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Isotopic geochemistry, zircon U–Pb ages and Hf isotopes of A-type granites from the Xitian W–Sn deposit, SE China: Constraints on petrogenesis and tectonic significance

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ABSTRACT

Zircon U–Pb geochronological, geochemical and petrological analyses have been carried out on the Xitian granite emplaced in the middle part of Shi-Hang zone, which is closely related to the economically important Xitian tungsten–tin deposit in Hunan Province, Southeast China. LA-ICP-MS zircon U–Pb dating of two representative samples yielded weighted means $^{206}Pb/^{238}U$ age of 151.7 ± 1.2 Ma and 151.8 ± 1.4 Ma. These granites are comprised mainly of K-feldspar, quartz, plagioclase, Fe-rich biotite and minor fluorite, and are characterized by enrichments in Rb, Th, REEs (total REE = 159–351 ppm), and HFSEs (e.g., Zr and Y) but depletions in Ba, Sr, P, Eu and Ti. They are metaluminous to weakly peraluminous and show a clear A-type granite geochemical signature with high SiO_2 (73.44–78.45 wt.%), total alkalis ($Na_2O + K_2O$ = 2.89–8.98 wt.%), $Fe_2O_3^*/MgO$ ratios and low P_2O_5, CaO, MgO and TiO_2 contents. In-situ zircon Hf isotope analysis suggests their $\varepsilon_{Hf}(t)$ values ranging from −7.43 to −14.69. Sr–Nd isotope data show their $\varepsilon_{Nd}(t)$ values in the range of −9.2 to −7.3, with corresponding T_{DM2} ages of 1.72–1.56 Ga. These characteristics indicate that the Xitian granite originated from partial melting of metamorphic basement rocks with a certain amount of mantle-derived materials. Combined with previous geochemical and isotopic data, it is derived that mantle–crust interaction was gradually enhanced from the early to late stages of magmatism. The ore-forming materials and fluids of the Xitian W–Sn deposit are mainly produced by the Early Yanshanian granitic magmatism, which is also responsible for the Late Jurassic (ca. 152 Ma) A-type granitic rocks that host the W–Sn polymetallic deposits distributed along the Shi-Hang zone, implying a significant Mesozoic extensional event in Southeast China likely caused by the subduction of the Paleo-Pacific plate.

1. Introduction

South China Block (SCB) was formed by the amalgamation between Cathaysia and Yangtze Blocks at ca. 1.0–0.9 Ga during the assembly of Neoproterozoic Rodinia supercontinent (Li and McCulloch, 1996; Li et al., 2007b, 2009; Ye et al., 2007). In Mesozoic era, the SCB was geologically characterized by widespread igneous rocks which consist predominantly of granites and rhyolites and subordinate mafic intrusive and volcanic rocks (Li et al., 2007a). A large number of geochemical, petrological and tectonic analyses were performed on these igneous in the past decades, but geodynamic background and tectonic setting in which they were generated have been a topic of debate (e.g. Faure and Natalin, 1992; Lapierre et al., 1997; Martin et al., 1994; Zhang, 2013; Zhou and Li, 2000). It is widely accepted that the active continental margin of eastern Asia is related to the subduction of the Paleo-Pacific plate beneath the Eurasia plate (e.g. Jahn et al., 1976; Lapierre et al., 1997; Martin et al., 1994). An alternative intraplate extension and/or rifting regime caused by super mantle plume (Zhang, 2013; Zhang et al., 2009) or collision between the Indochina and South China blocks during Early Mesozoic (Gilder et al., 1991) has been proposed to account for the development of subordinate rifting-related alkaline basalts and syenites (Li

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et al., 2004a; Wang et al., 2004a), bimodal volcanic and intrusive rocks (Chen et al., 1999; Wang et al., 2005), and mafic dykes in SE China hinterland (Li and McCulloch, 1998). In addition, a flat-slab subduction and slab-foundering model has been proposed by Li et al. (2007a) to interpret the development of the broad Mesozoic magmatic province in the SCB.

The Late-Mesozoic Xitian granites were exposed at the south-central of "Shi-Hang zone" which was proposed by Gilder et al. (1996) for a granitic belt with relative higher $\varepsilon_{Nd}(t)$ values and younger T_{DM2} of Nd model ages from Hangzhou City (Zhejiang Province) through central Jiangxi and southern Hunan Provinces to Shiwandashan (Guangxi Province) in South China (Fig. 1). Due to their close relationship with the giant Xitian W–Sn polymetallic deposit, Xitian granites have received a number of studies, most of which focused on the geological characteristics, prospecting potential and ore-controlling factors of the Xitian skarn tin-polymetallic orefield (Fu et al., 2012; Liu et al., 2008; Wu et al., 2012; Zhou et al., 2013). However, detailed petrogenesis and geodynamic setting of the granites, which are important to ore-forming potential evaluation, are not well understood. In this study, we present new geochronological, petrological and geochemical data for the Xitian granites, and combine them with previous data in order to (1) discuss their petrogenetic characteristics, (2) constrain their geodynamic background, and (3) explore the relationship between granitic magmatism and tungsten–tin mineralization.

2. Geological setting

The SCB is bordered by the North China Craton through the Qinling-Dabie-Sulu orogenic belt to the north, the Three River orogenic belts and the Songpan-Gantze Block to the west, the Indochina Block through Red River-Ailaoshan Fault to the southwest, and the Philippine Sea Plate in the east. The SCB consists of the Yangtze Block in the northwest and the Cathysia Block in the southeast. The southeastern margin of the SCB used to be considered as a passive margin until Late Paleozoic to Early Mesozoic when the Pale-Pacific plate was subducted beneath the SCB along the Taiwan–Mariana Islands (Hsü et al., 1990; Li et al., 2006a, 2012). A large number of Late Mesozoic volcanic–intrusive complexes were exposed in SE China from the Early to Late Yanshanian in three major episodes: 180–160 Ma, 160–135 Ma and 135–90 Ma (Zhou and Li, 2000; Li et al., 2010a; Jiang and Li, 2014). Different types of granitoids including I-, A- and S-type granites during Late Mesozoic were generated, and the A-type granites mainly distributed along the regional and local fault zones (Wong et al., 2009).

Abundant Cretaceous–Tertiary NE-trending red-bed basins such as the Shiwandashan basin and Gan-Hang basin emerged concurrently with the latest phase of the regional magmatic activity, and consist mainly of red-colored clastic rocks and basalt interlayer (Gilder et al., 1996; Fig. 1). Bimodal volcanic activity took

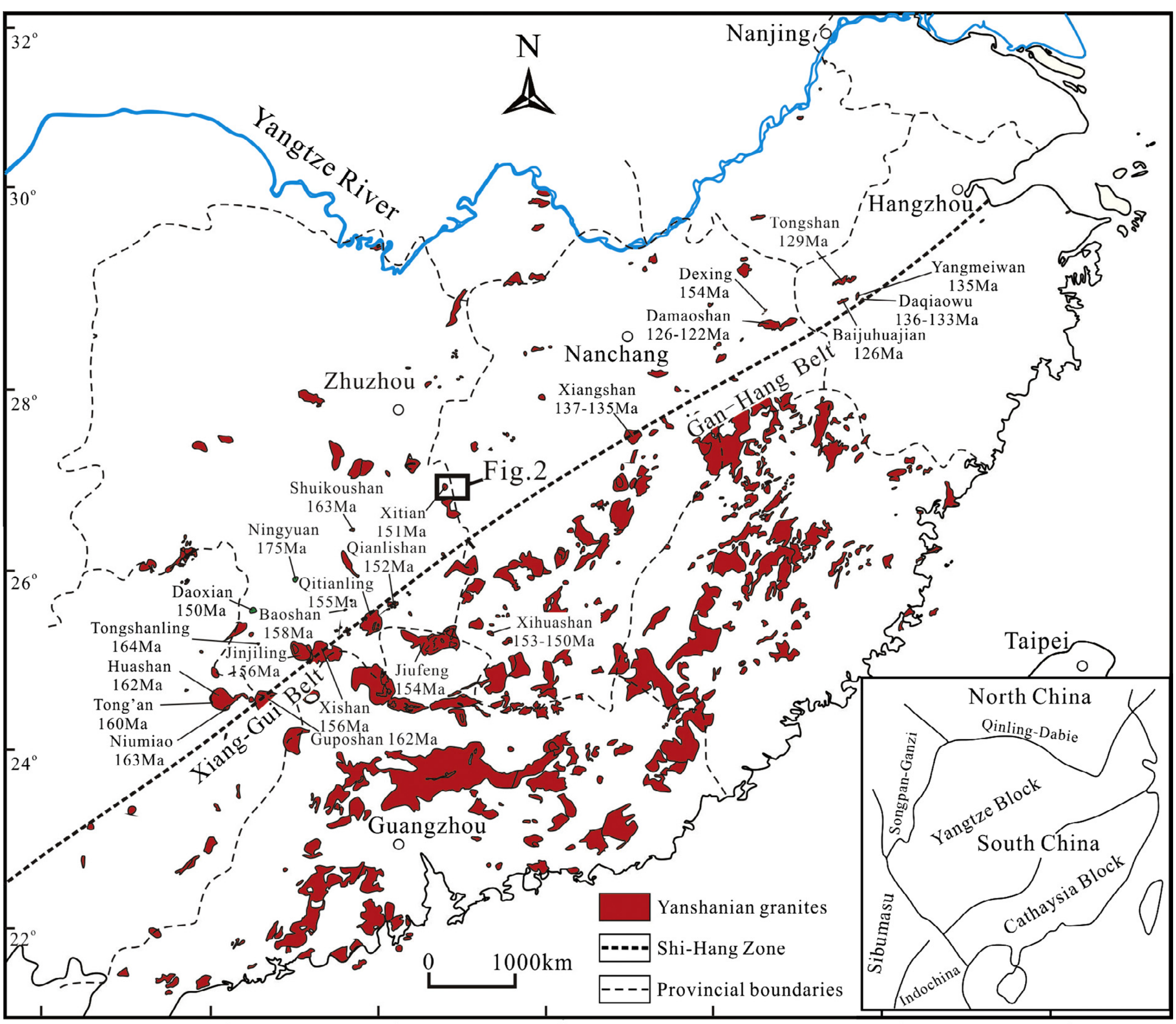

Fig. 1. Schematic geological map showing distribution of Mesozoic granitoids (modified after Zhou et al., 2006). The cited geochronological data are from Table 7.