ores have been formed from the $NaCl–CO_2–H_2O \pm CH_4$ fluids of low (~2 wt% NaCl-equiv.) to moderate (8–16 wt% NaCl-equiv.) salinity at temperatures of 210–330 °C. The oxygen isotopic composition of quartz ($\delta^{18}O$) varies from 14.7 to 15.4‰ (Mechnikovskoe deposit), 13.2 to 13.6‰ (Altyn-Tash deposit) and 12.0 to 12.7‰ (Ganeevskoe deposit). The oxygen isotopic composition of albite from altered rocks of the Ganeevskoe deposit is 10.1‰. The calculated $\delta^{18}O_{H2O}$ values of the fluid in equilibrium with quartz are in a range of 5.7–6.3, 4.2–4.6 and 6.3–6.7‰ respectively, and most likely indicate a magmatic fluid source.

1. Introduction

Gold mining in the Urals started in the second half of the 18th century and it is still active (Sazonov et al., 1999). The earliest record on gold production goes as early as the Bronze Age (Zaykov et al., 2012). More than 1000 t of gold have been extracted in the Urals during 250 years of mining, half of which was mined in the South Urals. Extraction of placer gold brought a well-deserved honor to the South Urals gold-bearing province. At present, gold in the South Urals is mostly a by-product of massive sulfide deposits mining. However, relatively large Bereznyakovskoe, Kochkar and Svetlinskoe gold deposits in Chelyabinsk district are also being mined. The South Urals resource base also includes numerous small sub-economic lode gold deposits, which were the major sources for gold placers. Some of them are associated with specific metasomatic rocks (listvenites).

In the Russian scientific literature dedicated to Urals, most attention was traditionally paid to the large gold deposits (Sazonov et al., 1999; Kisters et al., 1999; Kolb et al., 2000; Bortnikov, 2006), and deposits with atypical geological setting or debatable genesis (Murzin et al., 2001, 2002; Spiridonov and Pletnev, 2002; Murzin and Shanina, 2007; Znamensky and Michurin, 2013; Plotinskaya et al., 2009). Numerous small deposits, which are located within the Main Uralian fault (MUF) zone and smaller regional faults, were mostly studied in the first half of the 20th century (see review in Znamensky, 2009) and later on were almost completely ignored by researchers, although listvenite occurrences with gold deposits are traced along the entire MUF zone. The results of their previous studies of this specific deposit type are scattered in unpublished exploration reports and briefly summarized in the Russian publications (Sazonov et al., 1999; Znamensky, 2009).

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http://dx.doi.org/10.1016/j.oregeorev.2016.11.008
0169-1368/

Listvenites and associated quartz–sericite–carbonate metasomatites (beresites) are the alteration products of ultramafic and mafic (in less extent, intermediate to felsic) rocks, respectively. The process of alteration occurs under influence of CO_2- and S-rich fluids (Sazonov, 1998; Zharikov et al., 2007). Listvenites are mainly composed of quartz, carbonates (dolomite and magnesite), sericite (fuchsite or mariposite) and pyrite (Fig. 1a–e). The other alteration assemblage is made up of quartz, carbonates of dolomite–ankerite series, sericite, albite and pyrite (Fig. 1f).

The term "listvenite" was proposed by Gustav Rose in 1837 for the green rocks from the lode gold deposits of the Miass ore region. Its root is based on the Russian name for a larch tree (Rose, 1837). The term "beresite" was described for the first time at the Berezovskoe gold deposit in the Central Urals and its name derives from the deposit's name. Previously, the terms "listvenite" and "beresite" were used mostly in Russian geological literature (e.g., Kashkay and Allakhverdiev, 1965; Sazonov, 1998; Obolensky and Borisenko, 1978). Over the last years, these terms became also common in English geological literature, but "beresite" occurs rarely and its definition is contradictory (Ash and Arksey, 1990; Zharikov and Zaraisky, 1991; Halls and Zhao, 1995; Botros, 2004; Baksheev and Kudryavtseva, 2004; Yaghubpur and Abedi, 2005; Yigit, 2006; Zoheir and Lehmann, 2011). Nevertheless, these terms were recommended for usage by the IUGS Subcommission on the Systematics of Metamorphic Rocks (Zharikov et al., 2007).

Gold in these metasomatic rocks occurs as inclusions in pyrite (refractory gold), metasomatites or selvage of carbonate–quartz veinlets and veins (Fig. 1d). Gold-bearing quartz, quartz–carbonate or quartz–albite veins are typical constituents of listvenites (Fig. 1b–d).

It is commonly accepted that granitic magmatism is responsible for the formation of most productive listvenite-related gold deposits (Buisson and Leblanc, 1986; Sazonov, 1998; Likhoidov et al., 2007). However, some deposits are not spatially associated with granitic plutons or their size is rather small. For example, the Au-bearing listvenites in the Iranian metaophiolites are regarded as a result of metamorphic dehydration and decarbonation reactions of the oceanic crust at the amphibolite–greenschist facies (Aftabi and Zarrinkoub, 2013).

The lode gold deposits in listvenites are known in the suture zones of Russia, Iran, Turkey, Egypt, Morocco, Ireland, Canada and other countries (e.g., Buisson and Leblanc, 1986; Aydal, 1990; Halls and Zhao, 1995). The largest deposits are situated in the Barramiya–Um–Salatit ophyolite belt in Egypt, where they have been exploited for a few thousand years since the Pharaoh Period. The El Barramia and some other deposits are of economic interest (Zoheir and Lehmann, 2011). Several large listvenite-related gold deposits with ore reserves of 1–2 Mt and Au grades of 3–5 g/t are known in the Atlin ore district, Canada (Ash and Arksey, 1990; Hansen et al., 2005). In Russia, gold deposits in listvenites are mostly small. For example, the resources of the Khaak-Sair deposit in West Sayany (Siberia) are ~18 t (mean of 2 g/t with a range from 0.5 to 57 g/t Au) (Kuzhuget et al., 2015).

In this paper, we review the small subeconomic listvenite-related gold deposits of the South Urals. The interest in these deposits is twofold: first, they constitute the sources of gold for the rich gold placers, and, second, their features reflect the metallogenic potential of large tectonic zones. The ore bodies at these deposits are mostly localized in collision structures (Sazonov et al., 1999; Znamensky, 2009). Granitic intrusions within the deposits are either unknown or rather small. These features are also typical of other deposits mentioned in the paper, allowing us to consider them as orogenic-style deposits (cf., Groves et al., 1998). Taking into account their importance for the resource base of the South Urals and ambiguous genesis, the aim of our work is to review the mineral composition of ores and metasomatites, and to establish the formation conditions and fluid sources for these deposits. These features may be specific to the processes related with the late subduction and/or early collision stages (Puchkov, 2016; Herrington et al., 2005; Kisters et al., 1999). The specific features of these deposits are then compared with large deposits, the origin of which is related to the gabbro–tonalite–granodiorite–granitic magmatism of the Main Plutonic Axis of the Urals (cf., Fershtater et al., 2007, 2010; Fershtater, 2013).

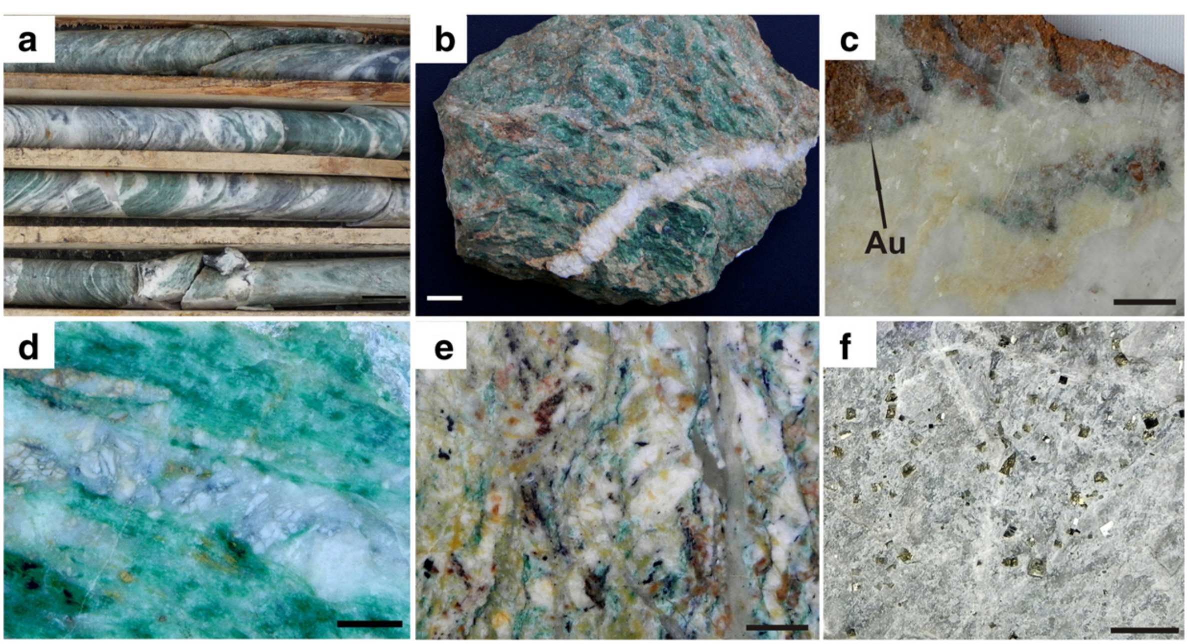

Fig. 1. Gold-bearing listvenites and beresites from the South Urals deposits: a – alternation of schistose listvenites and beresites with quartz veins; b – listvenite with zonal carbonate–quartz vein; c – free gold in oxidized listvenite near calcite–quartz vein; d – listvenite with quartz–albite vein; e – albite-bearing listvenite with quartz vein; f – beresite. Scale bar: a – 5 cm, b–f – 1 cm. Photos: a – Altyn-Tash deposit, b, d – Miass ore field; c – Mechnikovskoe deposit; e, f – Ganeevskoe deposit.