Ore Geology Reviews 59 (2014) 55–65

Contents lists available at ScienceDirect

Ore Geology Reviews

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

The Kuranakh epithermal gold deposit (Aldan Shield, East Russia)

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ARTICLE INFO

Article history:
Received 2 May 2013
Received in revised form 2 December 2013
Accepted 9 December 2013
Available online 13 December 2013

Keywords:
Kuranakh gold deposit
Low-sulfidation epithermal
Aldan
Russia

ABSTRACT

The Kuranakh deposit, one of the largest lode gold deposits in Russia, is located within the Central Aldan Ore District on the southern flank of the Siberian craton. The host rocks are flat-lying Jurassic arkose and Lower Cambrian limestone and dolomite overlying a Precambrian metamorphic basement. The hydrothermal mineralizing event is associated with Mesozoic igneous activity. In the mine area, this igneous activity is manifested by three swarms of dikes with a few small plugs and sills of bostonite, microgabbro, and minette. Gold mineralization is spatially related to the dikes, which may be both pre-ore and post-ore in age. The Kuranakh deposit is interpreted as a low-sulfidation epithermal gold deposit with quartz–adularia alteration. Several sub-horizontal, blanket- or ribbon-like orebodies, up to 50 m thick, occur mainly along the karstified contact between Cambrian calcareous footwall rocks and overlaying Jurassic clastic rocks within a narrow, but very long zone of about 25 km. Originally, gold mineralization was associated with pyrite, arsenopyrite, sphalerite, and galena; however, total sulfides constituted only a few percent of the total rock mass. The deposit has been thoroughly oxidized and only traces of arsenopyrite and pyrite are rarely found. Gold occurs primarily as mineral grains, less than 5 μm in size, usually contained within friable grains of porous goethite. Studies of fluid inclusions show a range of homogenization temperatures from 80 °C to 220 °C, but generally ranging from 110 °C to 160 °C. The center of the heat source may have been located in the southern end of the deposit, at its transition to the gold and uranium mineralization hosted in the Precambrian basement of the Siberian craton.

1. Introduction

The Kuranakh gold deposit was discovered in 1947 and modest production began in 1955. Large-scale open pit mining began in 1965 and continues up to Present. The Kuranakh mine was the largest lode gold producer in Russia before 1991 (Benevolskiy, 2002) and has produced 10.6 million oz of gold by end-2012 (Benevolskiy, 2002; Polyus Gold, 2012). Through 1997, the mine has extracted 74.1 million tonnes of ore grading 3.57 g/t gold, reaching its peak of 240,000 to 350,000 oz annual production between 1973 and 1991 (Benevolskiy, 2002), followed by the decline in grade and production afterwards. Current annual output is sustained at 120,000 oz of gold (Polyus Gold, 2012). Gold recovery averages 83% using resin columns. Various estimates suggest that the deposit still contains more than 6.6 million oz of gold in low grade and stockpile material (SRK Consulting, 2006).

Although the Kuranakh deposit is one of the largest and long-lived Russian hard-rock gold mines, the problem of its origin is still under discussion and has been postulated differently by various workers because of its stratabound nature, uncertain relationship between ore and dikes, intensive weathering and karst development, and a close spatial relation of gold mineralization to karst bodies. Our study (Fredericksen, 1998; Fredericksen et al., 1999), accompanied by intensive drilling, assaying, detailed large-scale mapping, structural, mineralogical and fluid inclusion analyses, as well as available mining and published data, proposes a new hypothesis for the origin of Kuranakh deposit.

2. Geological setting

The Kuranakh gold deposit is located within the Central Aldan Ore District (CAD) (Khomich and Boriskina, 2010), situated within the Aldan Shield on the southern flank of Siberian craton (Fig. 1). The Aldan Shield consists predominantly of an Archean rock complex that is metamorphosed to granulite and amphibolite facies. Ancient rocks are folded into a complex system of isoclinal folds. The original rocks are interpreted as mafic volcanic, sedimentary, and volcano-sedimentary rock packages.

Rosen et al. (2006) reported the oldest rocks of the region are mafic schist from the southern part of the shield with an age of ca. 4500 Ma (K–Ar, pyroxene). The gneiss has an age varying from 3960 to 3300 Ma (Rb–Sr, bulk rock samples), and the marble from 3800 Ma (K–Ar, bulk rock samples) to 3150 Ma (Pb–Pb method). Nonconformable Lower Proterozoic calcareous–terrigenous sequences, with minor amount of volcanic material, cover Archean basement,

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http://dx.doi.org/10.1016/j.oregeorev.2013.12.004

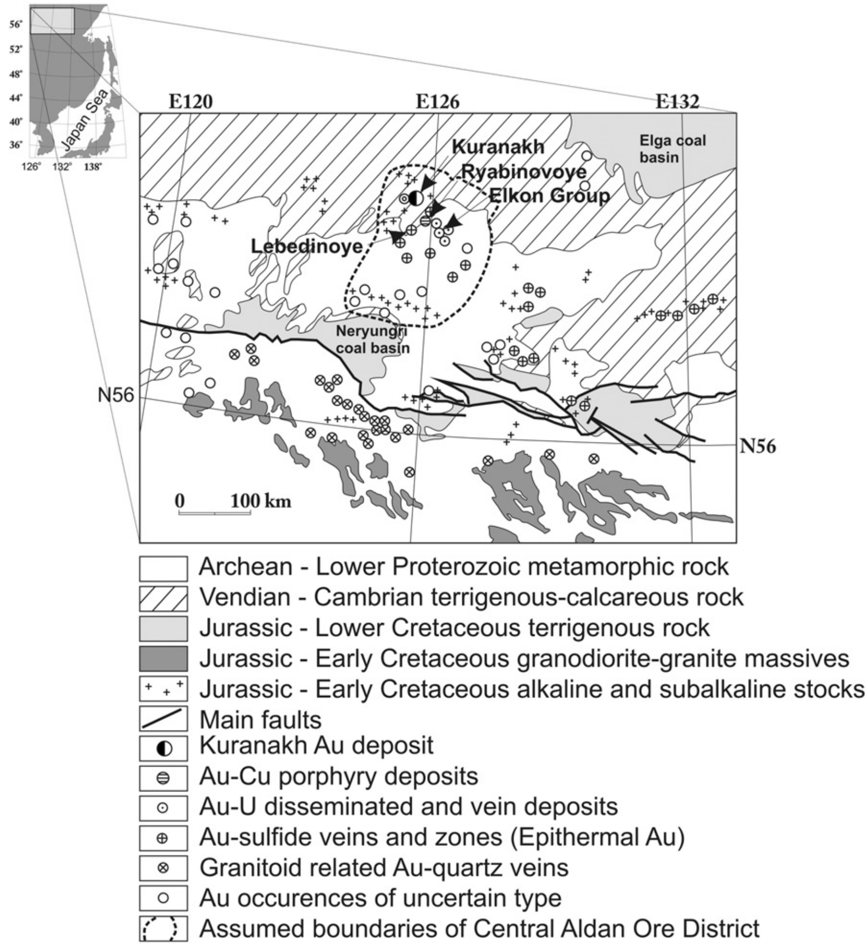

Fig. 1. Geologic setting of Central Aldan District (adapted from Vetluzhskikh and Kim, 1997).

filling the graben-like depressions. The ages of these rocks are older than 1800 Ma, as they are intruded by 1800 to 1750 Ma granite (K–Ar, bulk rock samples). Rare interlayers and sills of diabase, with ages of 1350 Ma (K–Ar, bulk rock samples), occur in places within the Lower Proterozoic sequence. Vendian–Cambrian marine terrigenous–calcareous sequences, forming the platform cover, are widespread in the northern part of the CAD. The age of glauconite from the bottom and top of Vendian–Cambrian sequence varies from 650 to 580 Ma (Drugova et al., 1985; Kozlovskiy, 1988).

The Mesozoic sedimentary basins are filled with Jurassic and, partly, Lower Cretaceous coal-bearing terrigenous deposits, which are interpreted to have formed in response to collision of the Siberian platform with the Bureya superterrane (Natal'in, 1991; Parfenov, 1984, 1997; Parfenov et al., 1983, 1995). The continued collision resulted in intensive folding of Mesozoic sedimentary rocks with development of complex systems of gentle folds, isoclinal folds, and overturned folds (Mokrinsky, 1961), as well as numerous northward thrusts.

Widespread Mesozoic magmatic activity in the Aldan Shield is commonly related to the heating of the lithosphere, generally occurring in extensional settings. Horizons of tuffaceous and pyroclastic material, 0.5 to 2.0 m thick, occur in lower part of Mesozoic sequence (Ishina, 1968; Syundyukov et al., 1979; Zhelinsky, 1980).

Potassium–argon ages of the CAD magmatic rocks vary from 98 to 190 Ma (Fig. 2). Mesozoic magmatic rocks are subdivided into several complexes that reflect different stages of tectonic evolution (Kochetkov et al., 1981; Maksimov, 1991; Maksimov and Seredin, 1982; Maksimov and Uyutov, 1990; Kochetkov, 1991; Uyutov, 1991).

The Early Jurassic stage was manifested by the formation of sill-like intrusions of sub-alkaline syenite, syenite–porphyry, and quartz syenite, as well as alkaline trachyte flows that are preserved mainly as xenoliths in syenite. Magmatic rocks of the Early Jurassic stage are rare in the Aldan Shield and have been found only within the CAD (Maksimov, 1991). Formation of the main structural elements of the district and origin of the initial magmatic melts from peridotite mantle is assumed to be related to this early stage of Mesozoic tectonic evolution (Maksimov and Seredin, 1982; Maksimov and Uyutov, 1990; Uyutov, 1991).

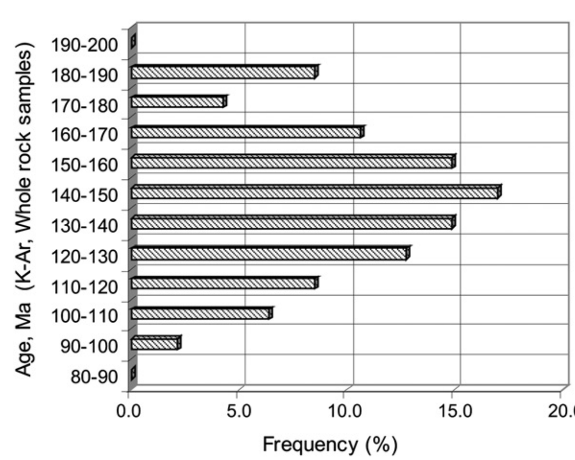

Fig. 2. K–Ar ages of the intrusive rocks of Central Aldan District (Kozlovskiy, 1988).