Gondwana Research 41 (2017) 65–76

Contents lists available at ScienceDirect

Gondwana Research

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

Miocene adakitic intrusions in the Zhongba terrane: Implications for the origin and geochemical variations of post-collisional adakitic rocks in southern Tibet

Yalin Li *, Xiaohan Li, Chengshan Wang, Yushuai Wei, Xi Chen, Juan He, Ming Xu, Yunling Hou

State Key Laboratory of Biogeology and Environmental Geology, Research Center for Tibetan Plateau Geology, School of Earth Sciences and Resources, China University of Geosciences, Beijing 100083, China

ARTICLE INFO

Article history:
Received 3 May 2015
Received in revised form 9 September 2015
Accepted 14 September 2015
Available online 19 October 2015

Keywords:
Tibetan plateau
Zhongba terrane
Adakitic rocks
Petrogenesis
Lower crust

ABSTRACT

Post-collisional adakitic rocks (26–9 Ma) have been recognized in southern Tibet for almost 20 years; however, their origins and geodynamics remain highly controversial. This paper reports geochronological and geochemical data for the Lasa intrusion exposed in the Zhongba terrane and proposes implications for the origins of the Miocene adakitic rocks in southern Tibet. The Lasa intrusion consists of granite and granodiorite porphyries with zircon U–Pb ages of ca. 16 Ma. The porphyries have high SiO_2 (65.14–67.61 wt.%), Al_2O_3 (15.13–16.10 wt.%), K_2O (2.87–3.54 wt.%), and Sr (727–1046 ppm) contents and low Y (9–13 ppm) and Yb (0.82–1.19 ppm) contents. They are enriched in light rare earth elements (LREEs) and depleted in heavy rare earth elements (HREEs). The porphyries display relatively low MgO contents (1.39–1.98 wt.%), high Sr/Y (65–98) and $(La/Yb)_N$ (18.8–25.5) ratios, initial $(^{87}Sr/^{86}Sr)_i$ ratios of 0.70912–0.70805, $\varepsilon_{Nd}(t)$ values of −6.4 to −7.9, $(^{206}Pb/^{204}Pb)_t$ ratios of 18.7108–18.7665, $(^{207}Pb/^{204}Pb)_t$ ratios of 15.6837–15.7118, and $(^{208}Pb/^{204}Pb)_t$ ratios of 39.1600–39.3034. These signatures indicate that the Lasa porphyries are adakitic rocks derived from the partial melting of a thickened lower crust. The Miocene adakitic rocks in the Zhongba terrane have similar Sr–Nd isotopic compositions to those of western Lhasa and the Himalaya terrane, which differ from coetaneous adakitic rocks of the eastern Lhasa terrane in terms of Sr–Nd isotopic compositions. Based on the spatial distributions and isotopic features of the post-collisional adakitic rocks in southern Tibet, we suggest that all of the adakitic rocks were derived from the partial melting of thickened lower crust and that their geochemical variations are mainly caused by the heterogeneity of lower crust.

1. Introduction

The Himalayan–Tibetan orogen, a typical example of a collisional belt, was considered to be the result of the continued convergence between the Indian and Eurasian continents following their initial collision approximately 55–50 Myr ago (Yin and Harrison, 2000; Tapponnier et al., 2001; DeCelles et al., 2002; Dupont-Nivet et al., 2007; Meng et al., 2013; Replumaz et al., 2014; Wang et al., 2014; Li et al., 2015). The crustal thickening and uplift of the Tibetan plateau are long-standing problems in the geological evolution of the Himalayan–Tibetan orogen. An understanding of the post-collisional magmatism is crucial to understand the mechanism of the crustal thickening and should provide important constraints on both the evolution and geodynamics of the Tibetan plateau (Turner et al., 1996; Williams et al., 2004; Mo et al., 2008a; Zhu et al., 2009a).

Miocene adakitic rocks are the most distinguished post-collisional magmatism in southern Tibet and are widely distributed along the southern Lhasa terrane and the Indus–Yarlung Zangbo suture, with a total length of more than 1100 km (Fig. 1A) and ages ranging from 26 to 9 Ma (Chung et al., 2003; Hou et al., 2004; Gao et al., 2007; Guo et al., 2007; King et al., 2007; Chung et al., 2009; Xu et al., 2010). Although the ages and distributions of the Miocene adakitic rocks have long been recognized, their origins and geodynamics are still controversial. Thus far, four models have been proposed for the origins of the post-collisional adakitic rocks. These include 1) partial melting of subducted oceanic crust with minor melts of sediments and mantle wedge components (Qu et al., 2004); 2) partial melting of the thickened lower crust of the Lhasa terrane (Chung et al., 2003; Hou et al., 2004; Guo et al., 2007; Chung et al., 2009; Hou et al., 2011; Guan et al., 2012; Zheng et al., 2012; Yang et al., 2015), where the adakitic rocks of the Himalaya terrane indicate that mid-lower crust material from the Lhasa terrane extended into the Himalaya terrane via ductile flow in the mid-lower crust (King et al., 2007; Chen et al., 2011); 3) partial melting of enriched mantle metasomatized by slab-derived adakitic melts (Gao et al., 2007, 2010); and 4) partial melting of subducted Indian continental crust (Xu et al., 2010; Jiang et al., 2011).

Regardless of which genesis model is correct, these adakitic rocks record deep dynamic processes of the Himalayan–Tibetan orogen and

* Corresponding author. Tel.: +86 10 82321586; fax: +86 10 8232217.
E-mail address: liyalin@cugb.edu.cn (Y. Li).

http://dx.doi.org/10.1016/j.gr.2015.09.004
1342-937X/

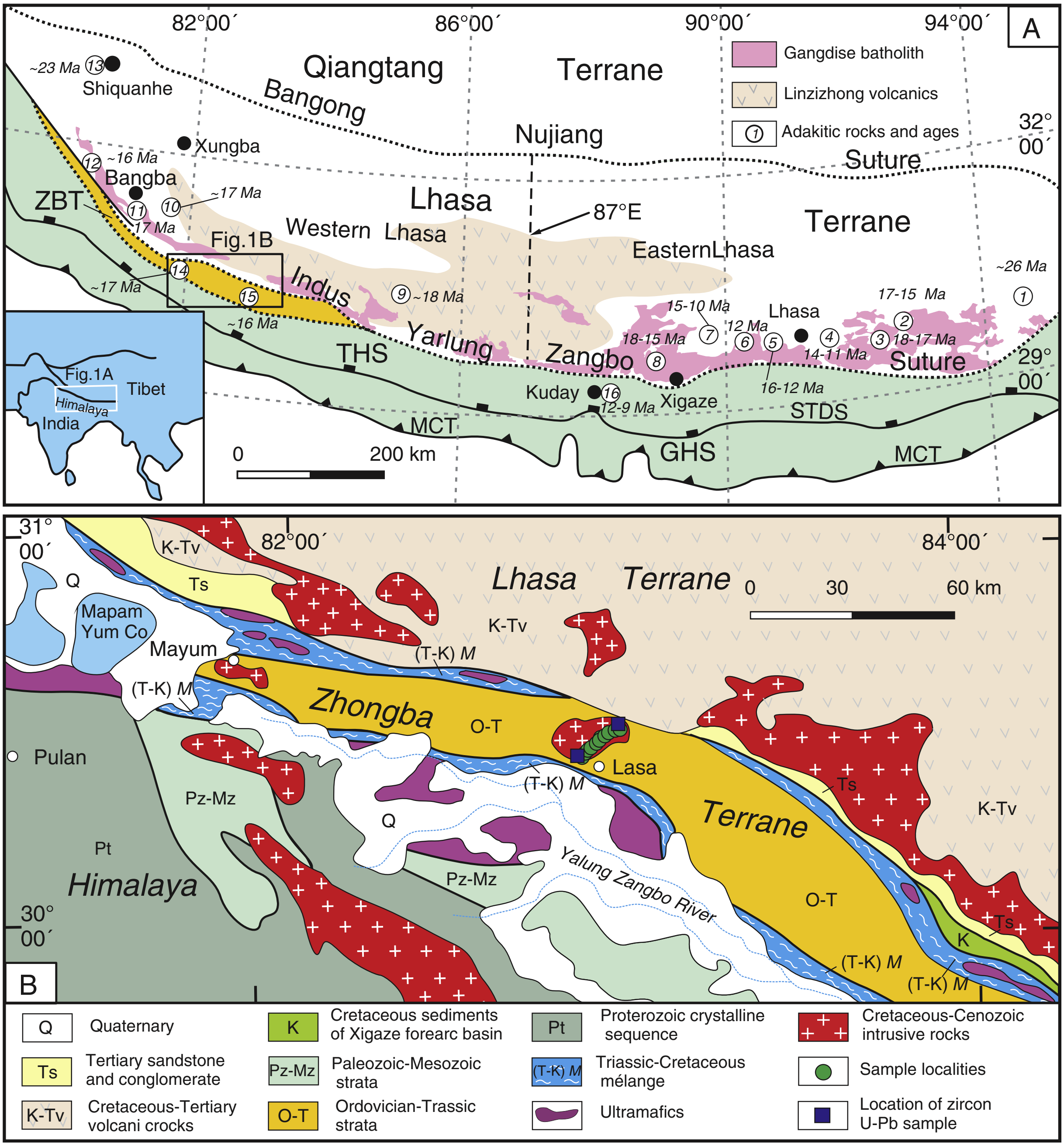

Fig. 1. (A) Distribution of major adakitic rocks (26–10 Ma) and their ages in southern Tibet and the Tethyan–Himalayan zone (modified after Chen et al., 2011). (B) Geological map of the Lasa-Pulan area. STDS, South Tibet detachment system; THS, Tethyan–Himalayan sequence; GHS, Greater Himalayan sequence; MCT, Main Central thrust; ZBT, Zhongba terrane. The followings are the main adakitic rocks. 1, Linzhi (Chung et al., 2003); 2, Jiama (Hou et al., 2004); 3, Qulong (Hou et al., 2004); 4, Lakang'e (Qu et al., 2004); 5, Nanmu (Hou et al., 2004; Chen et al., 2011); 6, Nimu (Hou et al., 2004; Chen et al., 2011); 7, Maquiang (Turner et al., 1996); 8, Xigaze (Chung et al., 2003); 9, Daggyaio Tso (Williams et al., 2004); 10, Manasarowar and Gegar (Miller et al., 1999); 11, Bangba (Chen et al., 2011); 12, Shiduo (Cai et al., 2005); and 13 Shiquanhe (Guo et al., 2007). The adakitic rocks in the Zhongba terrane are as follows: 14 Mayum (Jiang et al., 2006) and 15 Lasa (this study). The 16 Kuday is adakitic rocks in the Tethyan–Himalayan zone (King et al., 2007).

will provide great insights into the evolution of the Tibetan plateau. The poor constraints on their origin and geodynamic implications can be attributed to an incomplete understanding of the componential and spatial variability of these adakitic rocks. In this study, we report geochronological and geochemical data for adakitic rocks from the Lasa area of the Zhongba terrane (Fig. 1A). In addition, we summarize the geochemical variations of the post-collisional adakites in the Zhongba terrane, the eastern and western Lhasa terranes, and the Tethyan–Himalayan zone to provide new insights into the origins of these adakitic rocks and their correlations with the evolution of the Himalayan–Tibetan orogen.

2. Geological background

The Himalayan–Tibetan orogen is composed of four terranes, including the Songpan–Ganzi, Qiangtang, Lhasa, and Himalaya from north to south. These terranes are separated by the Jinsha, Bangong–Nujiang and the Indus–Yarlung Zangbo suture zones, representing Paleo-, Meso-, and Neo-Tethyan oceanic relicts, respectively. The Indus–Yarlung Zangbo suture (YZSZ), with a length of over 2000 km, is the youngest and southernmost suture in the Himalayan–Tibetan orogen. Deep-sea sedimentary sequences and ophiolitic fragments found along the YZSZ are considered to be the remnants of the Neo-Tethyan