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Late Carboniferous-Early Permian Mafic-Ultramafic Complexes in Beishan, Southwestern Central Asian Orogenic Belt and Their Significance

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Numeral Permian mafic-ultramafic complexes occur in the Beishan terrane atthe northeastern margin of the Tarim craton, southwestern Central Asian Orogenic Belt, including the Pobei, Cantoushan, Bijiashan, Hongshishan, Xuanwoling, Zhongposhan and Luodong etc., intrusions (Qin et al., 2011; Zhang et al., 2017; Xue et al., 2018). These Beishan mafic-ultramafic complexes are composed of peridotite, pyroxenite, troctolite and gabbro with significant cumulate rhythmic layers of magmatic minerals, and are commonly considered to be layered mafic-ultramafic intrusions of large size (Qin et al., 2011; Xue et al., 2018). They are contemporaneous in formation ages (289 to 260.7 Ma) with the mafic-ultramafic intrusions, mafic dykes and flood basalts in the adjacent Tarim Large Igneous Province (LIP) with an age spectrum from 290 to 273 Ma (Wei et al., 2014; Xu et al., 2014; Zhang et al., 2017). According to the origin, temperature and dynamic mechanisms of magma, most consider these mafic-ultramafic complexes have close relationship with mantle plumes (Qin et al., 2011; Xu et al., 2014; Zhang et al., 2017).

Recently, the Baishan mafic-ultramafic complex which was discovered in eastern Beishan terrane (Fig. 1), is a large complex intrusion with an exposed area of about 132 km^2, and has been confirmed to host economic Ni-Cu sulfide deposits. It consists of dunite, peridotite, olivine pyroxenite, troctolite, norite, olive-gabbro and gabbros with significant cumulate rhythmic layers. We present a preliminary result of an integration study, including of field mapping, LA-ICP-MS zircon U-Pb dating and Lu-Hf isotope, whole-rock major and trace element and Sm-Nd isotope analyses. Three U-Pb zircon LA-ICP-MS ages of gabbro samples, are 306.5±4.0Ma (MSWD=0.32, n=14), 297.5±5.2Ma (MSWD=0.0104, n=16) and 297.0±6.9Ma (MSWD=0.0054, n=30), respectively, which indicate that the Baishan mafic-ultramafic complex formed in Late Carboniferous-Early Permian. It is the oldest mafic-ultramafic complex recognized from the Beishan terrane.

Samples have lower SiO_2 (36.31% to 51.62%) and K_2O+Na_2O (0.22% to 4.72%), higher MgO (5.76% to 34.34%) and display an enrichment of light rare earth elements (LREEs) ($(La/Yb)_N$=1.07 to 4.09), enriching Eu elements to varying degrees, and pronounced negative Nb, Ta, enrichment of Rb, Ba, Th, U, K (LILE) (Fig. 2), indicating the characteristics of E-MORB. However, the mafic-ultramafic rocks have positive $\varepsilon_{Nd}(t)$ values (+1.7 to +5.7) and positive $\varepsilon_{Hf}(t)$ (mainly +4 to +18) (Fig. 3), which show isotopic signatures of depleted mantle. Systematic change trends in both major and trace elements of gabbro, olivine-gabbro, troctolite, norite, lherzolite and augite-peridotite, support their genetic linkage, and the crystallization differentiation of olivine, pyroxene and plagioclase during magma evolution. Considering their Nb/La=0.42 to 1.00 (≤1), $(Th/Nb)_N$=0.07 to 12.78 (mostly, ≥1) and positive anomalies for Th, K and Sr, we suggest that magma experienced crustal contamination.

These geochemical signatures suggest that all the mafic-ultramafic rocks were predominately derived from depleted mantle. Combined with the study of its tectonic setting, in Zr-Zr/Y and Ta/Hf-Th/Hf diagrams, the Baishan mafic-ultramafic complex should have formed in an initial continental rift tectonic setting. Moreover, we have newly determined Early Permian A-style granite (ca. 291Ma) in this area, which should be the production of high temperature partial melting of upper continental crust, such as sandstone and mudstone, in the continental extensional setting. When these data are combined with the regional tectono-thermal events, we suggest that the Baishan mafic-ultramafic complex should formed in an initial continental rift tectonic setting.

Recent work suggests that a possible mantle plume was responsible for the early to middle Permian LIP in Tarim and the southern part of the Central Asian Orogenic Belt (CAOB) (Zhou et al., 2009; Zhang et al., 2010; Yu et al., 2011). However, much work of Tarim LIP has been focused on numerous Permian basalt flows, mafic-ultramafic and acidic intrusions (ca. 290 to 273Ma). The initial magmatic pulse and the start-up time of Tarim mantle plume have notbeen fully resolved though individual scholars consider that the Tarim LIP should was emplaced atc. 300 Ma. Li et al. (2014) considered a crustal uplift event occurred at ~300 Ma, before Tarim LIP emplacement (~290 Ma), and suggested that the regions of Northern Tarim, or further north, represent the centre of the potential plume head.

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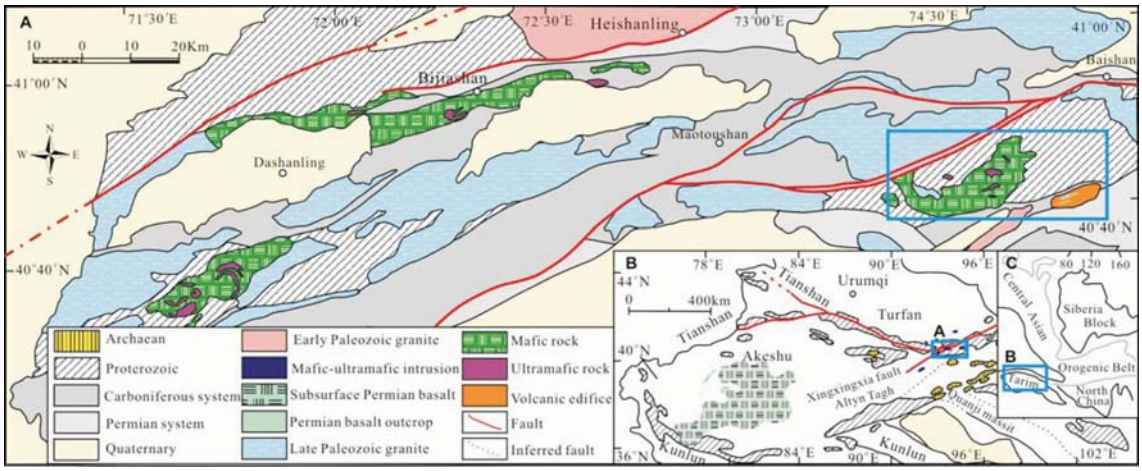

Fig. 1. Regional map of the Baishan mafic-ultramafic complex in the northeastern margin of the Tarim craton (modified after Zhang et al., 2017 and Lu et al., 2008).

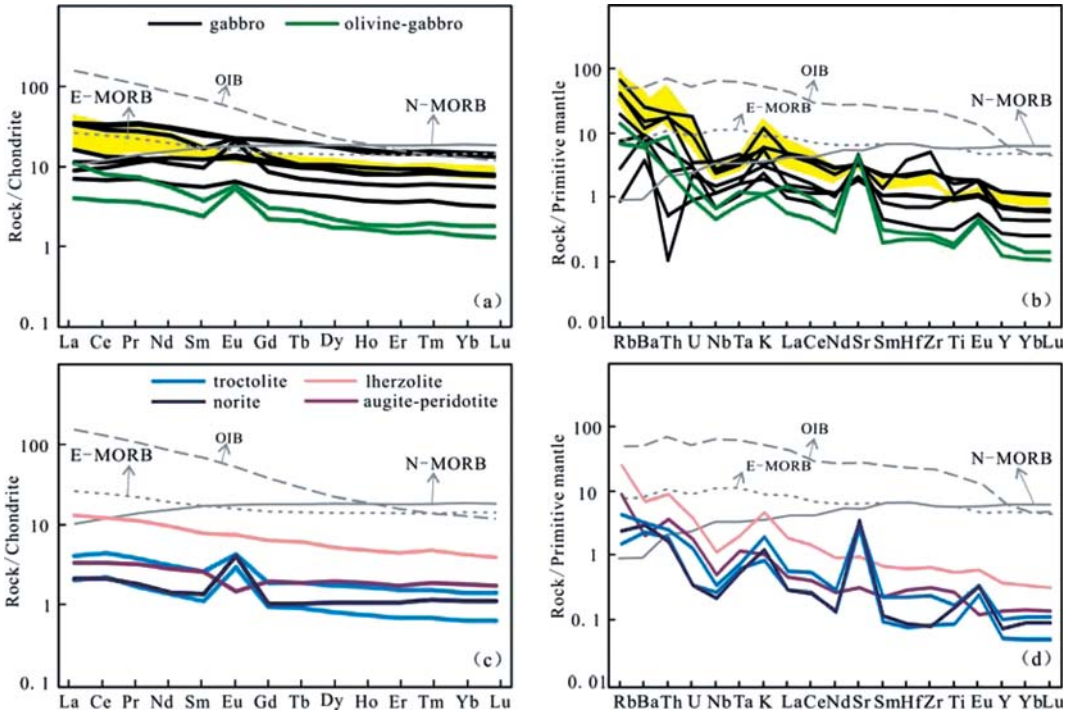

Fig. 2. REE patterns normalized to chondrite values (Sun and McDonough, 1989) (a, c) and trace element plots normalized to the composition of primitive mantle (Sun and McDonough, 1989) (b, d).

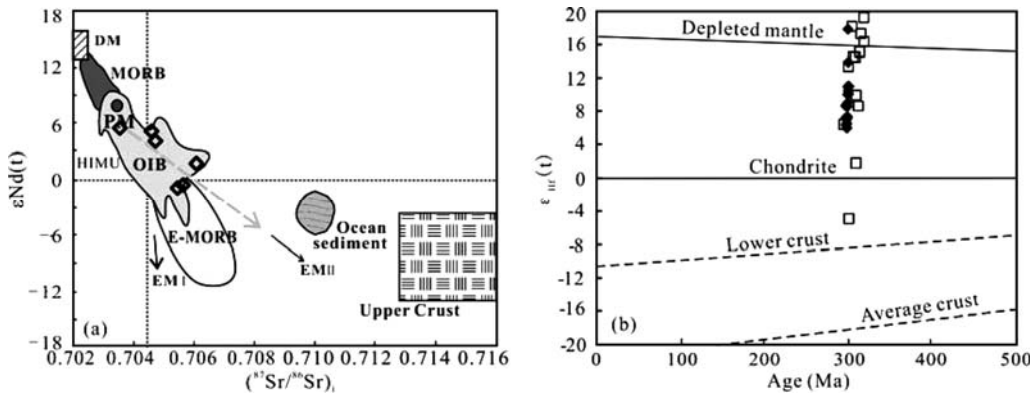

Fig. 3. $\varepsilon_{Nd}(t)$ versus $(^{87}Sr/^{86}Sr)_i$ diagram (a) and $\varepsilon_{Hf}(t)$ versus age diagram (b) for gabbro.

Particularly, Zhang et al. (2013) determined the late Carboniferous kimberlitic intrusions in the Wajilitag area in the western Tarim large, with identical concordia baddeleyite U-Pb ages of 300.8±4.7 Ma and 300.5±4.4 Ma, are slightly older than the eruption ages of Tarim flood basalts (ca. 291 to 273Ma), and signal the initial magmatic pulse triggered by mantle plume impingement.

The ca. 306.5 to 297.0Ma Baishan mafic-ultramafic complex represents the oldest known magmatic event, and is therefore provides a prominent signal for the initiation of Permo-Carboniferous magmatic event in the Tarim. Moreover, the Baishan mafic-ultramafic complex indicates that the northeastern margin of the Tarim craton had started rift in the Late Carboniferous, offering a critical information of the start or early time of the mantle plume and magma formation mechanism.

Key words: Late Carboniferous-Early Permian, Mafic-ultramafic Complexes, Beishan, Tarim Large Igneous Province

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