Earth-Science Reviews 128 (2014) 232–248

Contents lists available at ScienceDirect

Earth-Science Reviews

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

A review of the geochronology and geochemistry of Late Yanshanian (Cretaceous)plutons along the Fujian coastal area of southeastern China: Implications for magma evolution related to slab break-off and rollback in the Cretaceous

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ARTICLE INFO

Article history:
Received 20 August 2012
Accepted 21 September 2013
Available online 3 October 2013

Keywords:
Late Yanshanian plutons
Asthenospheric mantle upwelling
Slab break-off and rollback
Fujian coastal area
Southeastern China

ABSTRACT

The Cretaceous plutonic suites in the Fujian coastal area include abundant I-type and A-type granitoids and lesser gabbroids. They are important components of the Late Yanshanian magmatic belt along the southeastern coast of China, and define a linear NNE–SSW-trending belt of magmatism. Geochronological, geochemical and geological data from thirty intrusions are summarised in this paper, and the data provide distinct magmatic, geochemical and tectonic patterns in the area. A compilation of geochronological data for these intrusive rocks indicates emplacement mainly from around 125 to 90 Ma, with a major peak from 115 to 90 Ma, and a subordinate peak from 125 to 115 Ma. Besides their temporal and spatial coexistence, all these intrusive rocks have similar geochemical patterns which point to involvement of components from a depleted asthenospheric mantle source for the parental magmas, most probably by magma mixing. The first appearance of sparse I-type granitoids with post-collisional extensional granite affinities, and the emplacement of the Baijuhuajian and Suzhou A-type granites, mark the beginning of extension during the Early Cretaceous at ca. 125 to 119 Ma. The subsequent development of bimodal magmatism at 115 to 90 Ma, with numerous arc-related mafic gabbros and I-type granites, together with some A-type granites, suggests that this major igneous event took place as a response to back-arc extension. On the basis of petrology, geochronology, tectonics, and elemental and isotopic geochemistry, we speculate that break-off and rollback of the subducting Palaeo-Pacific Plate during the Cretaceous were responsible for the Late Yanshanian regional tectono-magmatic evolution in the area. We suggest that this process facilitated a strong and rapid linear upwelling of the asthenospheric mantle beneath the coastal area of southeastern China, with consequential extension of the overlying continental lithosphere, and ultimately the large-scale Late Yanshanian magmatism of the study area.

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0012-8252/$ – see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.earscirev.2013.09.007

1. Introduction

Located on the western Pacific margin, southeastern (SE) China is one of the major igneous provinces of the world, and an important part of the circum-Pacific magmatic belt. The Late Mesozoic geodynamic environment in SE China is interpreted to have been an active continental margin related to the subduction of the Palaeo-Pacific Plate beneath the Eurasian continent, triggering the widespread production of contemporaneous volcanic and intrusive rocks above the subduction zone (Maruyama and Seno, 1986; Lapierre et al., 1997; Maruyama et al., 1997; Xu et al., 1999; Li, 2000; Zhou and Li, 2000; Zhou and Chen, 2001). Previous studies of these igneous rocks have provided some petrological, geochemical and isotopic constraints on their origins and petrogenesis, as well as insights into the regional tectonic setting.

However, the Cretaceous tectono-magmatic evolution of SE China is still a subject of continuing debate (e.g. Charvet et al., 1994; Martin et al., 1994; Li, 2000; Zhou and Li, 2000; G.Q. Xie et al., 2006; X.M. Zhou et al., 2006; Li and Li, 2007; Wong et al., 2009; Liu et al., 2010). Taking into consideration the Cretaceous development of calc-alkaline magmatism in SE China, early workers suggested that a subduction-related compressive regime was dominant until the Late Cretaceous, when A-type granites were intruded along the Fujian coastal area (Jahn, 1974; Jahn et al., 1976; Huang et al., 1986; Charvet et al., 1994; Martin et al., 1994; Lan et al., 1996; Lapierre et al., 1997). But this model is now considered to be outdated, and has received little support as it evidently poses some problems (See Li, 2000, and references therein). Zhou and Li (2000) put forward a comprehensive model for the Mesozoic tectono-magmatic evolution of SE China involving a combination of lithospheric subduction and underplating of mafic magmas (the major mechanism responsible for the origin of Late Mesozoic magmatism), and changes in the subduction angle during Jurassic–Cretaceous magmatism. For nearly a decade, this model has appeared to be consistent with much of the geological, geochemical and geophysical data for the Late Mesozoic igneous rocks of SE China. More recently, however, the model has been challenged. Based on a newer compilation of isotope ages and geochemical data, Li and Li (2007) and Li et al. (2007) concluded that the temporal–spatial distribution of magmatism in SE China may not involve a simple coastward migration, as required by the changes in subduction angle in the model proposed by Zhou and Li (2000). As an alternative, Li and Li (2007) and Li et al. (2007) adopt the slab break-off and rollback mechanism to explain the development of Jurassic magmatism in SE China, and they speculated that the Jurassic–Cretaceous coastward migration of both the extensional and arc-related magmatism can be interpreted best by a retreating arc system.

The coastal area of Fujian province is situated along the southeastern edge of China, where the emplacement of voluminous Late Yanshanian (Cretaceous) volcanic–intrusive complexes formed a calc-alkaline volcanic–plutonic belt (Figs. 1 and 2). The acid and basic igneous plutons of the area offer excellent opportunities to investigate the origin and nature of Late Yanshanian magmatism (Fig. 3), as well as the regional tectonic setting of SE China at that time.

In this paper, we present a compilation of greatly improved geochronological and geochemical data for the Late Yanshanian granites and gabbro–granite complexes in the Fujian coastal area, with a special focus on up-to-date in situ zircon U–Pb and Lu–Hf isotopic data. This compilation provides us with a refined chronological and geochemical framework for these Late Yanshanian acid and basic igneous plutons, as well as the means to reevaluate the nature of the Cretaceous mantle beneath the Fujian coastal area, and to determine distinct tectonic, magmatic and geochemical patterns in the Cretaceous of SE China. Finally, more broadly, we try to reach a better understanding of the geodynamic processes that accompanied and followed the subduction of the Palaeo-Pacific Plate beneath the Eurasian continent.

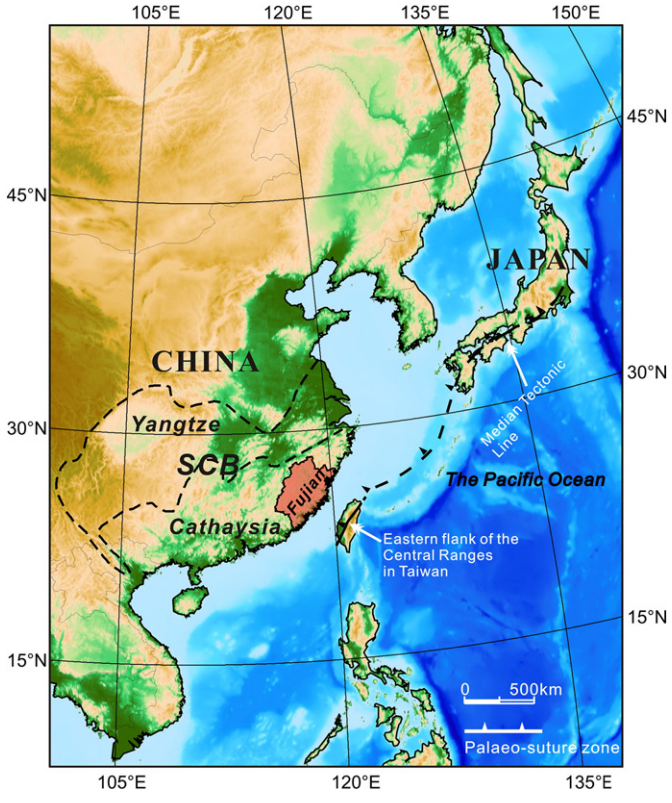

Fig. 1. Schematic tectonic map of SE China with a speculated location of palaeo-suture zone in Late Mesozoic subduction of the Palaeo-Pacific Plate beneath the Eurasian continent.

2. Geological background

To understand the development and evolution of the Late Yanshanian (Cretaceous) plutonism in Fujian, it is necessary to highlight some major aspects of general geology and the tectonic framework of the area. The Fujian province of SE China is within the Cathaysia Block, located in "the eastern part of the South China Block (SCB)" (Shu et al., 2008). As reviewed by Li et al. (2012a, and references therein), the Fujian province is conventionally subdivided into three main tectonic belts (from east to west): the Pingtan–Dongshan metamorphic belt (composed of Yanshanian regionally metamorphosed rocks, Mesozoic granites, volcanic rocks and mafic–ultramafic rocks), the Yanshanian magmatic belt (made up of Late Jurassic–Cretaceous granitic and volcanic rocks), and an Early Palaeozoic fold belt (developed on a Precambrian basement, which is overprinted by widespread Caledonian, Indosinian and minor Yanshanian magmatism). The three belts are separated from each other by two major NNE–SSW-trending faults: the Changle–Nan'ao and the Zhenghe–Dapu faults (Fig. 3, lower right inset).

The general pre-Yanshanian geology of Fujian province is characterised by accounts of geological record which attest to the Caledonian (Early Palaeozoic) and Indosinian (Early Mesozoic) orogenic events, especially in the Early Palaeozoic fold belt. For example, the Sinian–Lower Palaeozoic strata in the area are unconformably overlain by the Late Devonian conglomerates and coarse sandstones, deposited as a consequence of the Caledonian orogeny (Shu, 2006); and the regional Triassic–Early Jurassic angular unconformity in the area are regarded as the result of the Indosinian orogeny (Shu et al., 2008). Voluminous Caledonian and Indosinian peraluminous (usually S-type) granites, together with some Early Palaeozoic–Early Mesozoic I-type granites, are both exposed in the western Fujian. They are considered as a response to the tectonic change from compressive to local post-collisional extensional regime associated with the Caledonian and Indosinian orogenesis, respectively (Li et al., 2012b and references therein). In contrast, an extensional tectonic regime prevailed widely in the Late Mesozoic

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