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A fluid inclusion study of the Hetai goldfield in the Qinzhou Bay–Hangzhou Bay metallogenic belt, South China

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ABSTRACT

The Hetai goldfield is located in the southern section of the Qinzhou Bay–Hangzhou Bay metallogenic belt (QHMB), South China. Gold mineralization is controlled by NE-trending ductile shear zones. Gold grade is higher at the shear zone centers and decreases sharply away from the shear zones, regardless of the host rock type. Fluid inclusions (FIs) preserved in the auriferous quartz veins have been analyzed to constrain their genesis. Three types of gold mineralization-related FIs, including moderate-salinity aqueous (A-type), low-salinity H_2O–CO_2 (B-type) and CO_2-dominated (C-type), have been newly identified. The measured homogenization temperatures (T_h) range from 130 °C to 310 °C, with two peaks of about 245 °C and 170 °C. The calculated pressures of FIs range from 50 MPa to 170 MPa. Immiscibility and CO_2 effervescence of fluids may have played an important role in gold precipitation during the ascent of the ore-forming fluids. The Hetai goldfield is a typical example of orogenic gold deposits originating from auriferous metamorphic fluids.

1. Introduction

Orogenic gold deposits occur as fault-controlled lodes in the greenschist facies metamorphic terranes formed in accretionary or collisional orogens (Groves et al., 1998). A number of characteristics were used to identify orogenic gold deposits, viz.: 1) Orogenic gold deposits are formed in convergent, collisional to post-collisional tectonic settings (Chen, 2006; Chen and Fu, 1992); 2) the location and occurrence of orebodies are controlled by brittle to ductile structures (Kerrich et al., 2000); 3) the host rock lithologies vary, and are commonly metamorphosed from lower- to upper greenschist facies, and less commonly to lower amphibolite facies (Goldfarb et al., 2001); 4) alteration mineral assemblages are dominated by carbonate − sulfide ± sericite ± chlorite (Groves et al., 2003; Li et al., 2012); 5) element associations include Au, Ag, As, Sb, Hg, W, Mo, Te and B (Reich et al., 2005; Zhang et al., 2014); 6) the ore-forming process is characterized by mesothermal, low salinity, and carbon-rich fluids originating from metamorphic devolatilization (Chen et al., 2007; Phillips and Powell, 2010; Zhang et al., 2012). These characteristics have facilitated the recognition of some orogenic gold deposits, such as those in the Yilgarn Craton and Bendigo goldfields in Australia (Hagemann and Luders, 2003; Thomas et al., 2011), the Donlin Creek gold deposit (Alaska) in North America (Goldfarb et al., 2004), the giant Sukhoi Log gold deposit (Siberia) in Russia (Large et al., 2007, 2009), as well as in Qinling (i.e., Henan, Shaanxi and Gansu provinces), Jiaodong (Shandong Province) and Xinjiang Province in China (Chen et al., 2001, 2012a, 2012b; Fan et al., 2003; Li et al., 2008, 2011; Nie, 1997; Zhou et al., 2002).

The Qinzhou Bay–Hangzhou Bay metallogenic belt (QHMB) is one of the most important metallogenic belts in South China. The QHMB is associated with the Qinzhou Bay–Hangzhou Bay Juncture Orogenic Belt, which has been interpreted as a giant tectonic suture between the Yangtze and Cathaysia blocks that has experienced multi-stage orogeny from the Neoproterozoic to the Mesozoic (Pirajno and Bagas, 2002; Shu et al., 2011; Wang et al., 2003, 2008, 2013; Zhao and Cawood, 2012; Zhou et al., 2012). The suture is about 2000 km long and 70–130 km wide, extending from the Qinzhou Bay in Guangxi, through northwestern Guangdong, eastern Hunan and middle Jiangxi, to Hangzhou Bay in Zhejiang (Fig. 1). The southern section of the QHMB is one of the most important gold-producing areas in China (Wang et al., 1997; Zhou et al., 2012). Compared with the Jiaodong and Qinling gold deposit clusters (Fan et al., 2003; Li et al., 2008, 2011), gold deposits in the southern QHMB are less well documented in the international literature (Chen and Wang, 1994; Pirajno and Bagas, 2002; Zhang et al., 2001). The Hetai goldfield is located in the southern QHMB (Fig. 1), with proven gold reserves of over 100 t grading at 7 g/t, e.g., the Gaocun and Yunxi gold deposits contain 21 t and 18 t gold, respectively (Wang and Yao, 2001). The ore-forming fluids have been argued to be magmatic hydrothermal, metamorphic, meteoric or their mixing products (Li et al., 2001; Liu et al., 2005; Wang et al., 1997; Zhou, 1992). More specific studies on compositions and source of the fluids were needed to

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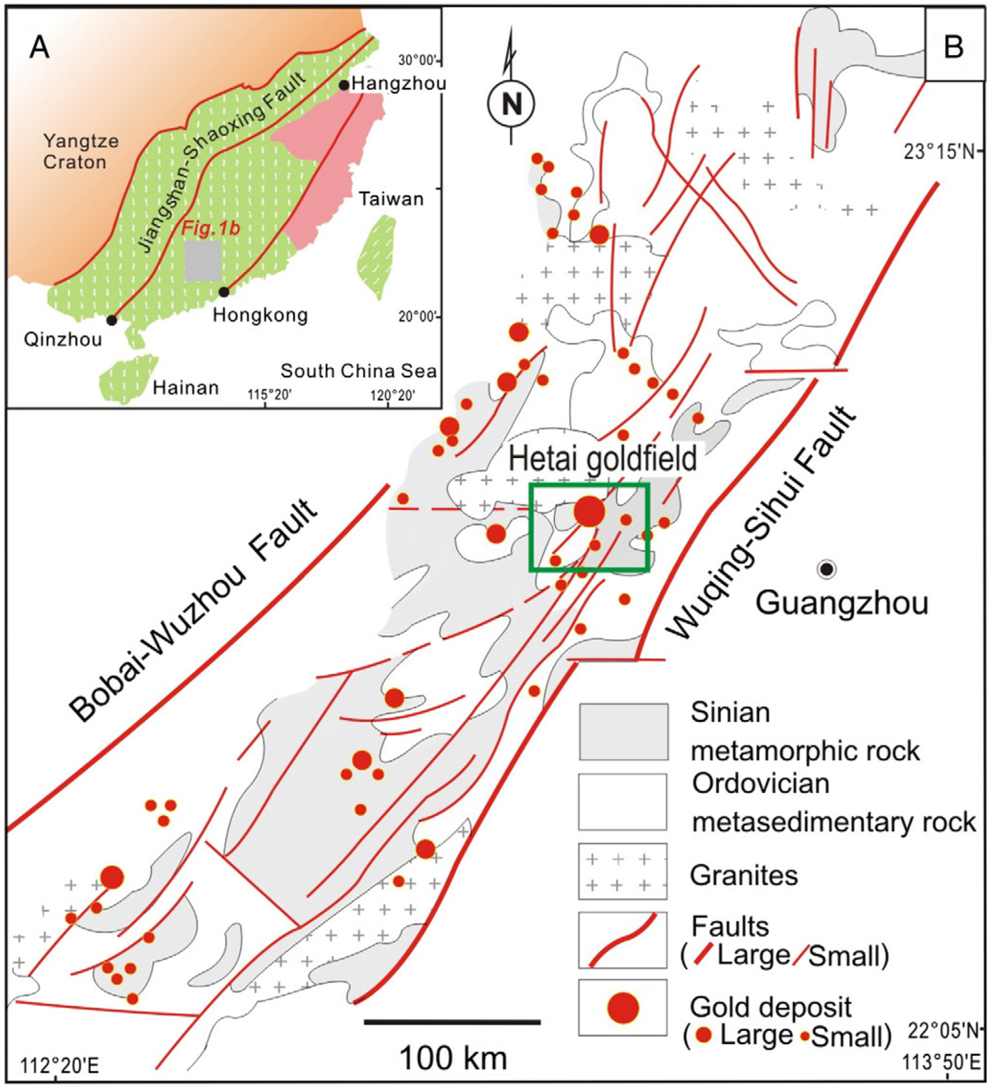

Fig. 1. Tectonic outline and distribution of gold deposits in the western Guangdong Province, South China.

enhance our knowledge on this giant gold field and to provide guidance for future exploration in this region.

The formation of gold deposits normally occurs as a consequence of various geological and geochemical conditions that are important to ore deposit model. Among the many contributing factors, the hydrothermal fluid is critical on the significant amount of gold (Chen et al., 2007; Lu et al., 2004; Pirajno, 2009). Changes in physiochemical conditions of the hydrothermal fluids and their interactions with the wall rocks have often led to the precipitation of gold from the solution (Li et al., 2012). Thus, the nature and compositions of hydrothermal fluids in the formation of gold deposit are becoming an increasingly important topic of research (Chen et al., 2007).

This contribution focuses on the fluid inclusions (FIs) preserved in the auriferous quartz veins of the Hetai goldfield. We will unravel the geochemical characteristics of these FIs and their metallogenic implications, with the aim to provide a case study to guide investigation of similar types of gold deposits in South China.

2. Geological background

The Hetai goldfield is situated in the western Guangdong Province, part of the southern section of the QHMB (Fig. 1). The gold deposits exposed in the mineral field include Xiniuding, Taipingding, Shangtai, Yunxi, Taozishan, Kangwei, Gaocun, Huojing and Hehai (Fig. 2).

It has been suggested that these gold deposits belong to the altered ductile shear zone-hosted type (Pirajno and Bagas, 2002; Wang et al., 1997; Zhou et al., 1995). The altered ductile shear zones are the most critical parameters for the formation of gold deposits. The NE-trending ductile shear zones control the geometry, extent and occurrence of the gold orebodies (Fig. 2). Gold abundance increases from anomalous level to a peak wherever a deformation zone is encountered, regardless of the host rock lithologies, and decreases sharply away from the shear zones.

The rock units exposed in the Hetai mining area are predominantly Sinian metamorphic rocks and Ordovician metasedimentary rocks (Fig. 2). The thick Sinian strata, subjected to migmatization and intruded by granodiorite (197 to 233 Ma, Wang et al., 1997), are the most important host rocks for the gold deposits, and they have been interpreted to have originated from terrigenous marine flysch sedimentary rocks intercalated with bedded cherts (No. 719 Geol. Team, 1987; Zhou, 1992; Zhou et al., 1994a). The migmatites at Hetai contain mainly plagioclase and quartz and minor biotite (Fig. 3A), whereas the Sinian schists contain mainly sericite and quartz (Fig. 3B).

The gold orebodies in the mining area are mainly controlled by a Hercyno-Indosinian deformation system comprising numerous NE-trending ductile shear zones (Fig. 2; Pirajno and Bagas, 2002; Wang et al., 1997). In the shear zones, deformation gradually increases inward towards the deformation center, with the rocks changing from