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Early Paleozoic Mafic-Ultramafic Rocks in the East Kunlun: Trace Subduction of Proto-Tethys

MENG Fancong*, CUI Meihui, REN Yufeng and Paul T. ROBINSON

Institute of Geology, Chinese Academy of Geological Sciences , Beijing，100037, China

The East Kunlun located in the northern margin of the Qinghai-Xizang(Tibet) Plateau, is a composite orogenic belt which has underwent multi-stages tectonic evolution (e.g.Wang and Chen,1987; Jiang et al., 1992; Yang et al., 1996, 2009). The East Kunlun orogenic belt (EKOB) is bounded by Altyn Tagh Fault in the west and Wenquan Fault in the east, bounded by the south margin of Qaidam Basin in the north and by the South Kunlun Fault (SKF) in the south. The Central Kunlun Fault (CKF) is a significant tectonic boundary in the EKOB, which is divided by CKF into North Kunlun terrane (NKT) and South Kunlun terrane (SKT) (Fig.1) (Meng et al., 2015 and therein).

Some serpentinite, gabbro, diabase, and mafic volcanic rock in the Precambrian and early Paleozoic metamorphic rocks as slices and blocks exposed discontinuously along the Central Kunlun suture, they are considered ophiolite such as the Yaziquan, Nuomuhon and Qingshuiquan ophiolites (Fig. 1) (e.g. Xiao et al., 1986; Jiang et al., 1986; Gao et al., 1988; Yang et al., 1996; Zhu et al., 2006; Cui et al., 2011). These are all considered to be early Paleozoic in ages of 518-420Ma, implying the existence of a Paleozoic-ocean (Proto-Tethys) (Yang et al., 1996; Bian

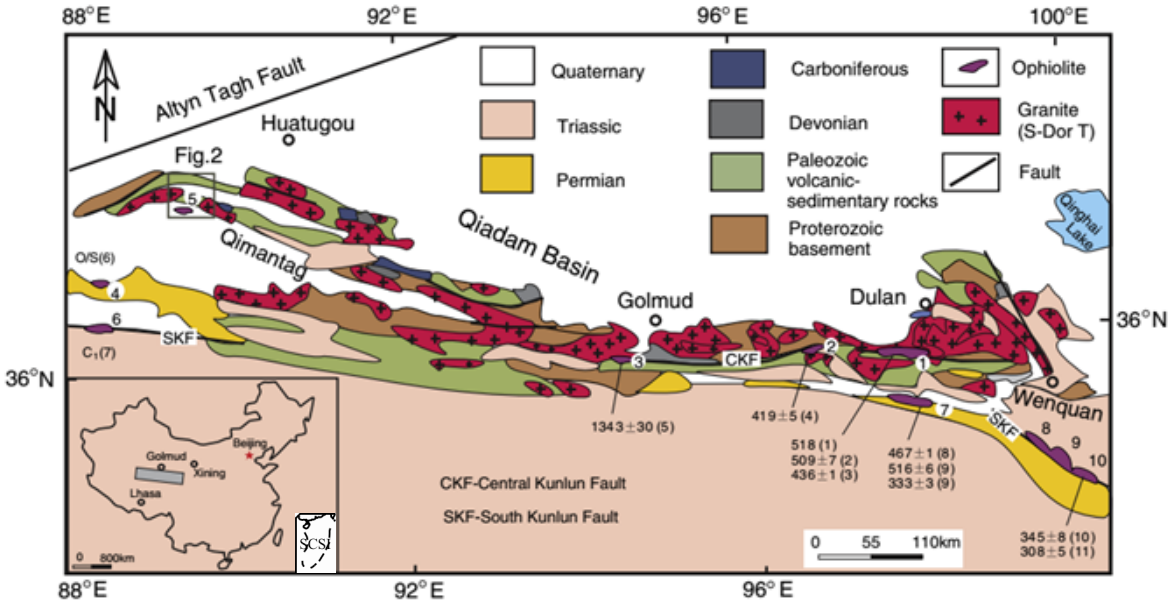

Fig. 1 Simplified geological map of the East Kunlun Mountains and distribution of ophiolites (modified after Pan et al., 2004 and Yang et al., 1996).

North Kunlun terrane: Proterozoic gneiss, Paleozoic-Mesozoic sedimentary rocks, volcanic rocks, and granite. South Kunlun terrane: Proterozoic gneiss and schist; Paleozoic-Mesozoic sedimentary rocks, and volcanic rocks. Ophiolites: 1-Qingshuiquan; 2-Nuomuhong basalt; 3-Wanbaogou basalt; 4-Achiq Kol; 5-Heishan complex; 6-Muztagh; 7-Buqingshan; 8-Xiadawu; 9-Majixueshan; 10-Maxin.

Methods and age data (Ma) source: (1) gabbro, zircon U-Pb (Yang et al., 1996); (2) gabbro, zircon U-Pb (Feng et al., 2010); (3) diabase, zircon U-Pb (Ren et al., 2009); (4) basalt, zircon U-Pb (Zhu et al., 2006); (5) basalt, zircon U-Pb (Wang et al., 2007); (6) inferred base on geological data (Wu et al., 2001); (7) radiolarias (Lan et al., 2002); (8) gabbro, zircon U-Pb (Bian et al., 2004); (9) gabbro, zircon U-Pb (Liu et al., 2011); (10) basalt, $^{40}Ar/^{39}Ar$ (Chen et al., 2001); (11) basalt, zircon U-Pb (Yang et al., 2004).

* Corresponding author. E-mail: mengfancong@yeah.net

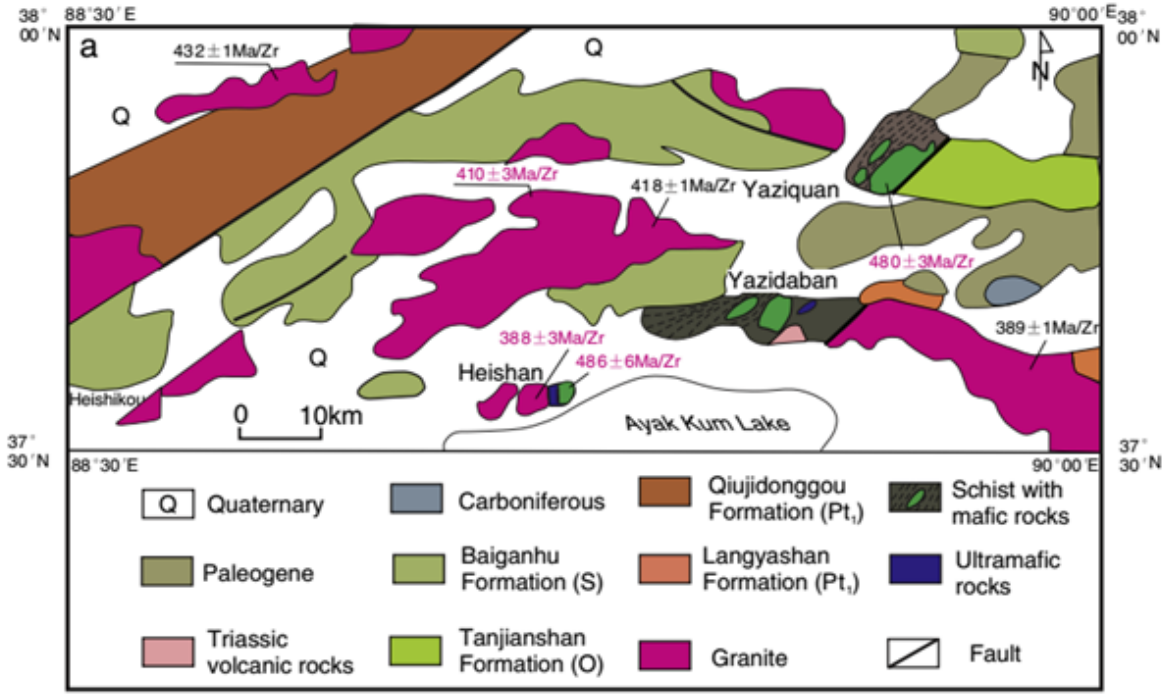

Fig.2 (a) Simplified geological map of the Heishan area (modified from Xiao et al., 2005).
Zr- zircon U-Pb age, black numbers are from the Shaanxi Institute of Geological Survey (2003); red numbers are from author. (b) Geological cross-section of the Heishan mafic-ultramafic complex. Ultramafic rocks, gabbro and basalt showing concordant contact.

et al., 2004;Zhu et al., 2006; Feng et al., 2010).

Kunlun Orogen, consist of olivine pyroxenites, pyroxenites, gabbros, and massive basalts (Fig.2). Zircons from the gabbros have magmatic sector zoning, with Th/U ratios of 0.5 - 2.3, and yield a SHRIMP age of 486 ± 6 Ma (MSWD = 0.31), which is taken as the time of magma crystallization. Spinel, pyroxene, and plagioclase mineral compositions indicate that the rocks formed in an island arc environment. The cumulates have low $(La/Yb)_N$ ratios (0.6-0.8) and depleted LREE patterns, high abundances of Cr (3031-1185 ppm), Co (119 - 50 ppm), and Ni (953 - 291ppm), and ε_{Nd} (t) values of about + 8.0. The massive basalts have somewhat higher contents of TiO_2 (1.0%-1.3%), Na_2O (2.6%-2.8%), total REE and $Mg^{\#}$s (55-63) than those of the cumulates. The $(La/Yb)_N$ ratios of the basalts range from 0.8 to 1.2 and the chondrite-normalized REE patterns are flat. ε_{Nd} (t) values of the basalts range from + 7.7 to + 9.4. The compositions of the cumulates and volcanic rocks, especially their similar Nd isotopes, suggest that the rocks were derived from similar depleted mantle sources. The primary magmas were probably generated in an initial arc environment. We conclude that the Heishan mafic-ultramafic complex in the Qimantag area preserves a record of Proto-Tethyan oceanic lithosphere formed in the early Paleozoic. It possibly marks a suture between the Qaidam and North Kunlun terranes in the western segment of the Eastern Kunlun Orogen.

The gabbro-diabase as vein or lens occurred in the marble and paragneiss at Qingshuiquan area, these rocks have negative to slight positive initial $\varepsilon_{Nd}(t)$ values, zircons display a negative initial $\varepsilon_{Hf}(t)$ values, these characteristics suggest their parental magma derived from enriched mantle and similar to Paleozoic Fushui complex in north Qinling orogenic belt, which formed active continental margin, it is different from gabbros among Heishan Paleozoic ophiolite in Qimantag. The gabbro-diabase is cannot as ophiolitic component. We proposed the formation of enriched mantle related with subduction of Proto-Tethys.

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