1 Introduction

In the North China Craton (NCC), hundreds of gold deposits are distributed in three main provinces: Xiaoqinling, Jiao–Liao, and Yan–Liao (Hart et al., 2002; Yang et al., 2003). The majority of gold deposits in the NCC are hosted by Mesozoic (mainly Late Jurassic to Early Cretaceous) granitoids or, less commonly, by basement rocks adjacent to the granitoids (Goldfarb et al., 2014; Yang et al., 2003). Consequently, many geologists have suggested that the ores are of magmatic origin (e.g., Hart et al., 2002). The gold mineralization occurs either in quartz veins or as bodies of disseminated gold and stockwork-type veins along altered shear zones that follow the boundary between the granitoids and the Archean metamorphic rocks (Goldfarb et al., 2014; Yang et al., 2003). Consequently, many geologists have suggested that the ores are of magmatic origin (e.g., Hart et al., 2002). The gold mineralization occurs either in quartz veins or as bodies of disseminated gold and stockwork-type veins along altered shear zones that follow the boundary between the granitoids and the Archean metamorphic rocks (Goldfarb et al., 2014; Yang et al., 2003).

The important Yu’erya gold deposit was discovered in 1887. It is located about 25 km SE of Kuancheng Manchu Nationality Autonomous County, Hebei Province. Up until December 31, 2010, total reserves of about 65 tons gold with a mean gold grade of 2.3 g/t were proven on the basis of detailed exploration (Zhang et al., 2012). After a few years of mining activities, this mine was defined as “the mine in crisis” due to an apparent depletion of the remaining resource. However, its fortunes have been revived following new underground exploration and the identification of additional resources, and the Yu’erya gold deposit remains today one of the largest active gold mines in China.

2 Ore Deposit Geology

The Yu’erya gold deposit lies in the eastern section of the Inner Mongolian Axis of the NCC and in the anticline of the northern Malanyu complex. The strata exposed in the district consist mainly of Proterozoic marine sedimentary sequences of limestone, dolomite, and minor shale belonging to the Gaoyuzhuang Formation and the Changcheng System; in addition, there are Quaternary deposits of slope wash and alluvia. The strata have an overall strike of NE 050–070°, and they dip northwards at 45–66°. In the ore district, the compressive-shear SW–NE trending faults are the best developed, followed by SSW–NNE trending fractures, and these two groups control the morphology, distribution, and scale of the majority of the gold veins.

The mineralization occurs in auriferous pyrite quartz veins, disseminated veinlets, quartz diorite dikes, and altered rocks in shatter zones. In the vicinity of the Yu’erya granitic pluton (G1), there are at least two similar concealed rock masses (G2 and G3), and G2 has proven gold reserves of 8 tons. G1 is a high-K calc-alkaline, metaluminous to peraluminous, I–S transitional granite. The orebodies of the Yu’erya gold deposit occur mainly in the contact zone between the white and red granites, and there is little mineralization in the contact zone between the white granite and the country rock (limestone of the Gaoyuzhuang Formation). The distribution of orebodies is controlled significantly by the SW–NE trending fractures. In this ore district there are four types of mineralization, namely auriferous pyrite quartz veins, disseminated veinlets, quartz diorite veins, and ores in altered rocks within shatter zones. A total of 148 auriferous quartz veins and mineralization alteration zones have been discovered. Bordered by Sajingou and Xigou, the Yu’erya ore district is divided into southern, middle, and northern metallogenic belts. The southern belt has the most veins and the highest-grade ores. The region has four ore-rich districts named I–IV.

The main metallic minerals are pyrite and sphalerite. The gold exists in the form of native gold and as inclusions in pyrite, sphalerite, galena, quartz, and tellurobismuthite. The associated types of alteration include pyritization, silicification, sericitization, albition, carbonatation, and skarnization. Four stages...
of mineralization, in chronological order, are (1) quartz and medium- to coarse-grained pyrite; (2) quartz, fine-grained pyrite, and gold; (3) quartz, polymetallic sulfide, tellurobismuthite, and gold; and (4) quartz, pyrite, and carbonate. The gold mineralization occurred mainly in the second and third stages (Kong et al., 2013).

3 Ore Genesis and Metallogenic Model

The mesothermal hydrothermal fluids in the Yu’erya gold deposit were relatively rich in H$_2$O, CO$_2$, K$^+$, Ca$^{2+}$, Cl, and S, weakly alkaline, and of low salinity. H–O isotope analyses demonstrate that the water of the Yu’erya gold deposit came mainly from a deep-seated magma. The $\delta^{34}$S values of the pyrite, chalcopyrite, and pyrrhotite in the Yu’erya gold deposit range from 1.0‰ to 5.7‰, the $\delta^{34}$S values of Niuxinshan pyrite range from 3.2‰ to 6‰, and the $\delta^{34}$S values of Jinchangyu pyrite range from $-5.7‰$ to $-2.6‰$, and 2.1‰ to 3.8‰. The positive $\delta^{34}$S values represent metallogenic materials that are related to Mesozoic magmatic activity, whereas the negative $\delta^{34}$S values represent Paleoproterozoic metallogenic materials in Jinchangyu that are related to the Precambrian metamorphic country rocks. In the Yu’erya, Niuxinshan, and Jinchangyu gold deposits, the ratios of $^{206}$Pb/$^{204}$Pb, $^{207}$Pb/$^{204}$Pb, and $^{208}$Pb/$^{204}$Pb in the pyrite and galena are close to 15.67–16.25, 15.02–15.31, and 35.25–36.20, respectively, and these data correspond to various mixtures of mantle and lower crustal materials; in contrast, the Precambrian metamorphic rocks in the upper crust contributed little to the mineralization. The gold deposits at Yu’erya, Niuxinshan, and Jinchangyu are associated with magmatism that took place during four episodes at 230–220, 200–160, 140–120, and 110–100 Ma; the episodes at 200–160 and 140–120 Ma are dominant. The ages of the mineralization include the three periods 200–150 Ma, 140–130 Ma, and 100–90 Ma, with the main stage being 200–150 Ma. This Mesozoic gold mineralization was mainly related to the subduction of the Mongolia–Okhotsk and Paleo-Pacific oceans.

The genetic model for gold mineralization at Yu’erya must account for the following factors: (1) gold mineralization hosted by the SW–NE or SSW–NNE-trending faults that cut the Yu’erya granitic pluton; (2) the presence of ore types associated with quartz veins, diorite dikes, fracture zones, and disseminated and stockwork ores; (3) ore fluids characterized by medium temperatures and low salinity; (4) H–O and S isotope compositions that suggest the existence of fluids from a deep source; (5) a mixed crust–mantle source for the ore-forming material; and (6) the close temporal and spatial association of the gold mineralization and the middle–late Mesozoic granitoid magmatism.

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