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Petrogenesis of Cretaceous shoshonitic rocks in the northern Wuyi Mountains, South China: A result of the roll-back of a flat-slab?

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ABSTRACT

Potassic magmatism is commonly linked to post-/late-orogenic environments, such as foundering or convection thinning of continental lithosphere. Their petrogenesis is crucial for constraining the chemical and physical properties of the remnant sub-continental lithospheric mantle. Here we report new SHRIMP zircon U–Pb ages, whole rock geochemical results and Sr–Nd and zircon Hf isotope data from four potassic plutons (the Da'an, Yingcheng, Zixi and Honggong plutons) in the northern Wuyi Mountains, South China. SHRIMP U–Pb zircon analyses indicate that these potassic rocks formed at 139–126 Ma. They are characterized by high SiO_2 (56–73%) and K_2O (3.8–6.7%), with a K_2O/Na_2O ratio of 2.18–2.04, plotting within the field of high-SiO_2 shoshonites. Their I_{Sr} and εNd(t) values vary from 0.7077 to 0.7162 and −5.66 to −10.52, respectively. The initial zircon εHf(t) values range from 2.3 to −13.1, corresponding to T_{DM} modal ages between 707 and 1330 Ma. These geochemical and isotope characteristics indicate that these shoshonites derived from a subduction-modified ancient subcontinental lithospheric mantle, and then underwent significantly fractional crystallization of K-feldspar, plagioclase, and accessory minerals, such as apatite and Fe–Ti oxides during magma ascent. We interpret that asthenospheric mantle upwelling (caused by eastward roll-back of a flat-slab?) triggered partial melting of the metasomatized lithospheric mantle to result in the Early Cretaceous shoshonitic magmatism in the northern Wuyi Mountains. An integration of our new results with compiled data from the interior of the South China Block reveals that the arc-like geochemical signature is confined to the Wuyi Mountains region, but becomes little or even invisible toward inland in South China. This implies that the far-field effects of the early Mesozoic subduction only reached the Wuyi Mountains, ca. 500 km away from the trench, consistent with flat or shallow subduction models.

1. Introduction

Petrogenesis of potassic rocks from the Sierra Nevada of California, USA (Manley et al., 2000), the westernmost Mediterranean (Duggen et al., 2003, 2005), and Tibetan plateau (Chung et al., 1998; Turner et al., 1993; Williams et al., 2004) shows that small-volume potassic magmatic rocks with arc signatures are often attributed to low-degree melting of the remnant sub-continental lithospheric mantle caused by hot asthenosphere upwelling as a result of foundering or convection removal of continental lithosphere (e.g., Chung et al., 1998; Duggen et al., 2003, 2005; Kay and Kay, 1993; Manley et al., 2000; Turner et al., 1993, 1996; Williams et al., 2004). Therefore, potassic and/or shoshonitic rocks are usually regarded as an important petrological index for the foundering and/or thinning of the lithospheric mantle (Manley et al., 2000).

Late Mesozoic igneous rocks are widespread in southeastern China and cover an exposed area of ca. 218,000 km^2 (Zhou et al., 2006) (Fig. 1a). They are dominantly Jurassic (~190–155 Ma, known as the "Early Yanshanian" event) and Cretaceous (145–80 Ma, known as the "Late Yanshanian" event) in age (e.g. Cen et al., 2016; Li, 2000; Li et al., 2007; Zhou and Li, 2000; Zhou et al., 2006). The Jurassic igneous rocks are mainly distributed in the continental interior, consisting predominantly of bimodal volcanic/intrusive rocks (~190 Ma), as well as large granitic batholiths (165–155 Ma). The Cretaceous igneous rocks occur dominantly in the coast areas, east of the Wuyi Mountains, and are composed predominantly of felsic volcanic and intrusive rocks (>95%) plus minor mafic rocks. In addition, minor amounts of shoshonitic to ultra-potassic rocks are sporadically distributed from the interior of South China to the Wuyi Mountains region (Fig. 1a). These ultra-potassic to shoshonitic rocks were interpreted to be formed by partial melting of an enriched sub-lithospheric mantle owing to a raised geotherm caused by lithosphere thinning (Li et al., 2004a). However, the ages and petrogenesis of shoshonitic rocks in the northern Wuyi

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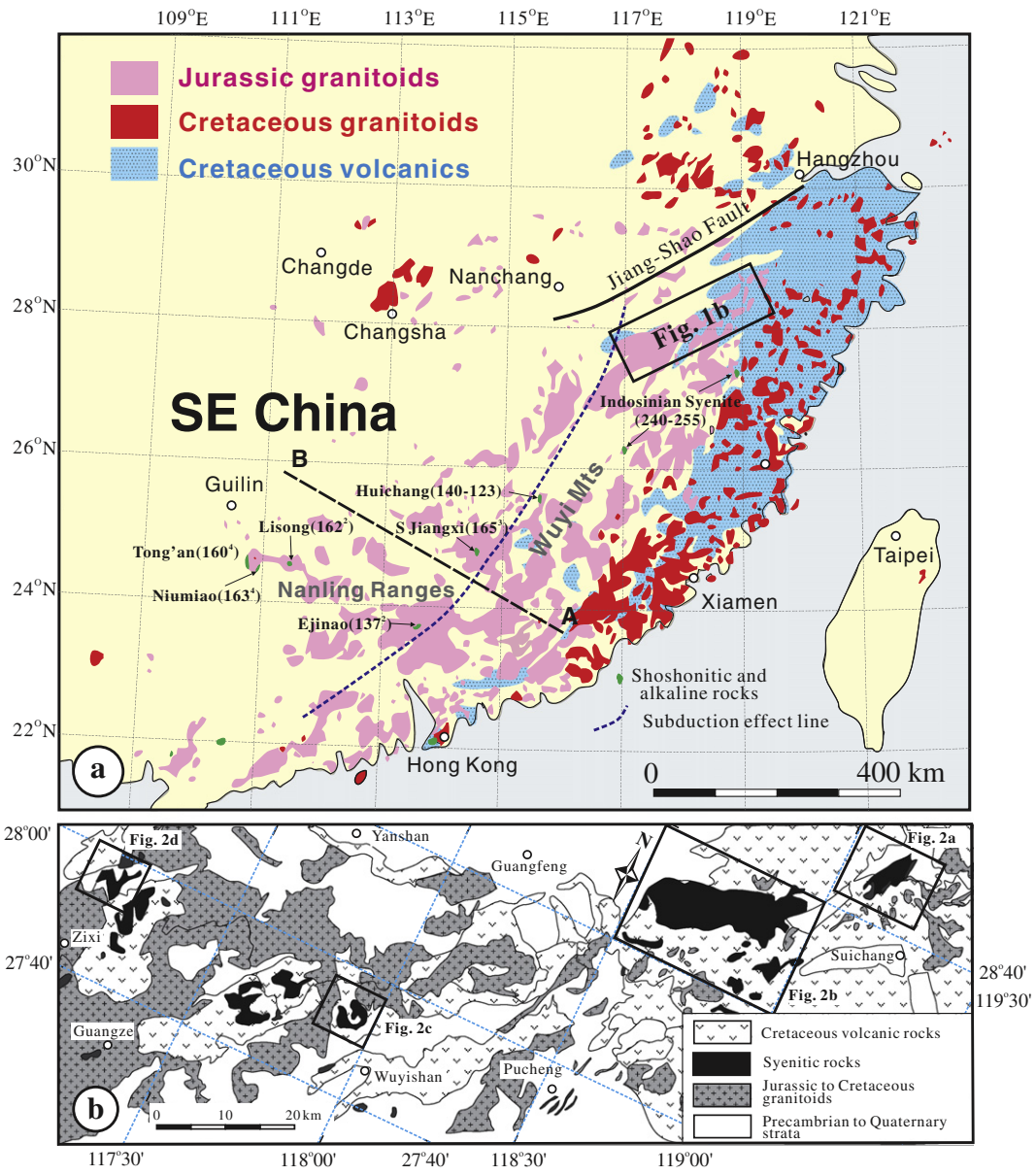

Fig. 1. (a) A simplified map showing the distribution of Late Mesozoic igneous rocks in Southeast China (modified after Li et al., 2007), and (b) locations of the shoshonitic plutons in the northern Wuyi Mountains region.

Mountains are still poorly constrained. In this paper, we report new SHRIMP U–Pb zircon age, zircon Hf isotope and whole rock geochemical results for these shoshonitic rocks, with the goal of investigating their origin and petro-tectonic implications.

2. Geological background

The South China Block consists of the Yangtze Block in the northwest and the Cathaysia Block in the southeast. The Jiangshan–Shaoxing Fault is conventionally regarded as the eastern boundary separating the two blocks. The Yangtze Block consists of dominant greenschist-facies metamorphic early Neoproterozoic arc volcanic rocks and rift-related sedimentary sequences (Li et al., 2008, 2009, 2010; Ye et al., 2007), whereas the Cathaysia Block mainly composes of high-grade metamorphic Paleoproterozoic to Neoproterozoic volcanic–sedimentary rocks (Li, 1997; Li et al., 2010; Yu et al., 2009). There are several small potassic plutons with hypabyssal to subvolcanic facies outcropped along the northern margin of the Wuyi Mountain region in the Cathaysia Block (Fig. 1a, b). For the exception of the Honggong pluton which has an outcrop area of over 450 km^2, the potassic intrusions are typically <100 km^2 each. In this paper, four potassic plutons were selected for detailed geochronology, geochemistry, and whole rock Sr–Nd and zircon Hf isotopic studies. They are, from east to west, the Yingcheng, Honggong, Da'an and Zixi plutons.

The Yingcheng pluton has an area of ~60 km^2 and is an amphibole–biotite-bearing quartz monzonite (Fig. 2a). Some dark elliptical enclaves, mostly between 10 and 15 cm in diameter, were observed occasionally in the quartz monzonite (Lu et al., 2006a). The quartz monzonite consists of about 35–40% K-feldspar, 40–45% plagioclase (An = 30–35), 5–8% quartz, 5–15% amphibole and biotite, as well as accessory minerals including zircon, apatite and Fe–Ti oxides. Most of the mafic minerals, i.e. biotite and amphibole, have been altered to chlorite. The mafic enclaves are monzodiorite, and have the same mineral assemblage as the quartz monzonite but have a higher percentage of mafic mineral. The pluton intrudes Precambrian metamorphic rocks, and faulted contact with Cretaceous volcanic rocks. A 141 ± 7 Ma whole rock Rb–Sr isochrone age is reported for this pluton (Lu et al., 2006a).