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A possible genetic model of the Shuangwang hydrothermal breccia gold deposit, Shaanxi Province, central China: Evidence from fluid inclusion and stable isotope

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ABSTRACT

The Shuangwang gold deposit (with a gold resource of approximately 70 t Au), hosted in a NW-trending breccia belt, is located in the Fenxian-Taibai fore-arc basin in the West Qinling Orogen of central China. Four stages of ore paragenesis are identified, demonstrating mineral assemblages of ankerite–quartz–albite, quartz–albite–pyrite–ankerite, pyrite–calcite–quartz, and fluorite–dickite–gypsum, respectively. Fluid inclusions hosted in stages I, II, and III hydrothermal minerals yield homogeneous temperatures of 300–463 °C, 220–340 °C and 100–279 °C, with salinities lower than 22.7 wt% NaCl equiv. Trapping pressures estimated from CO_2–H_2O fluid inclusions show a gradual decrease from 100–170 MPa (KT8 ore body) to 17–55 MPa (KT2 ore body), corresponding to mineralization depths from 3.8–6.4 km (KT8) to 0.6–2.1 km (KT2). Hydrogen and oxygen isotopic data suggest that the ore-forming fluids evolved from metamorphic water to magmatic water, and lately meteoric water. Sulfur and carbon isotope compositions show that these fluids might have originated from interaction with the host rocks with minor additional magmatic source. Based on geochemical investigations, with combination of regional and ore deposit geology, a possible genetic model with a three-step ore-forming process is proposed. The Devonian Xinghongpu sedimentary rocks are characterized by a relatively high gold content, which might provide the initial gold source. Linear folds and faults formed during Triassic orogenic processes provided the subsequent pathways for ore-forming fluids and suitable space for gold mineralization. Postorogenic magmatic activity induced voluminous hydrothermal fluids that mixed with the basinal fluids and may have started the ore formation process. Over pressure led to hydrofracturing and the subsequent pressure drop promoted fluid boiling, which in turn resulted in abundant gold deposition. Induced by postorogenic magmatic hydrothermal activity, the Shuangwang gold deposit is considered a special type of orogenic gold deposit formed in a compression–extension transition.

1. Introduction

The E–W trending Qinling Orogenic Belt (QOB), located between the North China Block (NCB) and South China Block (SCB) (Fig. 1a), is one of the major composite collisional orogens in China (Dong et al., 2011; Wu and Zheng, 2013). Multiple orogenic events might be responsible for different types of gold mineralizations, making the QOB one of the most important gold metallogenic belts in China. The Xiaoqinling and the West Qinling gold districts are two important gold deposit concentrating districts in the QOB. The Xiaoqinling gold district, which is principally dominated by orogenic gold deposits, has more than 1200 gold-bearing quartz veins with a proven resource of 390 t Au and an estimated resource of 800 t Au (Zhou and Yao, 2008). The gold mineralization in the Xiaoqinling district was mainly deposited in the Yanshanian epoch, which coincides with gold ore-forming age of the Jiaodong Peninsula (Wang et al., 1998; Mao et al., 2002a; Li et al., 2003a, 2003b; Jiang et al., 2009; Goldfarb et al., 2013). The West Qinling is another important gold district, which demonstrates a total gold resource of >500 t and more than ten gold deposits with resource of >20 t Au (Mao et al., 2002b). These gold deposits are present in the West Qinling gold district and have been classified into two distinct genetic types: orogenic and Carlin-like deposits

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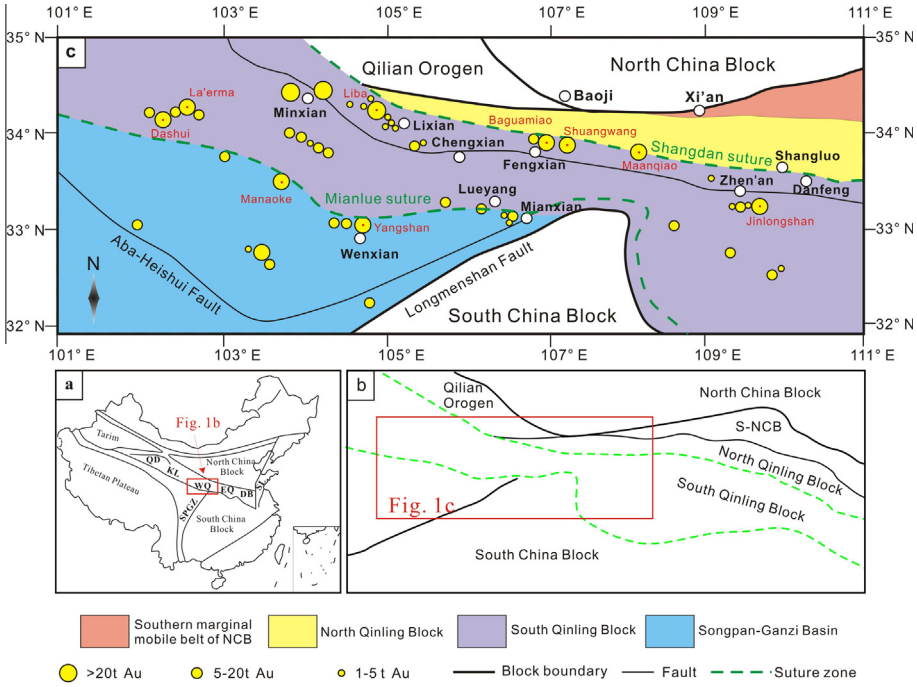

Fig. 1. Simplified geological map of the West Qinling Orogen showing distributions of major gold deposits and the location of the Shuangwang gold deposit (modified after Dong et al., 2011; Zeng et al., 2012). QD – Qaidam; KL – Kunlun Shan belt; WQ – West Qinling; EQ – East Qinling; DB – Dabie belt; SL – Sulu belt; SPGZ – Songpan-Ganzi terrane.

(Mao et al., 2002a; Li and Peters, 1998). The orogenic gold deposits, represented by the Shuangwang, Baguamiao, Liba, Maanqiao deposits, etc., are mainly hosted in middle to late Paleozoic (mainly Devonian) clastic metasedimentary rocks; whereas the Carlin-like gold deposits (e.g., the La'erma, Dashui, Manaoke deposits, etc.) are associated with unmetamorphosed to weakly-metamorphosed, mainly Middle to Late Triassic clastic and carbonate rocks. In contrast to the Xiaoqinling district, the West Qinling district is characterized by an intense gold mineralization in Indosinian epoch, based on the recently obtained geochronological data (Mao et al., 2002b; Zeng et al., 2012, 2013).

The Shuangwang gold deposit (>70 t Au) is one of the largest gold deposits in West Qinling (Fig. 1b). This deposit is characterized by a hydrothermal breccia type gold mineralization, which has attracted a broad interest since its discovery in 1976 (Shi et al., 1989; Zhang et al., 2004; Zeng et al., 2005). However, its genetic type and ore genesis are still controversial. Li and Peters (1998) classified it as a Carlin-type gold deposit, whereas Mao et al. (2002a), Zhou et al. (2002), Zhang et al. (2004) argued that it is an orogenic gold deposit for the strong structural control, the abundant CO_2 in the ore-forming fluids, relatively coarse-grained native gold, metamorphic setting, and alteration assemblages. Furthermore, previous works mostly focused on the KT8 and KT9 ore bodies due to the limitation of accessible samples. Currently it is possible to make a holistic investigation on samples from more available ore bodies after more than twenty years of mining. In this contribution, we present entirely new fluid inclusion and stable isotope data to decipher hydrothermal fluid origins and constrain its genetic type. In combination with regional and deposit geology, a possible genetic model for the Shuangwang breccia-type gold deposit is proposed.

2. Geological setting

The Shuangwang gold deposit is located in south of the Shangdan fault in West Qinling (Fig. 1b). The Shangdan fault is considered a major suture which separates the North China and South China Blocks (Mattauer et al., 1985; Li et al., 1993a; Ratschbacher et al., 2003). The QOB (also called Central Orogenic Belt in China) is a tectonic collage comprising oceanic and continental fragments that were assembled during the Paleozoic era. Previous studies identified two sutures (i.e., the Shangdan suture in the north and the Mianlue suture in the south) with ophiolitic mélanges in this region (Zhang et al., 1988, 1995; Dong et al., 2004). Separated by these sutures, the Qinling Orogen can be divided into four zones from north to south: the southern margin of the North China Block (S-NCB), North Qinling Block (NQB), South Qinling Block (SQB) and the South China Block (SCB) (Fig. 1b) (Dong et al., 2011).

Generally, the West Qinling geographically refers to the Qinling Orogen west from the Baoji–Chengdu railway (Zhang et al., 2001). The West Qinling Orogen, which is confined by the Linxia–Zhang xian–Wushan fault (westward extension of the Shangdan suture) to the north and the Mianlue suture to the south, reflects 300 Ma of Paleozoic closure of the Shangdan and Mianlue Oceans between the North China and South China blocks within the broader Paleotethys Ocean (Dong et al., 2011). The Phanerozoic lithostratigraphic sequence in this area is a continuum from Cambrian to Triassic, but majority of the sequence are Devonian–Cretaceous sedimentary rocks. Granitoids are mainly distributed along the Shangdan and Mianlue sutures in an approximately E–W-trending belt, which is nearly parallel to the sutures and faults. These granitoids, mostly formed in Late Triassic (Li et al., 1993b, 2003a, 2003b; Li, 2005; Zhang et al., 2007), mark the final collision between the NCB and the SCB (Dong et al., 2011).

Gold, lead, and zinc mineralization are significant in this region. Numerous SEDEX type Pb–Zn deposits, i.e., the Bafangshan, Yindongliang, and Shoubanya Pb–Zn deposits, are hosted in Devonian strata. These Pb–Zn deposits might be related with the hydrothermal sedimentation in Paleozoic rift basins along the Shangdan belt (Yao et al., 2005; Ren et al., 2013). In addition, abundant orogenic gold deposits are also widely distributed in this area.