

Geochronological, geochemical and geothermal constraints on petrogenesis of the Indosinian peraluminous granites in the South China Block: A case study in the Hunan Province

Yuejun Wang^{a,b,*}, Weiming Fan^a, Min Sun^b, Xinquan Liang^a,
Yanhua Zhang^c, Touping Peng^a

^a Key Laboratory of Isotope Geochronology and Geochemistry, Guangzhou Institute of Geochemistry,
Chinese Academy of Sciences, Guangzhou 510640, China

^b Department of Earth Sciences, The University of Hong Kong, Pokfulam Road, Hong Kong

^c CSIRO Exploration and Mining, PO Box 1130, Bentley, WA 6102, Australia

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Abstract

The Indosinian granites in the South China Block (SCB) have important tectonic significance for the evolution of East Asia. Samples collected from Hunan Province can be geochemically classified into two groups. Group 1 is strongly peraluminous ($A/CNK > 1.1$), similar to S-type granites, and Group 2 has $A/CNK = 1.0–1.1$, with an affinity to I-type granites. Group 1 has lower $FeOt$, Al_2O_3 , MgO , CaO , TiO_2 and $\epsilon_{Nd}(t)$ values but higher $K_2O + Na_2O$, Rb/Sr , Rb/Ba and $^{87}Sr/^{86}Sr(t)$ than those of Group 2. Samples of both groups have similar LREE enriched pattern, with $(Eu/Eu^*) = 0.19–0.69$, and strongly negative Ba, Sr, Nb, P and Ti anomalies. Geothermobarometry study indicates that the precursor magmas were emplaced at high-level depth with relatively low temperature (734–827 °C). Geochemical data suggest that Group 1 was originated from a source dominated by pelitic composition and Group 2 was from a mixing source of pelitic and basaltic rocks with insignificant addition of newly mantle-derived magma. Eight granitic samples in Hunan Province are dated at the cluster of 243–235 and 218–210 Ma by zircon U–Pb geochronology. Together with recent zircon U–Pb ages for other areas in the SCB, two age-clusters, including 243–228 Ma just after peak-metamorphism (~246–252 Ma) and 220–206 Ma shortly after magma underplating event (~224 Ma), are observed. It is proposed that in-situ radiogenic heating from the over-thickened crust induced dehydrated reaction of muscovite and epidote/zoisite to form the early Indosinian granites in response to the isostatic readjustments of tectonically thickened crust. Conductive heating from the underplating magma in the postcollisional setting triggered the formation of late Indosinian granites. Such a consideration is supported by the results from FLAC numerical simulation.

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1. Introduction

South China Block (SCB) is composed of the Yangtze and outboard Cathaysian tectonic regions (or Yangtze and Cathaysian blocks). Indosinian granites

* Corresponding author. Current address: Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, P.O. Box 1131, Guangzhou 510640, People's Republic of China. Tel.: +86 20 85290527; fax: +86 20 85291510.

E-mail address: yjwang@gig.ac.cn (Y. Wang).

within the SCB have attracted considerable attentions since the “Indosinian movement”, which was also named Indosinian Orogeny originally recorded by unconformities between pre-Norian and pre-Rhaetian during Triassic in Vietnam (Deprat, 1914; Fromagat, 1932), was proposed (e.g., JXGBMR, 1984; Huang et al., 1987; HNGBMR, 1988; Ren, 1991; Chen and Jahn, 1998; Shen et al., 1998; Wang et al., 2002, 2003a,b,c; Deng et al., 2004; Qiu et al., 2004, 2005a,b,c). Previous studies showed that these granites are of large volume and mainly distributed in the central SCB (particularly in Hunan and Guangxi Provinces), far away from the continental margins (e.g., Huang et al., 1987; Chen and Jahn, 1998), and occur as laccoliths and batholiths along fault zones or fault intersections (JXGBMR, 1984; HNGBMR, 1988). These rocks were traditionally grouped as the Hercynian–Indosinian peraluminous S-type granites, and their high initial Sr isotopic ratios have been realized (Shen et al., 1998; Chen and Jahn, 1998).

However, due to the lack of precisely geochronological and systematically geochemical data, their petrogenesis remains poorly constrained and the tectonic implications have long been debated. Two controversial hypotheses have been proposed for the magma generation, including (i) the anatexis of thickened crust in the compressive setting due to the collision between the Yangtze and Cathaysian blocks probably along the Chenzhou–Linwu fault (e.g., Wang et al., 2003b, 2005b), and (ii) derivation of the newly underplating magma in response to upwelling asthenosphere.

The Indosinian granites were collected from Hunan Province for this study, where is the type region with predominant outcrops of the Indosinian granites in the SCB (e.g., Huang et al., 1987; HNGBMR, 1988; Wang et al., 2002, 2005a). Geochronological, elemental and Sr–Nd isotopic studies for these granites were conducted in order to better understand the petrogenesis and the implications on the Indosinian tectonic evolution of the SCB.

2. Geological setting, field relationships and petrography

The Yangtze and Cathaysian blocks in the SCB have distinctive crustal ages and tectonic histories (Huang et al., 1987; HNGBMR, 1988; Ren, 1991; JXGBMR, 1984). The basement of the Yangtze block consists of Archean rocks up to >3.2 Ga, with an average age of 2.7–2.8 Ga (Gao et al., 1999; Qiu et al., 2000). The basement of the Cathaysian block is dominantly Paleoproterozoic, with some late Achaean component

(~2.5 Ga; JXGBMR, 1989; Chen and Jahn, 1998). It is generally considered that the two blocks were amalgamated during the Jinningian (or Grenvillian) orogeny (e.g., Li et al., 2002). Subsequently, a failed rifting was developed roughly along the suture during the Neoproterozoic and Paleozoic, geographically through Hunan, Jiangxi, western Guangdong and eastern Guangxi Provinces. The failed rifting was manifested by the >13 km thick deposition of Neoproterozoic–Paleozoic abyssal marine carbonatitic/clastic sequence in the center and the 2–5 km shallow-sea carbonate deposits limited to the rifting margins (e.g., JXGBMR, 1984; HNGBMR, 1988; Wang and Li, 2003). These pre-Mesozoic sequences are overprinted by the Indosinian tectonothermal event and unconformably overlain by the lower Mesozoic terrestrial clastics (JXGBMR, 1984; HNGBMR, 1988). The Indosinian mafic magmatism is missing except for some gabbroic xenoliths (~224 Ma) hosted by Mesozoic basalts in Daoxian, southern Hunan Province (Guo et al., 1997).

The Indosinian granitic plutons predominantly outcrop in the failed rifting zone bounded by the Anhua–Luocheng and Heyuan–Guangfeng faults, geographically in the region between Xuefeng Mountains and Wuyi–Baiyun–Yunkai Mountains (Fig. 1a). These granites intruded the pre-Triassic strata as stocks and batholiths (JXGBMR, 1984; HNGBMR, 1988), and are mainly coarse- to medium-grained peraluminous granites and granodiorites with massive textures. The strongly peraluminous plutons in the Yunkai Mountains are dominantly muscovite-, garnet- and tourmaline-bearing leucogranites with gneissic texture, and cordierite is common but enclaves are rarely found (e.g., Deng et al., 2004). In contrast, the weakly peraluminous granites and granodiorites contain abundant angular to rounded enclaves, and hornblende is occasionally observed. Contacts with the country rocks are commonly sharp, but contact metamorphism is not prominent.

Hunan Province is the type region for distribution of the Indosinian granites in the SCB, where these plutons occupy areas of >5600 km² (HNGBMR, 1988). Previously geochronological studies (e.g., whole-rocks Rb–Sr, K–Ar and grain-zircon U–Pb methods) gave age-span of 163–267 Ma, mostly between 185 Ma and 235 Ma (HNGBMR, 1988). These granites in Hunan mainly outcropped in the region between the Chenzhou–Linwu and Anhua–Luocheng faults, and intruded the pre-Triassic sequences as stocks and batholiths (HNGBMR, 1988). The main plutons include Taojiang, Xiangzikou, Tangshi, Dingziwan, Dashenshan, Baimashan, Ziyunshan, Xiema, Tashan, Guandimiao, Wawutang,

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