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A Late Carboniferous–Early Permian slab window in the West Junggar of NW China: Geochronological and geochemical evidence from mafic to intermediate dikes

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ABSTRACT

The Late Carboniferous to Early Permian is a critical period for the formation of particular high-temperature magmatic associations in West Junggar, NW China and the geodynamic processes of ridge subduction and related slab windows in the Central Asian Orogenic Belt. Mafic to intermediate dikes, exposed in the central and southeastern West Junggar extensively, mainly consist of Nb-enriched and magnesian suites. The Nb-enriched dikes (305 Ma) are characterized by high Nb contents (5.63–9.08 ppm) and large variations of major element contents, exhibiting high-K to medium-K calc-alkaline characteristics with high Na_2O/K_2O (1.33–3.85) and low Sr/Y (9–32) ratios. The dikes have moderate $Mg^{\#}$ (44.6–52.9), LREE-rich and sub-horizontal HREE patterns ($(La/Yb)_N = 3.05–7.18$; $(Gd/Yb)_N = 1.43–1.78$) with weak Eu anomalies ($Eu^*/Eu = 0.81–1.10$) and positive ε_{Nd} (t) values (+5.2 to +8.0), and likely originate from partial melting of mantle peridotite that was metasomatized by subducted sediment-derived melts and slab fluids. The medium-K magnesian dikes (305 Ma) are characterized by high MgO (3.05–7.28 wt.%), Cr (22.3–311 ppm) and Ni (32.6–199 ppm) contents and all plot in the field of high-Mg andesite. Some have very high Mg numbers ($Mg^{\#} > 60$), suggesting a primitive melt composition. These samples display positive Ba, Sr, K and negative Nb–Ta–Ti anomalies as well as strongly-depleted HREE patterns with weak positive Eu anomalies. They have high Sr/Y (27–126) and relatively high ε_{Nd} (t) values (+6.0 to +8.3), which suggest a similar petrogenesis as the Nb-enriched dikes, but were metasomatized by adakitic melts. The high-K magnesian dikes (284 Ma) are high-K calc-alkaline and have lower MgO (3.63–5.57 wt.%) compared with the medium-K suite. They have high Sr (422–819 ppm), Sr/Y (26–62) ratios and ε_{Nd} (t) values (+7.0 to +7.1) with relatively flat REE patterns ($(La/Yb)_N = 2.4–5.5$), probably originating from partial melting of K-enriched mantle wedge peridotite metasomatized by adakitic slab melts. Based on these petrogenetic features, we suggest that a ridge subduction regime likely prevailed in West Junggar in the Late Carboniferous. The opening of related slab windows and upwelling asthenosphere have possibly triggered the formation of Late Carboniferous–Early Permian magmatic associations in West Junggar.

1. Introduction

The Central Asian Orogenic Belt (CAOB) lies between the Siberian craton to the north, and Tarim and North China cratons to the south (Fig. 1 inset A, Sengör and Natalin, 1996; Windley et al., 2007; Xiao et al., 2008; Yakubchuk, 2004). It encompasses a vast area from the Urals in the west, through Kazakhstan, NW China, Mongolia, and NE China to the Russian Okhotsk Sea in the east (Sengör et al., 1993; Windley et al., 2007; Xiao et al., 2004a,b). The CAOB is the largest accretionary orogenic belt in the world and its formation is associated with the evolution of the Paleo-Asian Ocean. It is generally accepted that this huge orogenic belt is composed of a complicated collage of various terranes, including island arcs, ophiolites, accretionary prisms, seamounts and microcontinents (Kröner et al., 2008; Windley et al., 2007; Xiao et al., 2008).

Ridge–trench interaction is an important geodynamic process which can be observed on the margins of present oceans, such as Chile, southern Alaska and western California in the Circum-Pacific subduction systems (Cole and Stewart, 2009; Lagabrielle et al., 1994; Maruyama, 1997; Sisson et al., 2003; Thorkelson et al., 2011; Wilson et al., 2005). It is suggested that most subduction zones would eventually interact with a spreading ridge and result in opening of slab windows (Sisson et al., 2003; Thorkelson, 1996). The upwelling of asthenospheric mantle through the slab window may produce specific magmas, including adakites, high-Mg andesites, MORB or OIB-like tholeiite (Abratis and Wörner, 2001; Breitsprecher et al., 2003; Cole and Stewart, 2009; Guivel et al., 1999; Hole et al., 1991; Rogers et al., 1985). Based on the occurrence of adakites, boninites, near-trench magmatism, Alaskan-type mafic–ultramafic complexes and high-temperature metamorphic

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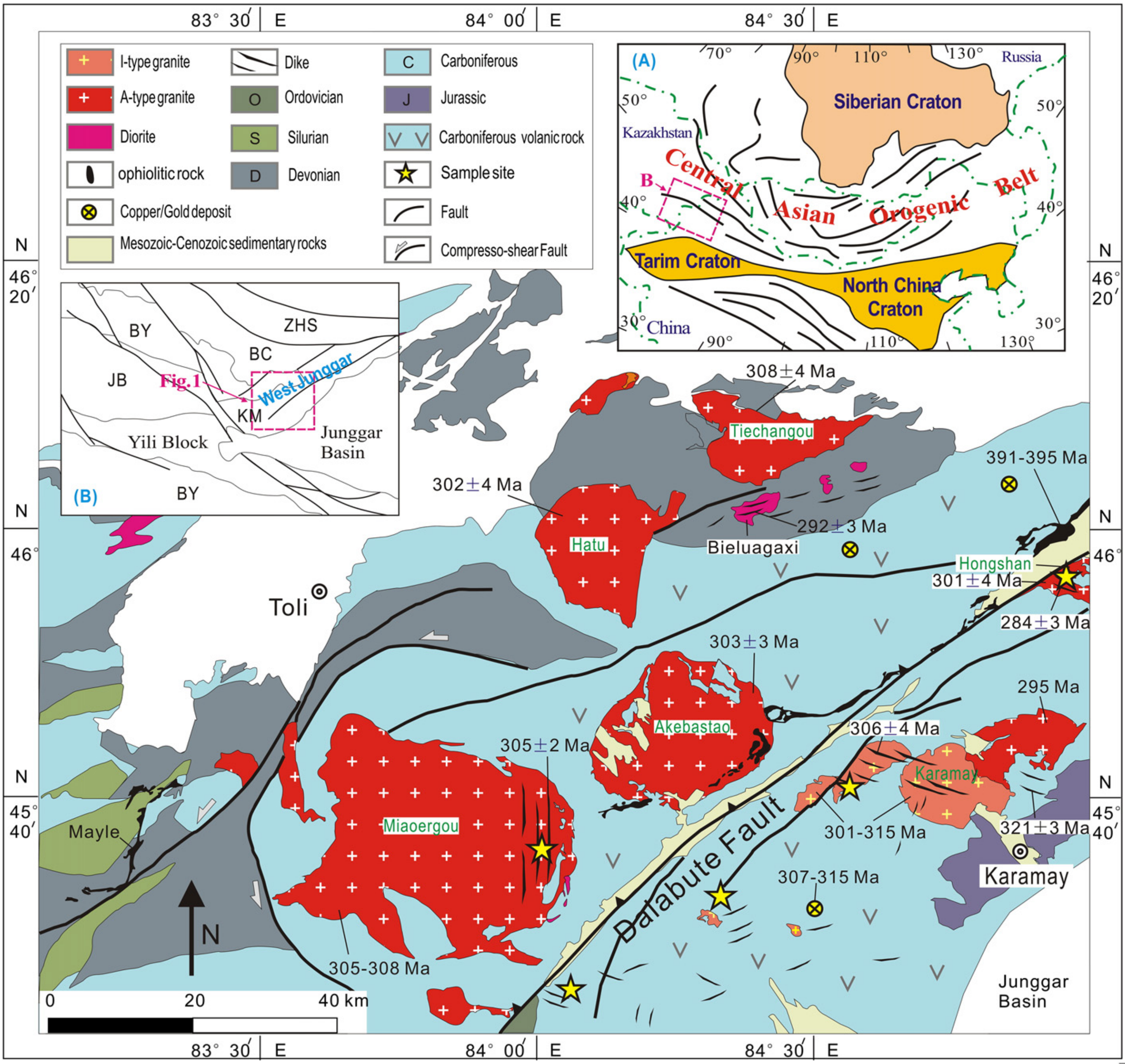

Fig. 1. Geological map of the western Junggar region (modified after Geng et al., 2009; Yin et al., 2010). Age data for mafic–ultramafic or ophiolitic rocks are from Yang et al. (2012), Xu et al. (2006) and Zhang and Huang (1992). Age data for granite intrusions and volcanic rocks are from Geng et al. (2009), Han et al. (2006), Su et al. (2006). Age data for Baogutu diorite–granodiorite porphyry plutons are from Tang et al. (2009). Age data for mafic to intermediate dikes are from Yin et al. (2010), Yin et al. (2012) and this study. The inset A shows a simplified tectonic map of the Central Asian Orogenic Belt (Jahn et al., 2000). The inset B shows a simplified tectonic map of West Junggar and adjacent areas (Windley et al., 2007). Abbreviations in inset B: BY, Balkhash–Yili active continental margin arc; JB, Junggar–Balkhash accretionary wedge and suture zone; BC, Chingiz volcanic arc; ZHS, Zharma-Saur volcanic arc; KM, Karamai accretionary wedge and suture zone.

belts, some authors inferred that several Paleozoic ocean ridges have been subducted in the CAOB (e.g. Windley et al., 2007). Recently, this speculation is supported by some new evidence found in the Chinese part of the CAOB, e.g. the West Junggar and Chinese Altai terranes (Cai et al., 2010; Geng et al., 2009; Ma et al., 2012; Sun et al., 2009; Tang et al., 2010, 2012a; Wong et al., 2010; Yin et al., 2010; Zhang et al., 2011a). However, the occurrence and evolution of ridge subduction-related slab windows are still indistinct and insufficiently documented in those areas.

The Late Paleozoic is a critical period in the southern CAOB because of extensive magmatism and abundant metal deposits developed due to the complex accretionary evolutionary history (An and Zhu, 2009, 2010; Seltmann and Porter, 2005; Shen et al., 2009; Yakubchuk, 2004). In West Junggar, voluminous Carboniferous to Permian high-temperature magmas intruded into the earlier sedimentary and volcanic rocks (Geng et al., 2009). The particular magmatic association includes adakites, A-type granites, charnockites and sanukites, some of which were suggested to be generated during the opening of slab windows (Sisson et al., 2003; Thorkelson, 1996). Previous studies mainly focused on the petrology, geochemistry and geochronology of granitic plutons (e.g. A-type granites and adakites) whereas the petrogenesis of mantle-derived magmatic rocks in West Junggar is still poorly constrained (Chen and Arakawa, 2005; Chen and Jahn, 2004; J.F. Chen et al., 2010; Fan et al., 2007; Geng et al., 2009, 2011; Han et al., 2006; Tang et al., 2010; Xu et al., 2012; Yin et al., 2010; Zhang et al., 2011a,b). Mafic to intermediate dikes are