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The Pre-Jurassic Ophiolitic MÉLange in the Northern Margin of North China Craton: Geochemical Characteristics and Tectonic Implications

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The central part of the northern margin of the North China Craton (NCC) is bounded by the Jining-Chicheng-Pingquan fault to the south, and by the Xianghuangqi-Duolun-Chifeng fault to the north. The major stratigraphic unit within the belt is regarded as the Palaeoproterozoic Hongqiyingzi Group which is experienced amphibolite-facies metamorphism.

Many ultramafic and mafic rock enclaves as well as mafic "plutons" occurs extensively as tectonic lenses or boudins within the biotite-plagioclase gneisses of the "Hongqiyingzi Group", having the long-axis parallel to the gneiss foliation. The mafic bodies have been identified as retrograded eclogites with the peak metamorphic age of *c*.325 Ma (Ni et al., 2006). Based on the field occurrence, petrological and geochemical features of these ultramafic and mafic enclaves and "plutons", we interpreted the amphibolites (including the retrograded eclogites) enclaves, the meta-gabbro, and the ultramafic blocks as a dismembered ophiolite; and the whole "Hongqiyingzi Group" is identified as a pre-Jurassic ophiolitic mélange developed along the northern margin of the NCC.

Three groups of mafic volcanics (amphibolites and retrograded eclogites) are categorized based on the chondrite-normalized REE pattern. The first group of mafic rocks occurred within the ophiolitic mélange exhibits LREE-depleted or nearly flat REE patterns (Fig.1); meanwhile, the second group has the slight enriched LREE pattern (Fig.2). Most rocks of these two groups have high contents of LILE (K, Rb, Ba), but lower HFSE, and the Group 2 rocks have negative anomalies of Nb-Ta and Zr-Hf (Fig. 1 and 2). The third group presents a LREE enriched pattern and high contents of LILE and HFSE, as well as the negative anomalies of Nb-Ta, and Zr-Hf (Fig.3). For the major elements, the group 1 and 2

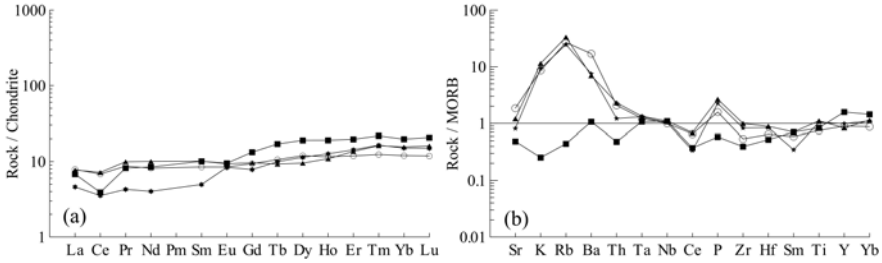

Fig. 1. Chondrite normalized REE pattern (a) and MORB normalized spider diagram (b) for the group 1 mafic meta-volcanics of the Hongqiyingzi mélange.

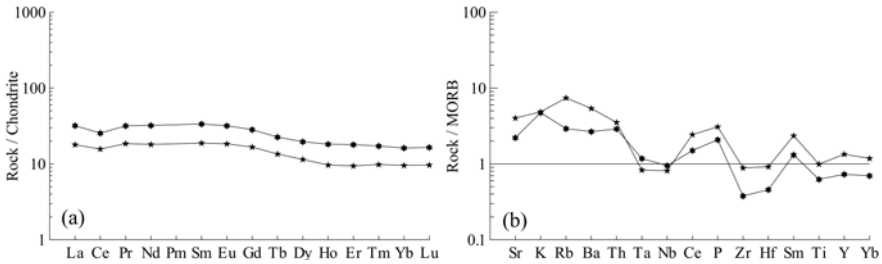

Fig. 2. Chondrite normalized REE pattern (a) and MORB normalized spider diagram (b) for the group 2 mafic meta-volcanics of the Hongqiyingzi mélange.

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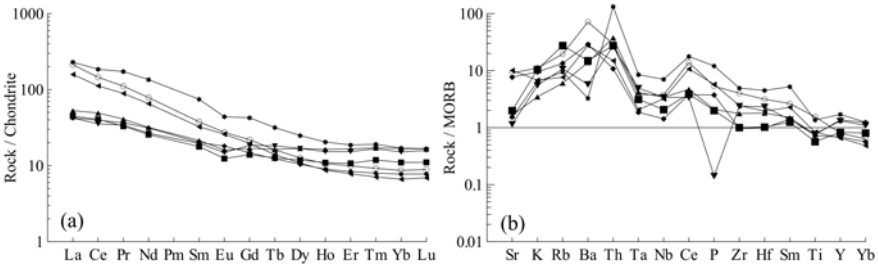

Fig. 3. Chondrite normalized REE pattern (a) and MORB normalized spider diagram (b) for the group 3 mafic meta-volcanics of the Hongqiyingzi mélange.

rocks exhibit tholeiitic characteristics, but the group 3 rocks have calc-alkaline affinity. According to the discrimination diagrams based on the La, Sm, Yb, Nb, and Th proposed by Agrawal et al. (2008), the group 1 rocks plot in the MORB field, and the group 3 rocks locate in the arc region, the group 2 shows transitional character. Moreover, using the traditional ("standard") tectonic discrimination diagrams, the group 1 mafic rocks plot in the MORB field, and the group 2 rocks locate in the arc region, but the group 3 samples plot into the continental arc basalt field.

Several tens of the serpentinite lenses are mapped in Chicheng area of the central part of the northern margin of the NCC. Originally, they are granular textured harzburgite, while contain more MgO (37.49%–38.91%), but less CaO (0.12%–1.17%), Al_2O_3 (0.54%–1.54%), and FeO* (5.51%–9.06%). Their total REE is less than that of the primitive mantle, and their normalized trace element values are similar to the ultramafic rocks from the SSZ-type ophiolite (Fig.4). The meta-gabbros exhibit the concave shape REE pattern as those of the gabbros occurred within the ophiolite suit (Fig.5). Some mafic "plutons" had been transformed into the rodingites. These rocks occurred as separate tectonic lenses within the "Hongqiyingzi Group". Their mineral assemblage is characterized by major components of Ca-rich garnet, albite or hyalophane and amphibole with minor residual diopside. Rodingites were SiO_2-undersaturated, CaO- and FeO*-rich and MgO-poor, and the compositional varieties of SiO_2, CaO, FeO* and MgO are 36.63%–44.46%, 17.81%–27.78%, 9.76%–18.36%, and 0.77%–4.56%, respectively. The protolith of rodingites should be the gabbros of ophiolitic suit.

The biotite-plagioclase gneisses from "Hongqiyingzi Group" have porphyroblastic texture with medium-fine grained lepido-granoblastic groundmass and gneissic structure. The content of total REE of the gneiss varies in the range of 49.45–140.10 ppm, displaying LREE-enriched and HREE-flattened pattern with chondrite-normalized La/Yb ratio of 5.07–8.70, and LREE/HREE ratio of 5.23–9.16; meanwhile, these rocks exhibit intermediate negative Eu anomalies and weak negative Ce

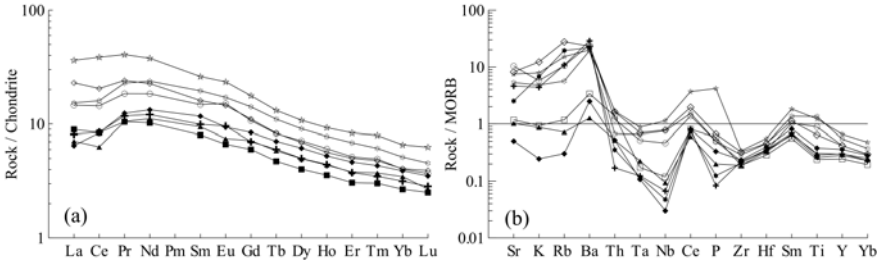

Fig. 4. Chondrite normalized REE pattern (a) and MORB normalized spider diagram (b) for the meta-gabbros of the Hongqiyingzi mélange.

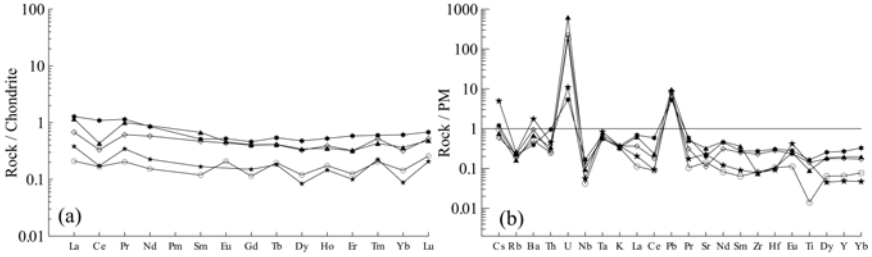

Fig. 5. Chondrite normalized REE pattern (a) and primitive mantle (PM) normalized spider diagram (b) for the serpentinites of the Hongqiyingzi mélange.

anomalies. The rocks also have lower Rb, Sr, Cs, ba, Zr, Hf, Nb, Ta, Th and U, but higher Sr/Ba and Th/U ratios relative to the upper crust. Accordingly, their geochemistry indicates a clastic sedimentary protolith.

In summary, the blocks of mafic meta-volcanics, meta-gabbros and ultramafic rocks in the "Hongqiyingzi Group" represent a dismembered ophiolite occurred within the northern margin of North China Craton The major elements of the mafic meta-volcanics from the "Hongqiyingzi Group" suggest tholeiitic - calcalkaline signatures of arc environment. The geochemical plots of tectonic discrimination suggest that the mafic meta-volcanics have originated in supra-subduction zone (SSZ) setting. The SSZ-type ophiolitic suit developed from the Late Paleozoic to Early Triassic, and then was dismembered and experienced regional metamorphism during the subsequence Late Mesozoic orogenesis (Yanshanian). Accordingly, the "Hongqiyingzi Group" exposed along the northern margin of the NCC is actually the metamorphic ophiolitic mélange associated with the Paleo-Asian Ocean closure. The identification of the Pre-Jurassic ophiolitic mélange confirms the idea that the subduction of the Palaeo-Asian ocean beneath the NCC was a long-term process. The dehydration of the subducted slab resulted in the weakening of the lithospheric mantle under the northern margin of the NCC, finally triggered the destruction of the NCC during late Mesozoic.

Key words: ophiolite; mélange; retrograded eclogite; serpentinite; North China Craton

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