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Geochemistry and geochronology of porphyries from the Beiya gold–polymetallic orefield, western Yunnan, China

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A B S T R A C T

The Beiya gold–polymetallic orefield, with gold reserves of 305 t, is one of the most representative porphyry-skarn orefields in the Jinshajiang–Ailaoshan Cu–Au ore belt within the Sanjiang region of southwest China. The orefield contains seven deposits: the Wandongshan, Hongnitang, Dashadi, Bijiashan, Weiganpo, Matouwan, and Bailiancun deposits. In this paper we report on the geochemistry and geochronology of porphyries associated with mineralization from the seven deposits. The results show that all the porphyries have similar geochemistry, with high alkalinity, high contents of SiO_2, Al_2O_3, K_2O, and Sr, high K_2O/Na_2O ratios, low MgO, Y, and Yb contents, enrichments in Ba, K, and Pb, depletions in P, Ti, Nb, and Ta, and non-evident to weak Eu depletions ($\delta Eu = 0.42–0.99$). In the SiO_2 vs. Th/Ce diagram, the porphyry samples are distributed in the area of thickened lower crust, and in the Sr/Y vs. Y and La/Yb vs. Yb diagrams, the porphyries broadly followed the batch-melting trend of amphibolite containing up to 10% garnet. LA-MC-ICP-MS zircon U–Pb dating analysis suggests that the porphyries were emplaced between 34.62 ± 0.25 and 36.72 ± 0.25 Ma. They were coeval with lamprophyres (34 to 36 Ma) in the Beiya area and with potassic–ultrapotassic intrusive rocks (40 to 35 Ma) within the Jinshajiang–Ailaoshan magmatic belt, indicating possible genetic relation between these rock types. We suggest that the porphyries in the Beiya gold–polymetallic orefield were derived from the partial melting of a K-rich mafic source in the thickened lower crust, with the melting triggered by asthenospheric upwelling following the removal of lower lithospheric mantle.

1. Introduction

An Eocene–Oligocene potassic–ultrapotassic magmatic belt, more than 2000 km long and 50–270 km wide (Xie et al., 1984; Zhang et al., 1987), occurs within the Jinshajiang–Ailaoshan tectonic belt in southwest China (Chung et al., 1998; Li et al., 2013; Wang et al., 2014). This magmatic belt is associated with several important porphyry-skarn ore deposits (Mao et al., 2008), including the Yulong Cu deposit in the northern segment of the belt (Guo et al., 2006; Jiang et al., 2006; He et al., 2014), the Beiya Au-polymetallic (Xu et al., 2007; W.Y. He et al., 2013; Deng et al., 2015), Machangqing Cu–Mo–Au (Z.H. Wang et al., 2012; Guo et al., 2013), and Yao'an Au deposits (Bi et al., 2006; Lu et al., 2013) in the central segment, and the Habo Cu–Mo–Au (Xu et al., 2012; Zhu et al., 2013), Tongchang Cu–Mo (Xu et al., 2014), and Chinh Sang (located in Vietnam) Cu–Au ± Mo deposits (Tran et al., 2014) in the southern segment.

The Beiya gold–polymetallic orefield, one of the largest in southwestern China, is located in the center of the Jinshajiang–Ailaoshan potassic–ultrapotassic magmatic belt (Deng et al., 2012, 2014a; Mao et al., 2014). The orefield contains seven deposits (Wandongshan, Hongnitang, Dashadi, Bijiashan, Weiganpo, Matouwan, and Bailiancun) with two types of mineralization: porphyry-skarn-stratabound Au–Fe–Cu–Pb–Zn–Ag and laterite-hosted Au mineralization (X.W. Xu et al., 2006, 2007; Xu, 2007; Mao et al., 2011a, 2011b; He et al., 2012; Liu et al., 2012). Alkaline porphyries associated with the gold mineralization are abundant in the Beiya area. The petrological and geochemical characteristics of the porphyries have been described by X.W. Xu et al. (2006), Xiao et al. (2009a, 2011), Yang (2010), and Jiang et al. (2013); the origins of the porphyries and ore-forming material were discussed by S.M. Xu et al. (2006) and Xiao et al. (2009b, 2011); the ages of the host rocks and mineralization were determined by Wang et al. (2001), Ying and Cai (2004), X.W. Xu et al. (2006), Xu (2007), Xiao et al. (2009a), and He et al. (2012); and the spatial distribution of the orebodies was investigated by Y.S. Guo et al. (2005), Xu et al. (2007),

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Jiang et al. (2012), and Z.H. He et al. (2013). However, most of the previous work has focused on Wandongshan and Hongnitang, and little work has been done on the other five deposits. Moreover, further comparisons need to be made of the petrology, geochemistry, and geochronology of the porphyries associated with the mineralization in the different deposits, and the origin of the porphyries requires further discussion.

In this paper we present new bulk-rock geochemical and LA-MC-ICP-MS (laser ablation-multicollector-inductively coupled plasma-mass spectrometry) zircon U–Pb age data for the potassic felsic intrusions associated with mineralization in the seven deposits. In conjunction with field and microscope observations in the Beiya gold–polymetallic orefield, we aim to use these new data to unravel the petrological and geochemical characteristics of the ore-bearing porphyries, discuss the origin and geodynamic setting of the porphyries, and constrain the genetic links between the granitic intrusions and associated mineralization.

2. Geological setting

The Beiya gold–polymetallic orefield is located in the center of the Jinshajiang–Ailaoshan magmatic belt, which bounds the western Yangtze block (Fig. 1a). The Jinshajiang–Ailaoshan magmatic belt is an Eocene–Oligocene potassic magmatic suite that was emplaced between ca. 40 and 30 Ma (Chung et al., 1998; Lu et al., 2013). It includes both mafic rocks and felsic intrusions. The mafic rocks are porphyritic with phenocrysts of olivine, clinopyroxene, and phlogopite, and the felsic intrusions are mainly porphyritic granitoids (Li et al., 2002; Z.F. Guo et al., 2005; Lu et al., 2013). Some of the felsic rocks are associated with important economic mineral deposits, including the Beiya gold–polymetallic orefield (Lu et al., 2013).

The Beiya orefield covers an area of ~800 km^2 and is located along the limbs of the N–S-trending Beiya syncline. The orefield consists of two zones, with the Wandongshan, Hongnitang, and Dashadi deposits on the west limb of the Beiya syncline, and the Weiganpo and Bijiashan deposits on the east limb (Fig. 1b). In addition, the Matouwan and Bailiancun deposits occur around the periphery of the orefield.

The wall rocks of the orefield include basalts of the upper Permian Emeishan Formation, sandstones, graywackes, sandy conglomerates, and basaltic volcaniclastic rocks of the lower Triassic Qingtianbao Formation, and limestones of the middle Triassic Beiya Formation. Quaternary sediments are also present in the area (Fig. 2). The middle Triassic Beiya Formation limestone is one of the main host rocks of the ore, and it is made up of five members. Eocene–Oligocene intrusions are abundant, and they are dominated by quartz monzonite porphyries, quartz syenite porphyries, syenite porphyries, biotite monzogranite

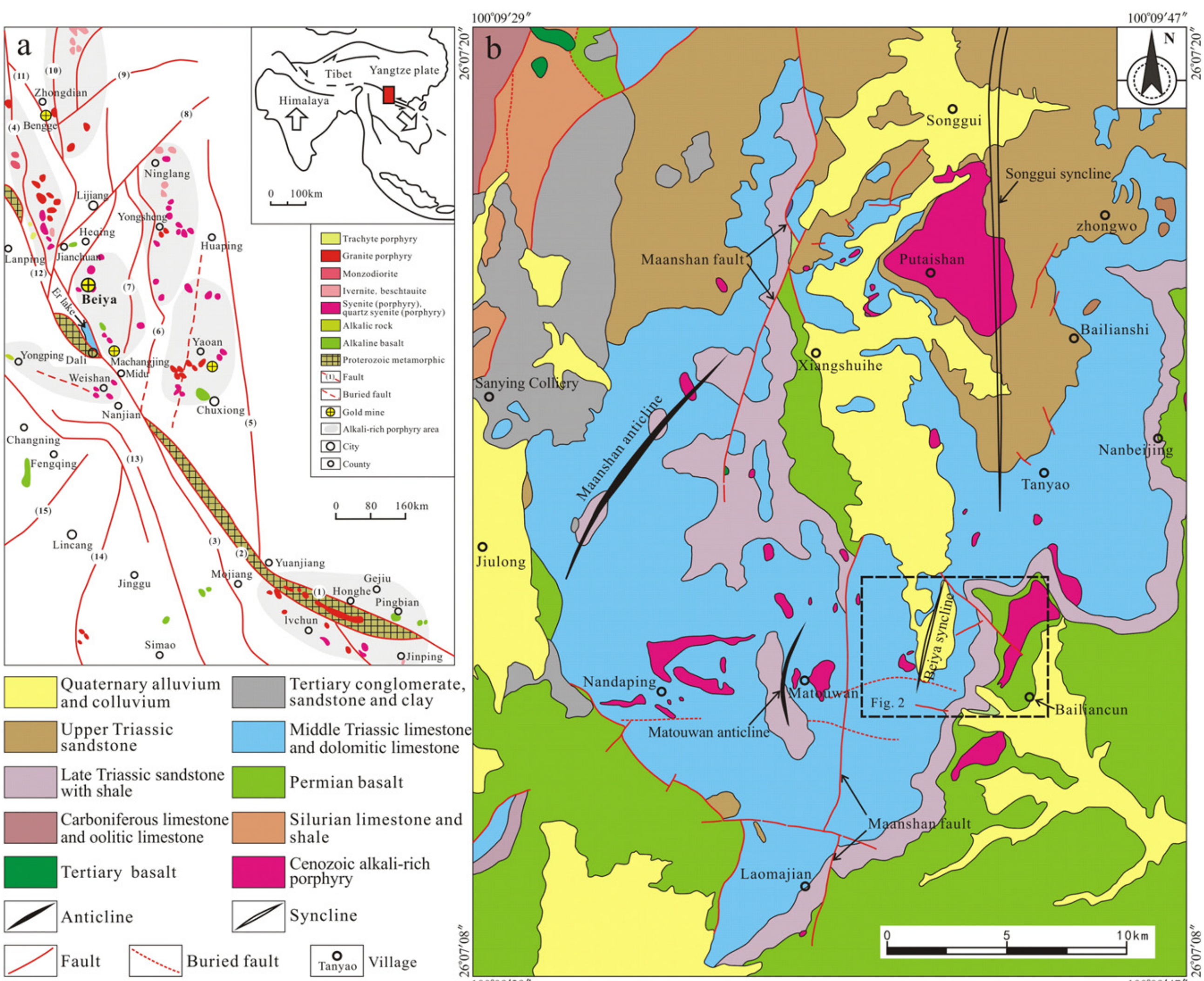

Fig. 1. (a) Regional structural position of the Beiya gold–polymetallic orefield and (b) a regional geological map (modified after Zeng et al., 2002; Yunnan Gold and Mineral Group Co. Ltd, 2011). The main faults are (1) Red River Fault, (2) Ailaoshan Fault, (3) Jiujia Fault, (4) Jinshajiang Fault, (5) Yongsheng–Xiangyun Fault, (6) Chenghai–Binchuan Fault, (7) Muli–Lijiang Fault, (8) Xiaojinhe Fault, (9) Gezanhe Fault, (10) Deqin–Zhongdian Fault, (11) Qiaohou–Xuelongshan Fault, (12) Gonglang–Yingpanshan Fault, (13) Lancangjiang Fault, (14) Nantinghe Fault.