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Petrogenesis and tectonic significance of the Eocene adakite-like rocks in western Yunnan, southeastern Tibetan Plateau

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ABSTRACT

Eocene magmatic rocks are widespread in western Yunnan, southeastern Tibetan Plateau. However, their petrogenesis and tectonic significance remain controversial. In this paper, we report geochemical and geochronological data of adakite-like rocks from the eastern part of western Yunnan. Zircon U–Pb dating reveals that they were emplaced at ca. 35 Ma. A geochemical study shows that these rocks have high SiO_2 (68.97–72.44 wt.%), K_2O (4.35–5.87 wt.%) and low MgO (0.61–1.16 wt.%), Y (6.65–12.6 ppm) and Yb (0.58–1.02 ppm) contents as well as high Sr/Y (74–228) and La/Yb (59–131) values, belonging to high-K calc-alkaline to shoshonitic adakite-like rocks. These rocks have high $(^{87}Sr/^{86}Sr)i$ (0.70623–0.70653), low $\varepsilon_{Nd}(t)$ (−4.5 to −7.5) and slightly low radiogenic Pb isotopic compositions with $(^{206}Pb/^{204}Pb)i = 18.042–18.179$. Zircons of these rocks show $\varepsilon_{Hf}(t)$ values ranging from −6.3 to +1.2 and model ages (T_{DM2}) of 1513–1035 Ma. The geochemical characteristics indicate that the Eocene adakite-like rocks from the eastern part of western Yunnan were derived from the partial melting of Neoproterozoic mafic rocks underplated in the lower crust of the western margin of the Yangtze Plate with input of mantle-derived potassic–ultrapotassic melt. Integration of published geochemical data clearly shows that zircon $\varepsilon_{Hf}(t)$ and whole-rock $\varepsilon_{Nd}(t)$ values of Eocene adakite-like rocks from the whole western Yunnan exhibit a trend of westward increase. We infer that the adakite-like rocks from the western part of western Yunnan were derived from the partial melting of late Paleozoic–Mesozoic mafic rocks formed as the lower crust of a continental magmatic arc during eastward subduction of the Paleo-Tethyan Ocean, and the Eocene magmatic rocks in western Yunnan were generated during the removal of thickened continental lithosphere triggered by the India and Asia collision.

1. Introduction

Cenozoic (50–0 Ma) magmatic rocks are widespread in the Tibetan Plateau and its surrounding regions (Chung et al., 2005; Guo et al., 2005; Wang et al., 2005; Campbell et al., 2014). These rocks are linked with the India–Asia collision that resulted in the formation of the Plateau (Yin and Harrison, 2000; Chung et al., 2005; Huang et al., 2010). Thus, understanding the petrogenesis and geodynamics of the Cenozoic magmatism may provide important constraints on the formation and evolutionary history of the Tibetan Plateau.

An Eocene–Oligocene potassic to ultrapotassic magmatic suite is widely distributed across the Eastern Qiangtang–Simao Block and the western margin of the Yangtze Plate in southeastern Tibet (Fig. 1a; Huang et al., 2010 and references therein). The rock suite consists of mafic to felsic rocks (Chung et al., 1998). The mafic rocks are generally considered to be derived from the metasomatized lithospheric mantle source (e.g., Xu et al., 2001; Li et al., 2002; Guo et al., 2005; Huang et al., 2007, 2010; Jia et al., 2013). The felsic rocks, including granitic and syenitic rocks, are closely related to the Cu–Mo–Au deposits (Hou et al., 2004a), and their petrogenesis and geodynamic mechanism remain hotly debated. For example, their sources have been speculated as asthenospheric mantle (Xie and Zhang, 1995; Zhang and Xie, 1997), enriched mantle (Xia et al., 2007; Xiao et al., 2009), thickened mafic lower crust (Zhao et al., 2004; Lu et al., 2013a, b), or the mixture of lower crustal and upper mantle materials in the crust–mantle transition zone (Deng et al., 1998a, b). The proposed tectonic models include: (1) activation of the Ailaoshan–Red River (ASRR) shear zone (Guo et al., 2005; Jiang et al., 2006; Liang et al., 2007; Zhu et al., 2013); (2) subduction of the continental lithosphere (Deng et al., 1998a, b; Wang et al., 2001; Campbell et al., 2014); (3) convective removal of the thickened continental lithospheric mantle (Chung et al., 1997, 1998; Lu et al., 2012, 2013a, b; Deng et al., 2014; Yang et al., 2014); (4) intraplate extension (Chung et al., 2005; Huang et al., 2010); and (5) asthenospheric mantle diapir (Hou et al., 2006). More importantly, spatial changes of the geochemistry and petrogenesis of the Cenozoic felsic rocks were not involved in previous studies.

In this paper, we conduct a petrological, zircon U–Pb dating and Hf isotopic and Sr–Nd–Pb isotopic study for the Eocene adakite-like rocks

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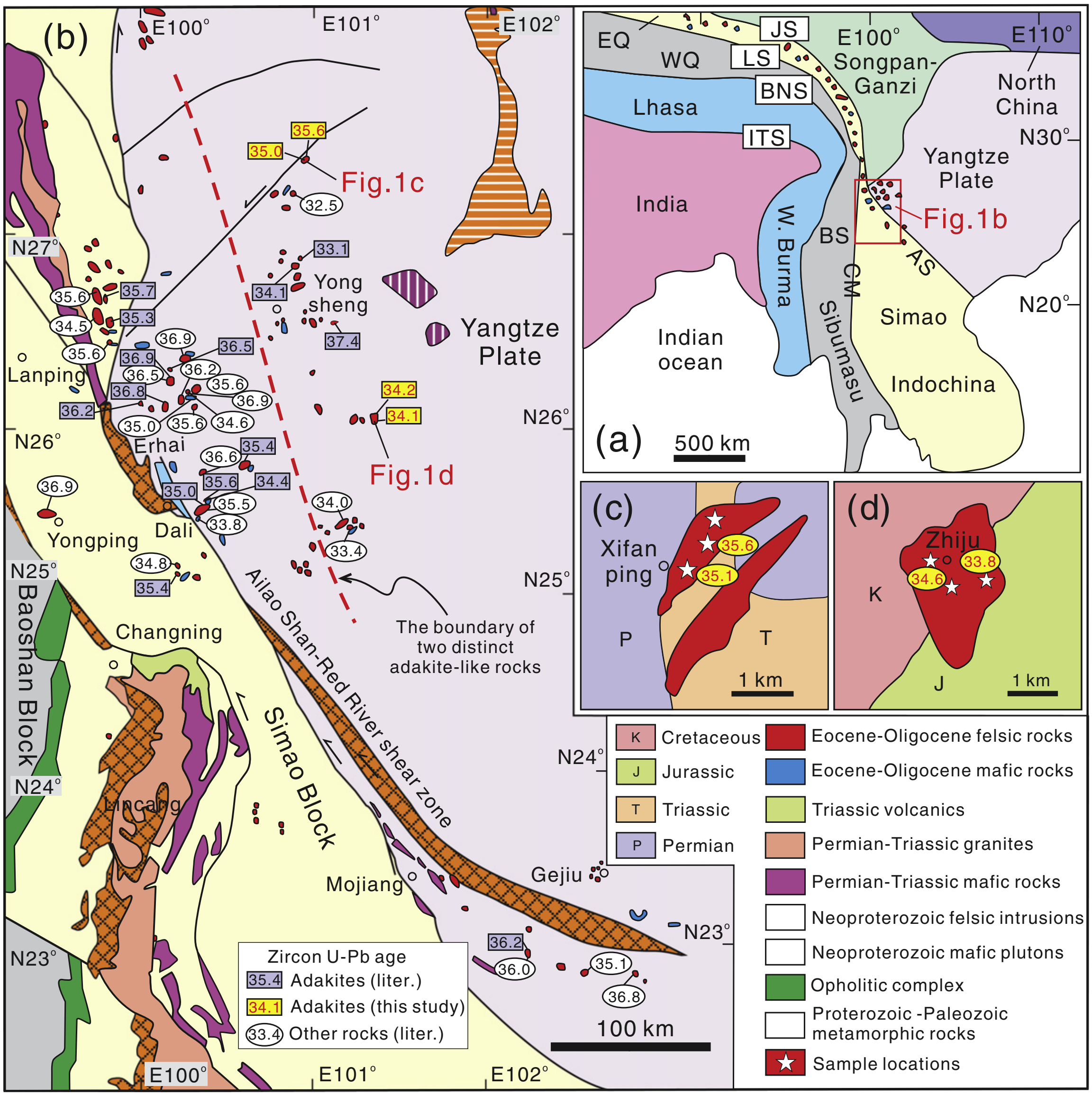

Fig. 1. (a) Simplified geological map of the eastern Tibetan Plateau, showing the distribution of Cenozoic potassic igneous rocks along the Jinsha suture zone (modified after Deng et al., 2014). EQ, Eastern Qiangtang; WQ, Western Qiangtang; BS, Baoshan; JS, Jinsha suture zone; LS, Longmu Tso–Shuanghu suture zone; BNS, Bangong–Nujiang suture zone; ITS, Indus–Tsangpo suture zone; CM, Changning–Menglian suture zone; AS, Ailaoshan–Song Ma suture zone. (b) Simplified geological map of western Yunnan (modified after Huang et al., 2008; Wang et al., 2010; Zhao and Zhou, 2008), showing the distribution of Eocene felsic and mafic rocks and U–Pb zircon ages for some rocks. The related age data are from Ding et al. (2012), He et al. (2014), Jia et al. (2013), Liang et al. (2007), Lu et al. (2012), Zhu et al. (2013) and this study. (c and d) Sketch geological maps of the Xifanping and Zhiju intrusive rocks, showing the locations of the studied samples.

from the eastern part of western Yunnan. Based on the integration of available geochemical data, we reveal spatial changes of Hf and Nd isotopic compositions of the Eocene adakite-like rocks from the whole western Yunnan, and suggest a possible petrogenetic model related to different components of the lower crust of western Yunnan. The present results not only help to elucidate the origin of Eocene magmatic rocks in western Yunnan, but also contribute to a better understanding of tectonic evolution of the southeastern Tibetan Plateau.

2. Geological background and petrography

The Tibetan Plateau consists of the Songpan–Ganzi flysch complex, Eastern Qiangtang, Western Qiangtang, Lhasa terranes and the Himalayas from the north to south (Fig. 1a; Yin and Harrison, 2000). They are separated by the Jinsha, Longmu Tso–Shuanghu, Bangong–Nujiang and Indus–Tsangpo suture zones. In western Yunnan, the Ailaoshan–Song Ma (AS) suture zone, representing the southern extension of the Jinsha suture zone, separates the Yangtze Plate in the east from the Simao Block in the west (Chung et al., 1997). The Simao Block, representing the northern segment of Indochina (Metcalfe, 2011), is separated from the Baoshan Block to the west by the Changning–Menglian (CM) suture zone (Fig. 1a). The Simao Block consists of the Proterozoic metamorphic basement, Paleozoic metasedimentary rocks, Permian to Triassic magmatic rocks and middle Triassic to Cenozoic sediments (Li et al., 2012 and references therein). The most remarkable geological feature of the Simao Block is the widespread occurrence of Permian–Triassic magmatic rocks (Fig. 1b). The voluminous Lincang batholith consists of monzonitic K-feldspar granite and granodiorite, with predominant ages of 230–220 Ma (Peng et al., 2013 and reference therein). Late Triassic (230–210 Ma) basalt, andesite and rhyolite (Wang et al., 2010; Peng et al., 2013) well as early Permian (298–280 Ma) arc-like gabbro, diorite and granodiorite (Jian et al., 2009; Li et al., 2012) occur to the east of the Lincang batholith (Fig. 1b).