Journal of Asian Earth Sciences 105 (2015) 32–47

Contents lists available at ScienceDirect

Journal of Asian Earth Sciences

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

Petrogenesis and geodynamic implications of the Mid-Triassic lavas from East Kunlun, northern Tibetan Plateau

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ARTICLE INFO

Article history:
Received 5 September 2014
Received in revised form 3 March 2015
Accepted 5 March 2015
Available online 11 March 2015

Keywords:
Volcanic rocks
Geochronology
Middle Triassic
Subduction
East Kunlun

ABSTRACT

Lying in the northern margin of the Tibetan Plateau, the East Kunlun Orogenic Belt (EKOB) is characterized by widespread of the late Permian to Late Triassic magmatic rocks. In order to better understand magma genesis and evolution during the waning stage of the Paleo-Tethyan oceanic subduction and subsequent collision, we present zircon U–Pb dating and Lu–Hf isotopes, whole-rock major and trace elements, and Sr–Nd isotope data for the Triassic volcanic lavas in the Haishigou area of the EKOB, northern Tibet. Lithologically, the Haishigou volcanic lavas are mainly composed of dacites and rhyolites. The LA–ICP–MS zircon U–Pb analyses for rhyolites have shown that the Haishigou volcanic rocks formed during the Middle Triassic with ages of ca. 244–245 Ma. The Haishigou volcanic lavas actually belong to part of the Middle Triassic Naocangjiangou Formation, rather than the Late Triassic Elashan Formation. Geochemically, Haishigou volcanic lavas have SiO_2 = 60.31–76.19 wt% and K_2O = 2.60–4.18 wt%, placing them in high-K calc-alkaline series. These lavas are characterized by enrichment in some large-ion lithophile elements (e.g., Rb, K and Pb) and light rare earth elements and depletion in some high field strength elements (e.g., Nb, Ta, and Ti), with geochemical affinities to those rocks forming in a continental or an oceanic arc setting. All the volcanic rocks exhibit high initial $^{87}Sr/^{86}Sr$ ratios (0.70614–0.70841) and moderately negative $\varepsilon_{Nd}(t)$ values (−5.9 to −4.3) that imply a continental rather than oceanic type magma source. The rhyolites in the Haishigou volcanics exhibit moderately negative to slightly positive $\varepsilon_{Hf}(t)$ values (−4.2 to 1.4). Combined with their zircon Hf two-stage model ages of 1187–1538 Ma and whole-rock Nd two-stage model ages of 1.37–1.38 Ga, it can be inferred that the crustal growth of East Kunlun occurred during the Mesoproterozoic, making them similar in age to the lower crust metamorphic basement beneath the EKOB (i.e., the Xiaomiao Group). We suggest that the Haishigou dacites were generated by partial melting of the mafic lower crust beneath the EKOB with addition of a mantle-derived mafic component and that the rhyolites were produced by fractional crystallization from a dacitic parent. Taking into account the Late Permian to Triassic geological record from the EKOB and surrounding regions, we argue that the Middle Triassic volcanic rocks in the Haishigou area erupted during the northward subduction of the Paleo-Tethyan oceanic plate. Consequently, the timing of closure of the Paleo-Tethyan Ocean just south of the EKOB is no earlier than the Middle Triassic.

1. Introduction

Dacitic to rhyolitic volcanic rocks often erupt in orogenic belts (e.g., Guo et al., 2014), and the origin of these rocks is very complicated and can involve complex interplay among several processes (Smith and Leeman, 1987). Various petrogenetic models have been proposed to explain the formation of dacitic to rhyolitic volcanic rocks including (1) extensive fractional crystallization processes from basaltic magmas, with or without concomitant crustal contamination (DePaolo, 1981; Bacon and Druitt, 1988; Singer et al., 1992; An et al., 2013; Kang et al., 2014), (2) partial melting of the mantle wedge, fluxed by a veneer of sediment or a slab-derived H_2O-rich component (Grove et al., 2002; Prouteau and Scaillet, 2003; Wang et al., 2011a), (3) partial melting of a mafic protolith in the lower crust (Smith and Leeman, 1987; Yamamoto, 2007; Dong et al., 2014; Yu et al., 2014), (4) magma mixing of rhyolitic and basaltic magmas (Eichelberger, 1975; Gerlach and Grove, 1982; Montanini et al., 1994), (5) formation of compositional gradients in response to convective and diffusive processes in evolving chambers (Smith and Leeman, 1987, and references therein), and (6) partial melting of the basaltic portion of the subducted oceanic lithosphere (Defant and Drummond,

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http://dx.doi.org/10.1016/j.jseaes.2015.03.009
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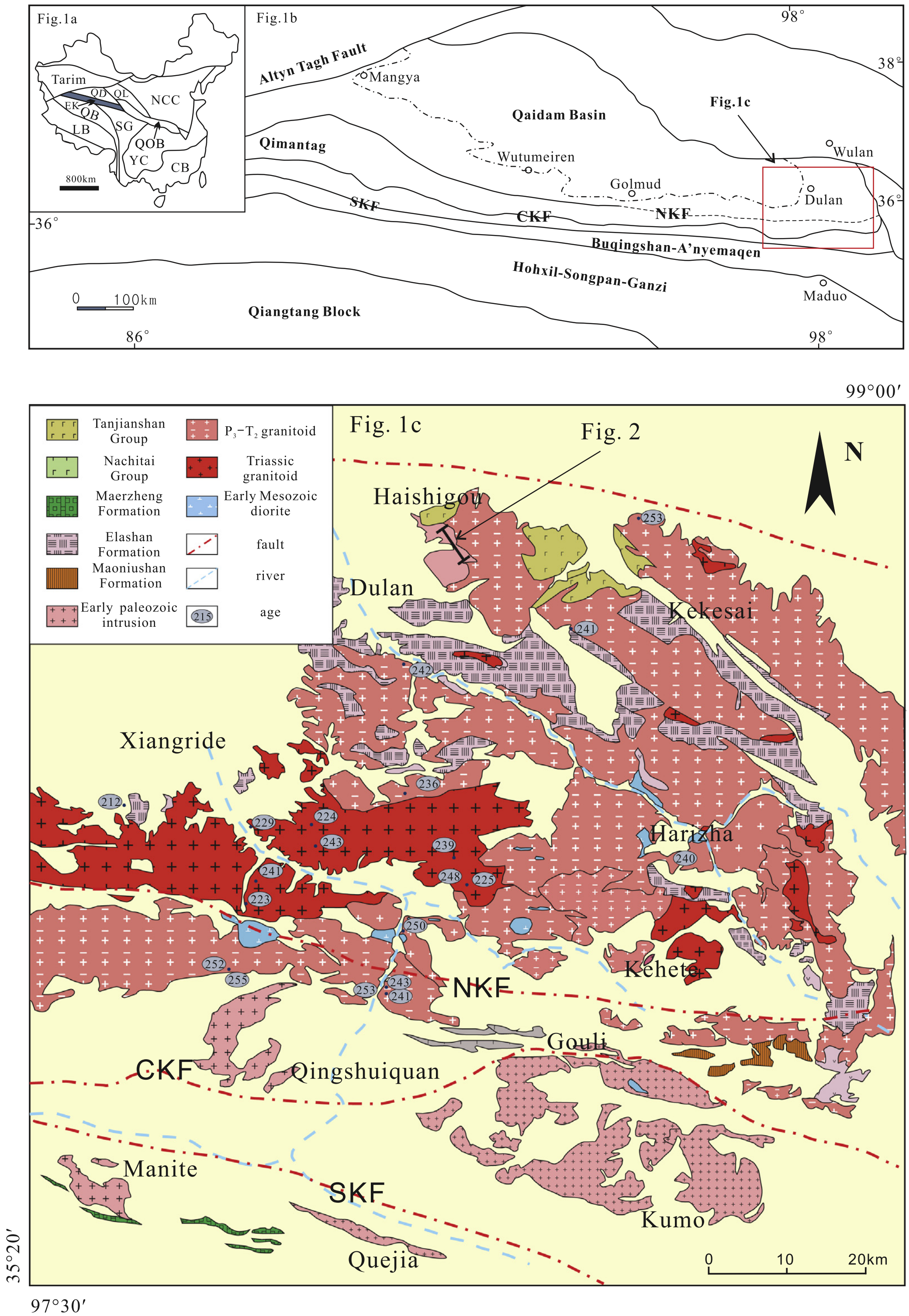

Fig. 1. (a) Schematic map showing major tectonic units of China. CB: Cathaysia Block; EK: East Kunlun; LB: Lhasa Block; NCC: North China Craton; QB: Qiangtang Block; QD: Qaidam; QL: Qilian; QOB: Qinling Orogenic Belt; YC: Yangtze Craton, (b) schematic map displaying three sub-tectonic zones of East Kunlun and (c) simplified geological map of the eastern segment of East Kunlun. Age data are cited from Liu et al. (2004), Sun et al. (2009), Ding et al. (2011), Chen et al. (2012), Huang et al. (2014), Luo et al. (2014), Xiong et al. (2014) and references therein.

1990; Kay et al., 1993; Drummond et al., 1996). Apart from this debate over their origin, the intermediate to felsic volcanic rocks can also provide valuable clues for crustal growth and tectonic evolution (Wang et al., 2011b; Dong et al., 2014).

The East Kunlun Orogenic Belt (EKOB) is characterized by immense volumes of Indosinian granitoids and minor coeval extrusive counterparts (Mo et al., 2007a). These volcanic rocks constitute the major part of the Early Mesozoic Naocangjiangou Formation and Elashan Formation of the EKOB (Wang, 1984; Ni, 2010; Wu et al., 2010; Lu et al., 2012). Based on the types of fossils and minor amounts of K–Ar and U–Pb age data, rhyolites in the Naocangjiangou Formation were considered to form in the