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Geology, fluid inclusion and stable isotope study of the Yueyang Ag-Au-Cu deposit, Zijinshan orefield, Fujian Province, China

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ABSTRACT

The large Yueyang Ag-Au-Cu deposit is commonly regarded as a low-sulfidation epithermal deposit in the Zijinshan orefield, Fujian Province, southeastern China. The Ag-Ag-Cu orebodies hosted in the Zijinshan granitic batholith are mainly stratoid and lens in shape, and controlled by a series of NW-trending listric faults with shallow dip angles. Four mineralization stages are recognized on the basis of mineral assemblage, ore fabrics, and crosscutting relationships of the ore veins, namely: pre-ore (pyrite + sericite + quartz ± chlorite), main Cu (chalcopyrite + pyrite + sericite + quartz ± bornite), main Ag-Au (Ag and Au minerals + pyrite + quartz + adularia ± calcite ± apatite ± chalcopyrite ± galena ± sphalerite) and post-ore (quartz ± chalcedony ± calcite) stages. Fluid inclusions (FIs) in the deposit include aqueous liquid-rich (WL-), aqueous vapor-rich (WV-), and minor carbonic (C-) and daughter mineral-bearing (S-) type ones. WL-subtype is the main inclusion type in the Yueyang deposit, accounting for more than 90% in proportion in each stage. Minor WV-subtype inclusions occur in both the main Cu and Ag stages, while the C-type and S-type ones are only observed in the main Cu stage. Fluid inclusion and H-O isotope study indicated that the ore-forming fluid of the main Cu stage is primarily magmatic vapor, which further underwent fluid boiling and mixing with meteoric water, while the ore-forming fluid of the main Ag stage is meteoric water-dominated, and the precipitation of silver and gold was mainly resulted from fluid boiling and the precipitation of other sulfides. On the basis of the aforementioned geological, fluid inclusion and stable isotope studies, we proposed a two-stage model for the Yueyang deposit, including a magmatic vapor-related porphyry type Cu mineralization and meteoric water-related low-sulfidation epithermal Ag-Au-Cu mineralization, although the porphyry Cu mineralization is very limited in scale. The mineralization and exhumation depths of the Yueyang deposit are estimated to be 448 527 m and 18 97 m, respectively. By comparison with the exhumation depths of other deposits in the Zijinshan orefield, it is suggested that more epithermal deposits could be found in the southwest of the orefield due to less uplift and exhumation therein.

1. Introduction

Since the late 1970s, the understanding of epithermal deposits was largely improved when exploration interest rose due to the increasing value of gold and silver, and a dozen classification schemes have been proposed, with the high-sulfidation and low-sulfidation subtypes (Hedenquist, 1987) most commonly used. Most of the high-sulfidation deposits are mined for Au and Cu as exemplified by Lepanto, Philippine (Hedenquist et al., 1998; Chang et al., 2011), Chinkuashih, Taiwan (Wang et al., 1999; Wang, 2010), Summitville, USA (Stoffregen, 1987), Pascua, Chile (Chouinard et al., 2005), while the low-sulfidation deposits usually lack large-scale Cu mineralization but favor Au, Ag, as well as base metals like Pb, Zn, e.g., Hishikari, Japan (Faure et al., 2002), Hauraki goldfields, New Zealand (Brathwaite and Faure, 2002; Simmons et al., 2005), Apacheta, Peru (André-Mayer et al., 2002), and those in North Xinjiang (Zhai et al., 2009; Chen et al., 2012) and West USA (John, 2001; John et al., 2003). Hydrothermal processes linked to Au-Ag mineralization and alteration are well understood in these deposits, with fluid boiling, mixing, conductive cooling and wall rock interaction as the effective ore-precipitation mechanisms (Hedenquist and Henley, 1985; Canet et al., 2011; Drummond and Ohmoto, 1985; Hedenquist et al., 1998). However, the genetic relationship between magmatic water and epithermal deposits,

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especially low-sulfidation ones, remains the subject of continued debate (Hedenquist and Lowenstern, 1994; John et al., 2003; Simmons et al., 2005).

The Yueyang Ag-Au-Cu deposit, also known as the Bitian deposit in many Chinese literatures (Chen et al., 1997a,b; Zhang et al., 2003a; Liu and Hua, 2005), is located about 3 km southwest to the Zijinshan Cu-Au deposit (Fig. 1), and recognized as a typical low-sulfidation epithermal deposit since its discovery in the late 1980s (Lin, 2006; Liu and Hua, 2005; Chen et al., 1997a,b; So et al., 1998). The large Ag-Au-Cu deposit can be divided into the east and west sections (Fig. 1), and holds total reserves of 1330 t Ag at average grade of 137.6 g/t, 8.2 t Au at 0.7 g/t and 0.04 Mt Cu at 0.9% (Zhang, 2013). The Ag-Au-Cu orebodies are stratiform or lens in shape and controlled by a series of NW-trending listric faults. They are mainly hosted in the Jurassic Zijinshan granitic batholith between the Neoproterozoic basement and overlying Cretaceous volcanic rocks (Fig. 3; Lin, 2006; Zhang et al., 2003a, b). Adularia grains intergrown with Au-Ag minerals yielded $^{40}Ar^{39}Ar$ ages of 91.5 ± 0.4 Ma (Liu and Hua, 2005) and 94.7 ± 2.3 Ma (Zhang et al., 2003a). Besides, Zhang et al. (2003b) reported two sericite $^{40}Ar^{39}Ar$ ages of 102.9 ± 1.9 Ma and 102.5 ± 1.5 Ma from phyllic alteration rocks in the Yueyang and Wuziqilong deposits (Zhang et al., 2003b), respectively, which are coeval to the alunite $^{40}Ar^{39}Ar$ age (∼103 Ma) in the Zijinshan

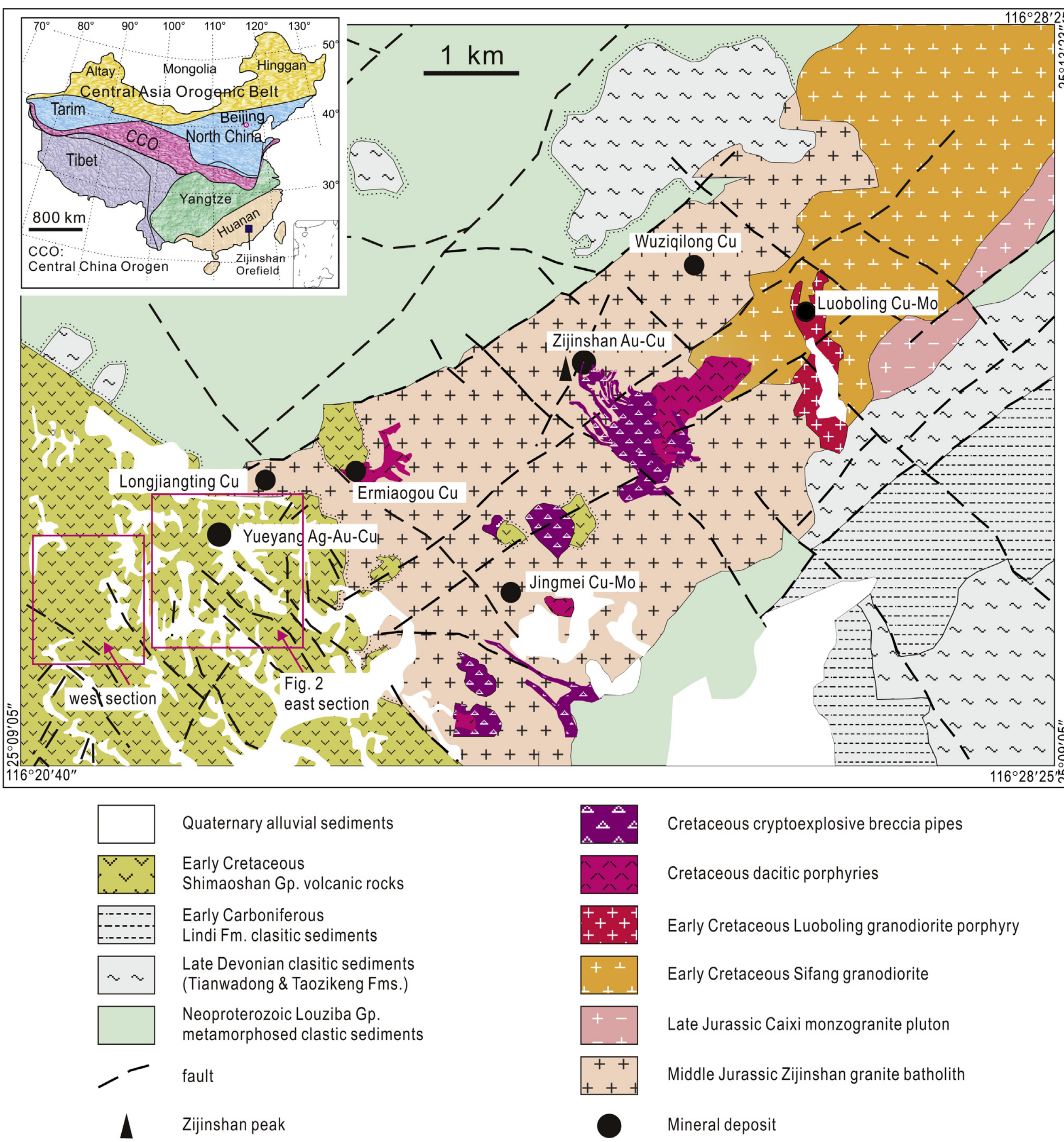

Fig. 1. Geological map of the Zijinshan Orefield (modified after Zhong et al., 2014).