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New tectono-geochronological constraints on timing of shearing along the Ailao Shan-Red River shear zone: Implications for genesis of Ailao Shan gold mineralization

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ABSTRACT

Several world class gold deposits are located along the Ailao Shan (ALS) belt in eastern Tibet, China. The genesis of gold mineralization along the belt, however, has been the subject of debates in the last decades, which highlights the importance of dating shearing, magmatism and mineralization along the Ailao Shan-Red River shear zone (ASRR). Through detailed field observations and microscopic analysis, a group of leucocratic intrusions from within and outside the shear zone along the ALS belt are investigated in the present paper. Pre-, syn- and post-shearing intrusions are grouped based on structural and microstructural analysis. LA-ICP-MS and SIMS dating of the intrusions revealed the existence of two age populations, a group of ages older than 30 Ma and the other younger than 28 Ma. The former are distributed both within and outside the shear zone, and the latter, in contrast, occur only within the shear zone. Our new results show that the ductile shearing along the ASRR shear zone initiated since ca. 30 Ma ago.

The dating results place major constraints on timing of shearing along the ASRR shear zone and have profound implications on the genesis of gold mineralization along the ALS belt. The present study reveals that ductile shearing along the ASRR shear zone was resulted from extrusion of the Indochina block late during the Indian–Eurasian plate collision. Meanwhile, we conclude that the gold mineralization took place prior to the shearing, but in close relation to an early magmatism (>30 Ma) ascribed to post-collisional extension collapse involving mantle processes, early during the plate collision.

1. Introduction

Several world class gold deposits are located along the ALS belt (Sun et al., 2009; Tran et al., 2014), constituting a major Cenozoic gold producer in Southeastern Tibet. Among them, 12 are of medium to large scale gold deposits, including the Laowangzhai, the Mojiang, the Chang'an and the Daping deposits, etc. (Fig. 1). Several models of mineralization, e.g. shear zone type, orogenic type and hydrothermal type, etc., have been proposed to interpret the formation of the ore deposits. The prevailing interpretations in the studies of the Ailao Shan gold belt has applied the concept of orogenic gold (e.g. Goldfarb et al., 2001) or shear zone gold deposit (Sun et al., 2009), on the basis that the deposits are particularly in spatial association with major crustal structures, e.g. the ALS belt. One of the most important arguments for this hypothesis is that the mineralization was supposedly associated with ductile shearing along the ASRR shear zone (e.g. Hu et al., 1995; Goldfarb et al., 2001; Zaw et al., 2007; Sun et al., 2009; Liang et al., 2011; Yang et al., 2010, 2011). The Oligo-Miocene shearing along the shear zone is, therefore, suggested to be the controlling factor of gold mineralization (Sun et al., 2009; Zhu et al., 2013). However, some recent studies revealed that the deposits along the ALS belt were formed in association with Paleogene plutonic rocks with mantle derived fluid systems within an extensional setting (e.g. Tran et al., 2014 and references therein). The deposits are spatially and also genetically related to the plutonic magmatisms, that are dominantly hosted in Neoproterozoic to Paleozoic plutonic, meta-volcanic or meta-sedimentary rocks along the western flank of the ALS belt.

The present paper tries to define the gold mineralization under the tectonic framework, preferably with reference to the timing of

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shearing, mineralization and associated magmatism. Our investigation reveals the existence of several types of intrusions within and outside the ASRR shear zone, which show various relations with ductile shearing fabrics along the shear zone. New zircon U–Pb SIMS and LA-ICP-MS dating results of the intrusions are presented, and previously published U–Pb geochronological data on magmatism and mineralization are also reviewed in the paper. These results place important constraints on onset timing of the ASRR shearing and its implication to the genesis of gold mineralization along the ALS belt. From the study, we show that gold mineralization associated with a major extensional magmatism along the ALS belt was prior to ductile shearing along the ASRR shear zone during the extrusion of the Indochina block.

2. Geology of the ALS belt

The ALS belt was referred to as the Ailao Shan belt or the Ailao Shan orogenic belt in the literature (Zhong et al., 1990; Zhong, 1998; Hou et al., 2006; Hou, 2010; Sun et al., 2007; Deng et al., 2014; Mo et al., 1998). The tectonic belt lies between the Yangtze-South China block to the east and the Indochina block (i.e. the Lanping-Simao basin in China) to the west (Fig. 1). The ALS belt is characterized by several separate tectonic units with different deformation-metamorphism histories, i.e. the ASRR high-grade massif or ASRR shear zone, the Ailao Shan suture zone and the low-grade metamorphic Paleozoic–Mesozoic unit (Fig. 1c). As an important element, Cenozoic intrusions are also common in any of the units. The various units are separated by brittle fault zones, e.g. the Ailao Shan fault, the Jiujia-Anding fault, etc. (Fig. 1c).

2.1. The ASRR shear zone

Two units constitute the Ailao Shan high-grade massif or the ASRR shear zone (Leloup and Kienast, 1993; Leloup et al., 1995), i.e. the high-grade metamorphic–migmatitic rocks and the mylonite zones (Fig. 2).

2.1.1. High-grade metamorphic–migmatitic rocks

Lower amphibolite to granulite facies metamorphic rocks and locally migmatitic rocks form the core of the ASRR shear zone along the central Ailao Shan mountain range. Major rock types in the massif include various schists and gneisses (e.g. two-mica schists and biotite schists, garnet-mica schists, garnet-sillimanite mica schists), calc-silicates (e.g. diopside quartzite, diopside-tremolite rocks), meta-mafic rocks (e.g. amphibolite, granulite, etc.), marbles and migmatites. Most of the rocks were metamorphosed up to upper amphibolite facies. Granulites are rarely observed as tectonic lenses in the central part of the high grade core. Meanwhile, the central high grade rocks containing granulite enclaves grade into upper, and further into lower amphibolite facies metamorphic rocks toward the mylonite zones on both sides of the core. These rocks often contain concordant or discordant leucocratic dykes possibly derived from partial melting of the host rocks (Zhang and Schärer, 1999).

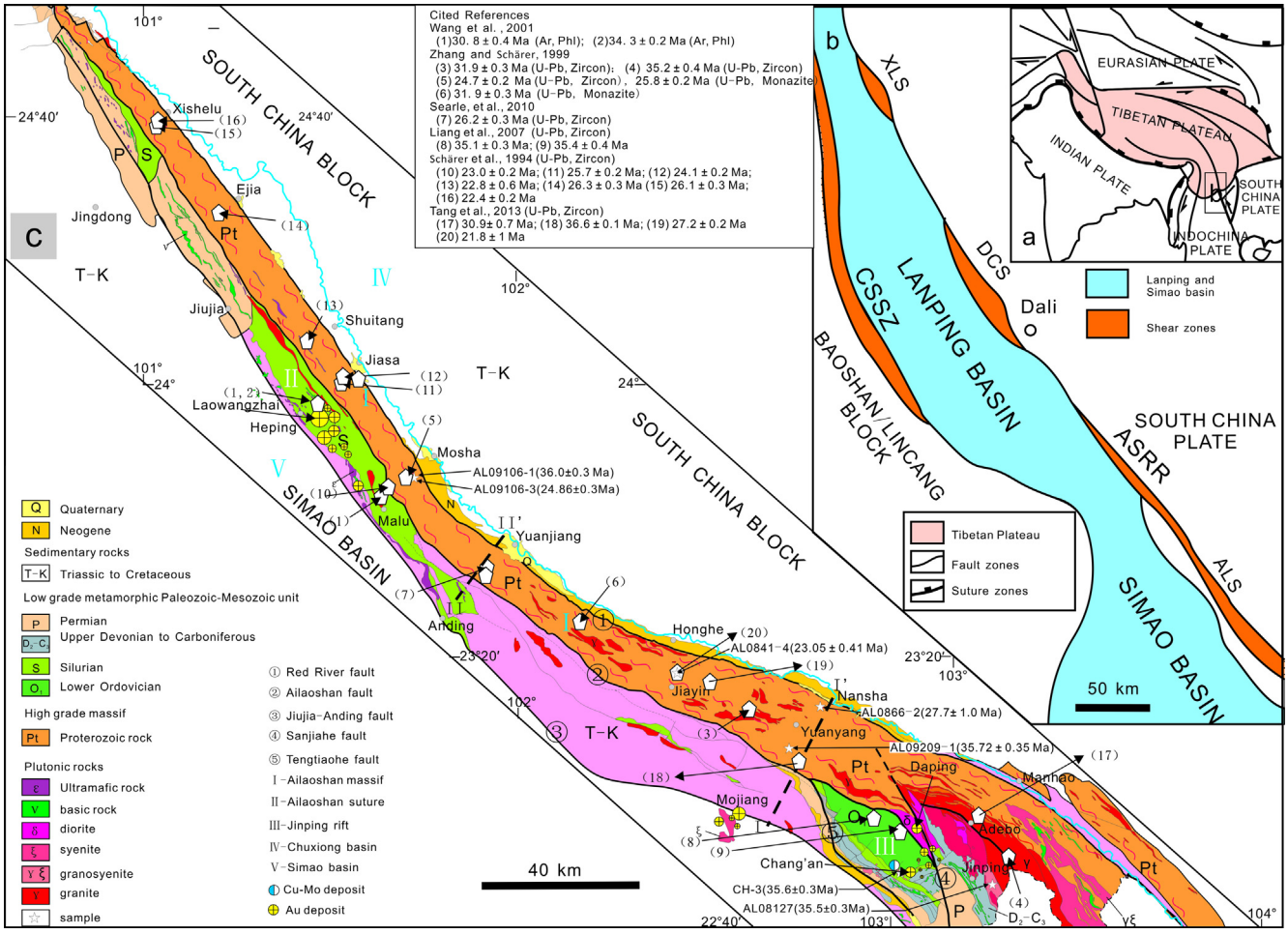

Fig. 1. (a) Regional tectonic framework of the Indian–Eurasian collision zone. (b) The ASRR shear zone and the Lanping-Simao basin between the South China plate and Baoshan–Lincang block. (c) Structural geology of the ALS belt. Locations of dated samples, dating results from the literature and Cenozoic gold deposits are also shown and listed.