Lithos 282–283 (2017) 403–419

Contents lists available at ScienceDirect

Lithos

journal homepage: www.elsevier.com/locate/lithos

Petrogenesis of two types of Late Triassic granite from the Guandimiao Complex, southern Hunan Province, China

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ARTICLE INFO

Article history:
Received 7 September 2016
Accepted 15 February 2017
Available online 31 March 2017

Keywords:
Zircon dating
Source rocks
Peraluminous and metaluminous granites
Microgranular enclaves
Guandimiao Complex

ABSTRACT

Two types of Late Triassic granite are found in the Guandimiao Complex of the South China Block (SCB). Here, we present new LA–ICP-MS zircon U–Pb ages as well as geochemical and Sr–Nd–Pb–Hf isotopic data in order to elucidate the genesis of these granites. The Guandimiao Complex, located in southern Hunan Province, consists dominantly of the Shizhuqiao two-mica alkali feldspar granite and the Jingtou hornblende-bearing biotite monzogranite. The latter contains abundant microgranular enclaves. Zircon U–Pb isotopic analyses show that the microgranular enclaves and the two types of granite were all emplaced during the Late Triassic (226–220 Ma). The Shizhuqiao peraluminous granite has high $(^{87}Sr/^{86}Sr)_i$ ratios (0.72173–0.72485), enriched $\varepsilon_{Nd}(t)$ and $\varepsilon_{Hf}(t)$ values (−9.6 to −9.4 and −10.5 to −5.5, respectively), and Pb isotopic compositions similar to those of the metamorphic basement of the Cathaysia Block (part of the SCB), implying derivation from the crust. The granite's low molar $CaO/(MgO + FeO^T)$ ratios and high molar $Al_2O_3/(MgO + FeO^T)$ ratios indicate a metasedimentary source. The Jingtou metaluminous granite exhibits $\varepsilon_{Hf}(t)$ values (−10.0 to −5.6) that are similar to those of the Shizhuqiao granite, but it has lower $(^{87}Sr/^{86}Sr)_i$ ratios (0.71326–0.71454) and higher $\varepsilon_{Nd}(t)$ values (−7.2 to −6.6). Its high ratios of molar $CaO/(MgO + FeO^T)$ and low ratios of molar $Al_2O_3/(MgO + FeO^T)$ suggest an amphibolitic source. The microgranular enclaves contain acicular apatite and are more mafic than their hosts. The combined textural, geochemical, and isotopic data indicate that the enclaves in the Jingtou granite originated from a more mafic crust-derived melt that was injected into the host felsic melt. The geochemical signatures indicate that the microgranular enclaves and the two types of coeval granite that constitute the Guandimiao Complex were derived from different source rocks. The Late Triassic granites in the SCB were emplaced in an extensional post-orogenic setting and related to underplating of mantle-derived magma.

1. Introduction

The South China Block (SCB) underwent two significant tectonic events in the Mesozoic: the Indosinian movement during the Triassic and the Yanshanian movement during the Jurassic–Cretaceous (Chen et al., 2005; Zhou et al., 2006). Large volumes of granitoid were generated during these events as well as associated W, Sn, Nb, Ta, Pb, and Zn polymetallic ore deposits (Hua et al., 2003; Mao et al., 2008). The Triassic granites are much smaller in total volume than the Jurassic and Cretaceous granites, and they are more scattered in their distribution (Fig.1b). Studies of the Triassic granites are important to understanding of the evolution of the SCB.

Many hypotheses have been proposed to explain the petrogenesis and tectonic setting of the Triassic granites in the SCB. In the collisional orogeny model, it is envisioned that the Triassic granites resulted from crustal anatexis (Hsü et al., 1988). Wang et al. (2007) considered that the S-type Triassic granites were derived from a metapelite-dominated source whereas the I-type granites were derived from a mixed metavolcaniclastic–metasedimentary source. Another model involved the generation of the Late Triassic granites as a result of underplating of basaltic magma, induced by extension and thinning of the lithosphere (Guo et al., 1997; Wang et al., 2002, 2003b, 2005). Zhou et al. (2006) further suggested that the Middle to Early Triassic granites were syn-collisional types while the Late Triassic granites were post-collisional types. Li and Li (2007) proposed a flat-slab subduction model for the Late Triassic granites based on the subduction of the

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http://dx.doi.org/10.1016/j.lithos.2017.02.021
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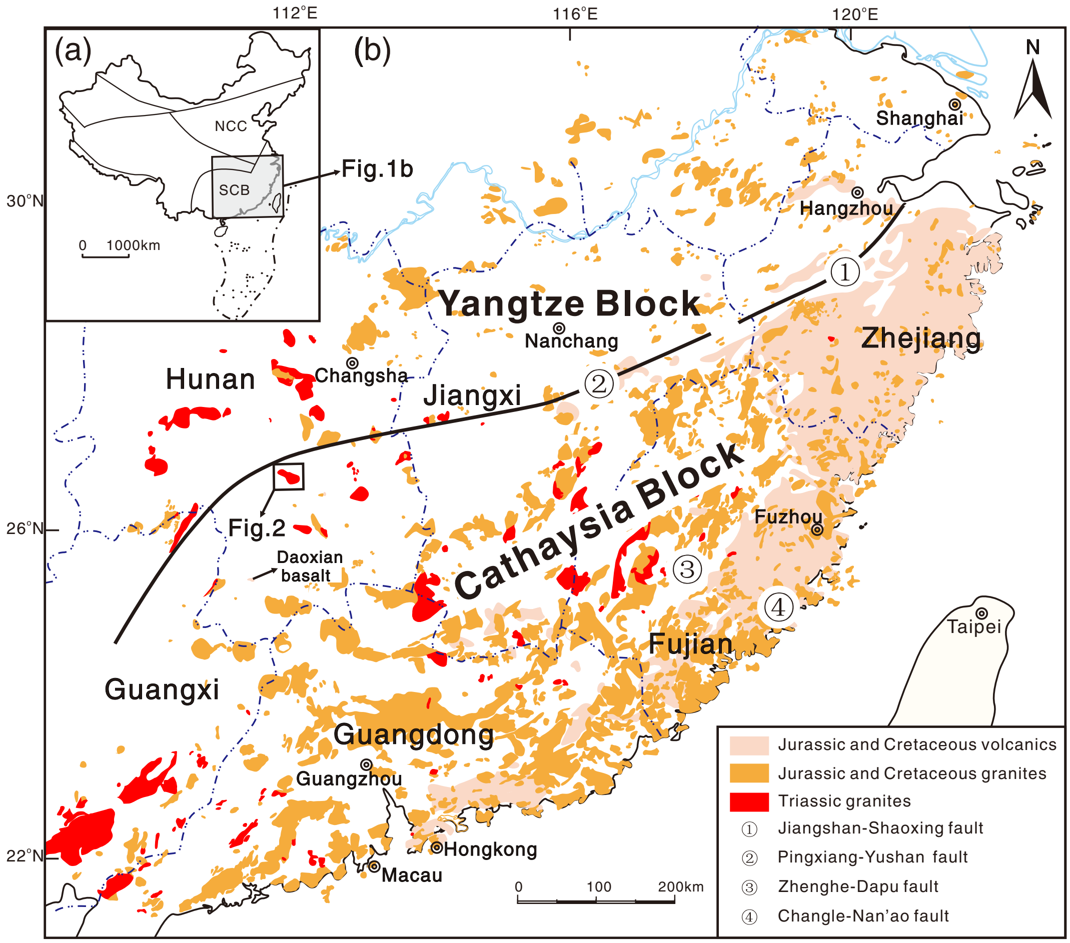

Fig. 1. Geological map of Mesozoic granitic plutons in South China. SCB = the South China Block; NCC = the North China Craton. (modified after Zhou et al., 2006)

Paleo-Pacific Plate beneath the SCB since ~265 Ma (Middle Permian). He et al. (2010a) considered that the Triassic S-type granites in western Cathaysia were produced by the melting of reworked Neoproterozoic crust.

The Guandimiao Complex, which is exposed in southern Hunan Province, consists dominantly of the Shizhuqiao two-mica alkali feldspar granite and the Jingtou hornblende-bearing biotite monzogranite, and previous studies have shown that the granites were intruded in the period 239–203 Ma (Chen et al., 2007b; Huang and Depaolo, 1989). Wang et al. (2007) and Zhao et al. (2015) conducted preliminary geochemical studies of the Jingtou granite, and provided some dating results, but as yet there has been no systematic investigation of the petrogenesis and tectonic setting of the two types of granite found in the Guandimiao Complex. In this paper, we focus on both the Shizhuqiao and Jingtou granites, as well as microgranular enclaves in the Jingtou granite, with the aim of revealing their emplacement ages and origins. A detailed study has been conducted on petrology, mineral chemistry, geochronology, whole-rock chemical compositions, and Sr–Nd–Pb–Hf isotopic geochemistry of the granites and the microgranular enclaves, thus shedding new light on the petrogenesis and tectonic setting of these Late Triassic granites in the SCB.

2. Geological background

The SCB is composed of the Cathaysia Block in the southeast and the Yangtze Block in the northwest, separated by the Jiangshan–Shaoxing and Pingxiang–Yushan faults (suture zones) (Fig. 1; Wang and Li, 2003). It is generally considered that the Cathaysia Block was amalgamated with the Yangtze Block during the Neoproterozoic (Li and McCulloch, 1996), and the two blocks have different tectonic histories and crustal basements (Qiu et al., 2000). The Cathaysia Block consists of a Proterozoic basement and a Sinian–Mesozoic sedimentary and volcanic cover (Chen and Jahn, 1998; Yu et al., 2007). The Yangtze Block consists of a late Archean to Proterozoic basement and a Sinian to Triassic sedimentary cover (Chen and Jahn, 1998).

The Triassic granites are distributed mainly in the interior of the SCB, occupying an area of about 14,300 km^2 (Fig. 1; Zhou, 2003). More than 90% of the granites are peraluminous S-type granites, with small amounts of I- and A-type granites (Zhou et al., 2006).

The Guandimiao Complex is located on the northwestern margin of the Cathaysia Block (Fig.1b). The outcrop of the elongate batholithic complex is rather like a gourd in shape, and it trends SE–NW, occupying an area of ~290 km^2. The batholitic complex intruded into Upper Sinian strata in the north and south, Lower–Middle Cambrian strata in the southeast, and Upper Cambrian and Lower Ordovician strata in the west (Fig. 2). The complex consists of a two-mica alkali feldspar granite in the Shizhuqiao area (hereafter called the "Shizhuqiao granite") and a hornblende-bearing biotite monzogranite in the Jingtou area (hereafter called the "Jingtou granite"). Microgranular enclaves are found in the Jingtou granite.

3. Petrography of the Guandimiao Complex

The Shizhuqiao two-mica alkali feldspar granite is grayish white, and has a fine-grained granitic texture and massive structure (Fig. 3a). The constituent minerals are mainly quartz (35–40%, in vol.% and similarly hereinafter), K-feldspar (42–50%), plagioclase (2–6%, with anorthite