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Mineralogical and Geochemical Constraints on the Origin of the Ultramafic Rocks from Wuwamen Ophiolite at the Southern Margin of Middle Tianshan, Xinjiang

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1 Introduction

Wuwamen ophiolite is located at the southern margin of Middle Tianshan, Xinjiang Province. In this paper, petrology, mineralogy and geochemistry of the ultramafic rocks from Wuwamen ophiolite were studied to constrain their origin and tectonic setting. The studies will be helpful in interpreting the evolution process of the South Tianshan Ocean.

2 Mineralogy, Major and Trace Element Compositions of the Wuwamen Ultramafic Rocks

The ultramafic rocks from Wuwamen ophiolite are serpentinized lherzolites, composed of olivine, orthopyroxene, clinopyroxene and spines. The olivines with Fo ranging from 89.1 to 90.6 and NiO contents from 0.19 to 0.42%. The orthopyroxenes fall in the range of $Wo_{0.4\text{-}2.4}En_{87.2\sim90.7}Fs_{8.9\text{-}10.9}$ with Al_2O_3 and Cr_2O_3 contents ranging from 2.86% to 4.44% and 0.14% to 0.42%, respectively. They have $Mg^{\#}$ varying between 89.0 to 91.0, which is similar to those of olivnes, indicating that an approximate equilibrium was achieved. The clinopyroxene are diopside with a composition of $Wo_{49.1\text{-}51.3}En_{16.0\sim48.4}Fs_{0.9\text{-}4.3}$. They have $Mg^{\#}$ anging from 90.2 to 92.1. They also have relatively high Al_2O_3 (4.90–6.69%) and TiO_2 (0.17–0.63%) contents. spinel ($Mg^{\#}$=71.8–77.5; $Cr^{\#}$=9.3–13.4). The spinels have relatively high $Mg^{\#}$ (71.8–77.5) and low $Cr^{\#}$ (9.3–13.4).

The Wuwamen ultramafic rocks have relatively lower contents of MgO (37.74%–41.34%), and higher contents of Al_2O_3 (2.58%–3.39%), CaO (2.23%–3.68%) and TiO_2 (0.05%–0.11%). They are also depleted in Rare Earth Elements (REE; total REE = 1.73 ppm–4.63 ppm) and incompatible elements (e.g., Rb=0.4 ppm–1.39 ppm, Zr=0.73 ppm–3.28 ppm, Hf=0.04 ppm–0.11 ppm), enriched in compatible elements (e.g., Cr=2516 ppm–2793 ppm, Co=84.6 ppm–119 ppm, Ni=1641 ppm–2261 ppm). They show LREE-depleted chondrite-normalized REE patterns with $(La/Yb)_{CN}$=0.50–1.71, $(La/Sm)_{CN}$=0.66–2.48 and $(Gd/Yb)_{CN}$=0.62–0.97.

3 Discussions and Conclusions

The results of our study of the mineral compositions and whole-rock geochemistry of the Wuwamen ultramafic rocks provide evidence that these rocks are residues of upper mantle rocks after variable degrees of basaltic magma extraction. The compositions of olivines and orthopyroxenes span a narrow range, and their Mg# are similar, characteristic of minerals from residual mantle peridotites after significant degrees of partial melting (Dick, 1977; Komor et al., 1990). Accordingly, the Wuwamen ultramafic rocks have higher MgO, lower Al_2O_3 and CaO contents than those of the primitive mantle (37.7%, 3.97%, and 3.50%, respectively).

The degrees of partial melting involved in the genesis of the Wuwamen ultramafic rocks can be constrained by comparing the HREE contents of the samples with the modeled HREE contents of the N-MORB-like mantle at different degrees of partial melting (Salters and Stracke, 2004; Workman and Hart, 2005; Dupuis et al., 2005; Bezard et al., 2011), because HREE are less mobile than LREE during mantle metasomatism. It is shown that the Wuwamen ultramafic rocks may be the residue of 5%–10% degrees of partial melting of a N-MORB-like mantle

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source. Degrees of partial melting can also be estimated based on the compositions of spinels and olivines (Arai, 1984; Hirose and Kawamoto, 1995), indicating that Wuwamen ultramafic rocks underwent from less than 10% degrees of partial melting.

In addition, the spinels from the Wuwamen ultramafic rocks have high $Mg^{\#}$ and low $Cr^{\#}$, consistent with the spinel compositions from Mid-Ocean-Ridge (MOR) peridotites.

Therefore, the ultramafic rocks from Wuwamen ophiolite are residues of mantle rocks after low degrees (ca. 5%~10%) of partial melting at MOR environment.

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