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Geochronology, geochemistry and tectonic significance of two Early Cretaceous A-type granites in the Gan-Hang Belt, Southeast China

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ABSTRACT

The widespread occurrence of Mesozoic granites in the Gan-Hang Belt in Southeast China is associated with similarly widespread, economically important mineralization, but the precise timing, origin, and plate tectonic significance of these granites are not well understood. We have studied two of these (Early Cretaceous) granite bodies, the Yangmeiwan granite and the Daqiaowu granitic porphyry, from the northeastern part of the Gan-Hang Belt in western Zhejiang Province by zircon U-Pb geochronology, major and trace element analyses, and Nd–Hf isotopic analyses. LA-ICP-MS and SHRIMP U–Pb dating of zircon grains from these two granites yield ages of 133–136 Ma, representing a Early Cretaceous magmatic event. These granitic rocks are metaluminous to weakly peraluminous and have a pronounced A-type geochemical signature with high $Na_2O + K_2O$, $Fe_2O_3^*$/MgO and Ga/Al ratios. They show low CaO, MgO and TiO_2 contents, enrichment in some LILEs (such as Rb and Th) and HFSEs (such as Zr, Y), depletion in Sr, Ba, P, Eu and Ti. They also show A_2 subtype affinity and were probably formed at a high temperature (~810 °C for Yangmeiwan granite and ~850 °C for Daqiaowu granitic porphyry). These A-type granitic rocks show bulk rock $\varepsilon_{Nd}(t)$ values in the range of −6.5 to −3.6 and zircon $\varepsilon_{Hf}(t)$ values from −7.8 to −0.9, with Mesoproterozoic T_{DM}^{c} ages for both Nd and Hf isotopes. Geochemical and isotopic data suggest that these A-type granitic rocks were generated largely by partial melting of granulitized Mesoproterozoic metamorphic basement rocks (including parametamorphic and orthometamorphic rocks), with a possible input of mantle-derived materials and followed by subsequent fractional crystallization. Our new data together with previous published data suggest that the Cretaceous A-type granitic rocks with ages between 137 Ma and 122 Ma occurred along the Gan-Hang Belt, indicating an important Mesozoic extensional event in Southeast China. This event represents either a back-arc extension or an intra-arc rift due to the roll-back of the paleo-Pacific plate, and it started as early as ~137 Ma in Xiangshan and Xinlu basins. It is earlier than ~130 Ma as previously suggested in the studied region and later than that along the south part of the Shi-Hang Zone. With ongoing extension during slab roll-back of paleo-Pacific plate, the crust and lithospheric mantle became progressively thinned. The upwelling of asthenosphere would have triggered crustal rocks to partially melt, generating granitic magmas. Our new geochemical data also suggest that mantle-crust interaction in the formation of the A-type granitic magma along the Gan-Hang Belt gradually intensified from early to late stages between ca. 137 and ca. 122 Ma.

1. Introduction

The geology of Southeast China in Late Mesozoic is characterized by occurrence of widespread granites and volcanic rocks, which are rich in mineral resources such as W, Sn, U, Nb–Ta, Cu, Pb, Zn and REE. These Late Mesozoic rocks are different in their ages. The intense magmatic activity in this region mainly occurred in two episodes, one in the Jurassic (Early Yanshanian) and the other in the Cretaceous (Late Yanshanian) (e.g. Zhou et al., 2006). The South China Block can be subdivided into two blocks: the Yangtze Block to the NW and the Cathaysia Block to the SE, which were connected by collision during the Proterozoic Grenvillian orogen (Charvet et al., 1996) (Fig. 1). The extensive and intensive Late Mesozoic magmatism in the Cathaysia Block formed a belt of volcanic-intrusive complexes (Fig. 1), which have been referred to as the "Southeastern China Basin and Range Province" (Gilder et al., 1991). The associated granitoids appear to be younger towards the coast regions with the Jurassic ages in the inland and Cretaceous ages along the coast. The volcanic rocks were mainly formed in the Cretaceous and crop out mainly along the coast (e.g. Zhou et al., 2006) (Fig. 1). Despite some controversy, most researchers now suggest that the origin and evolution of the "Southeastern China Large Igneous Province" and associated "Basin and Range Province" is attributed to the subduction of the paleo-Pacific plate beneath the Eurasian plate (e.g. Charvet et al.,

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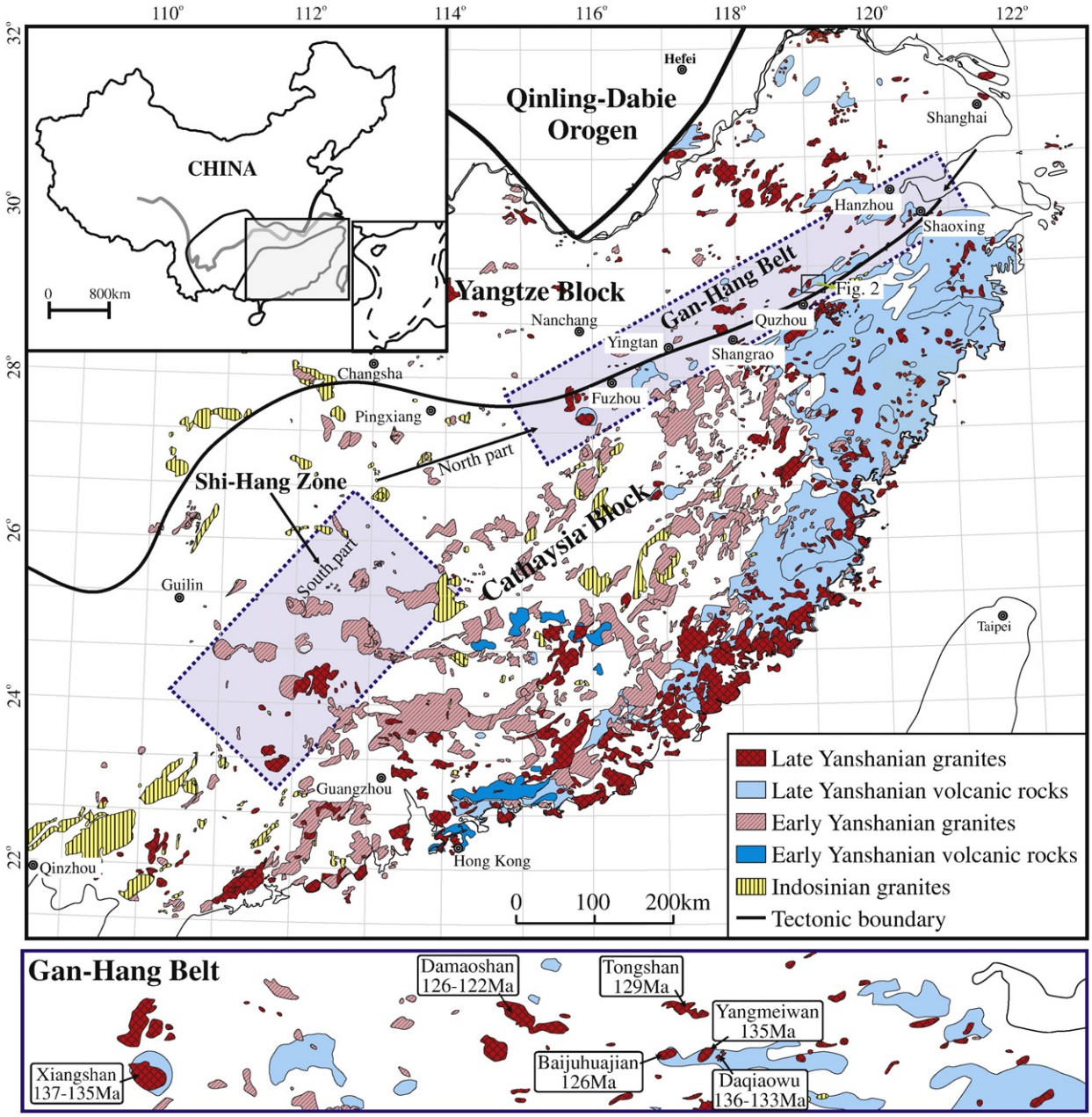

Fig. 1. Distribution of Mesozoic granites and volcanic rocks in South China (modified after Zhou et al., 2006). The South China Block is comprised of two blocks: Yangtze Block and Cathaysia Block. The approximate position of the Shi-Hang Zone is also outlined in the map, which can be further divided into the south part and the north part (also named Gan-Hang Belt).

1994; Jiang et al., 2009, 2011; Lapierre et al., 1997; Li and Li, 2007; Zhou and Li, 2000; Zhou et al., 2006).

The name "Shi-Hang Zone" has been proposed by Gilder et al. (1996) for a granitic belt from Hangzhou City through central Jiangxi Province to Guangxi Province in the interior of South China. It contains a number of NE-trending Mesozoic extensional basins and can be divided into the south part in the southern Hunan and northern Guangxi provinces and the north part in eastern Jiangxi and western Zhengjiang provinces (this part also called as Gan-Hang Belt). These basins underwent extension primarily in the Late Jurassic through Cretaceous (Gilder et al., 1991; Zhou and Li, 2000). The Shi-Hang Zone represents the northernmost boundary of the "Southeastern China Basin and Range Province" and is an important magmatic zone composed of granites with relative higher $\varepsilon_{Nd}(t)$ values and younger T^{S}_{DM} of Nd model ages (e.g. Gilder et al., 1996; Jiang et al., 2008; Xu, 2008; Zhou et al., 2006).

Recently a number of detailed investigations have been done on the geochronology and petrogenesis of the Late Mesozoic magmatic rocks from the south part of the Shi-Hang Zone (e.g. Chen and Jahn, 1998; Jiang et al., 2006, 2008, 2009). Their results show that the timing of the Late Mesozoic magmatic activity along the south part of the Shi-Hang Zone is Middle to Late Jurassic in age. Jiang et al. (2009) also suggested that during the Middle Jurassic SE China on the south part of the Shi-Hang Zone was a continental arc related to the subduction of the Palaeo-Pacific plate and since the beginning of Late Jurassic an intra-arc rift has been formed along the Shi-Hang Zone as a consequence of slab roll-back.

Precise and accurate isotopic age determination is crucial for understanding the relationships between emplacement of magmatic rocks and relevant tectonic events. *In situ* zircon U–Pb isotope systematic on magmatic rocks is often the means to attain a precise and accurate isotopic age and has been widely used. However, the