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Geochronology, geochemistry and petrogenesis of Early Permian alkaline magmatism in the Eastern Tianshan: Implications for tectonics of the Southern Altaids

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ABSTRACT

In the early Permian large volumes of volcanic rocks developed in the Eastern Tianshan of the southern Altaids. The Shaerhu alkaline complex, which occurs along a NW-trending transcurrent fault in the Dananhu arc, is composed of alkaline gabbro intrusions, granites and rhyolites; the gabbros and rhyolites have similar zircon crystallization ages of 286.5 ± 2.1 Ma and 286.7 ± 2.1 Ma, respectively. The granitic and rhyolitic rocks have typical A-type granite geochemical signatures, i.e. high oxide ratios (in wt.%): $K_2O + Na_2O$, $(K_2O + Na_2O)/CaO$, K_2O/MgO, and SiO_2, high trace element values: Zr, Nb, Ga, Ce, Y, and REE, and high Zr + Ce + Y, and 10,000 * Ga/Al ratios. However, spidergrams and REE patterns indicate major depletions in Ba, Sr, P, Ti and Eu. The presence of positive $\varepsilon_{Nd}(t)$ values of +7.0 to +11.2 and low $(^{87}Sr/^{86}Sr)_i$ (0.70148–0.70416) indicates that these alkaline rocks were derived from a depleted mantle, and not from old continental crust. The geochemical characters indicate that the rocks of the complex have the same source and that fractionation was important in their generation. A-type granitic rocks are the most highly fractionated of alkaline basic rocks. In summary, the Shaerhu complex is a product of mantle-derived alkaline magma fractionation, which is one of the main mechanisms of A-type granite genesis. The felsic rocks of the Shaerhu complex have the geochemical signature of an A_2-type granite, and thus were not derived from a rift or mantle plume. In the early Permian, oblique subduction in the southern Altaids gave rise to strike-slip extensional faults, which controlled the emplacement of large volumes of mantle-derived melts.

1. Introduction

A-type granites include alkaline, metaluminous, and peraluminous granites that commonly occur in post-orogenic or intraplate tectonic settings (Eby, 1990, 1992; Loiselle and Wones, 1979; Sylvester, 1989). The origin of A-type granites has long been controversial; different proposed mechanisms include: (1) fractionation of mantle-derived magmas (e.g. depleted, sub-alkaline, or alkaline basic magmas) (Bonin et al., 1978; Foland and Allen, 1991; Han et al., 1997; Hollings et al., 2004; Nédélec et al., 1995; Turner et al., 1992); (2) melting of tonalitic or felsic crust (Anderson et al., 2003; Clemens et al., 1986; Collins et al., 1982; Creaser et al., 1991; King et al., 1997); and (3) a combination of crustal and mantle sources (Anderson et al., 2003; Foland and Allen, 1991; Kerr and Fryer, 1993; Landenberger and Collins, 1996), and their geological settings have proved to be just as varied or controversial; i.e. anorogenic, mantle plume; rifted continent; or back-arc (Anderson et al., 2003; Collins et al., 1982; Eby, 1990, 1992; Hollings et al., 2004; Loiselle and Wones, 1979; Menuge et al., 2002; Whalen et al., 1987).

The Altaids (~600–250 Ma) (or Central Asian Orogenic Belt; ~1.0 Ga–250 Ma) was one of the most important sites of juvenile crustal growth (Jahn, 2004; Jahn et al., 2000; Şengör and Natal'in, 1996; Şengör et al., 1993; Wilhem et al., 2012; Windley et al., 2007; Xiao et al., 2010a) (Fig. 1). Extensive late Paleozoic alkaline granitic rocks occur predominantly in intrusive, generally undeformed and unmetamorphosed, anorogenic intrusions. Geochemical and Sm–Nd isotopic data indicate that the rocks have positive $\varepsilon_{Nd}(t)$ values, suggesting considerable juvenile crustal growth (Ao et al., 2010; Chen and Arakawa, 2005; Chen and Jahn, 2004; Han et al., 1997, 1998; Jahn, 2004; Jahn et al., 2000; Wang et al., 1993, 2007; Wu et al., 2000, 2002). From eastern Junggar to the eastern Tianshan several transcurrent faults (Fig. 1), such as Kangguer, Wulonggu, Kalameili,

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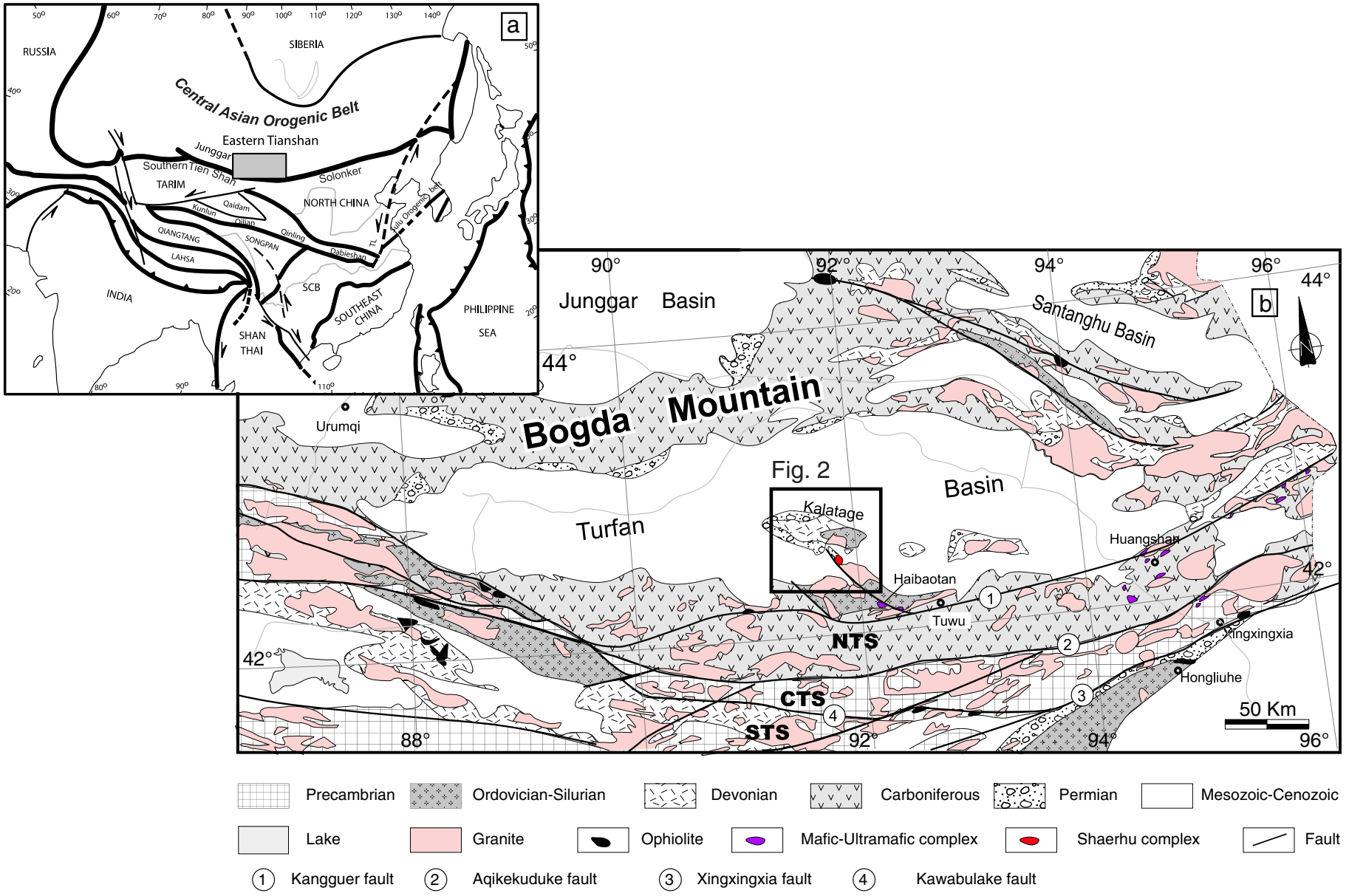

Fig. 1. a. Schematic tectonic map of Central Asia and adjacent regions. b. Schematic geological map of the eastern Tianshan mountains. NTS: North Tianshan; CTS: Central Tianshan; STS: South Tianshan. Modified after XBGMR (1993) and Xiao et al. (2004).