Mineral inclusion and exsolution in mantle rocks from the Luobusa ophiolite, Tibet: origin implication

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Luobusa ophiolite locates in the east part of Indus-Yarlung Zangbo suture zone, Tibet and hosts fresh mantle peridotites and the largest known chromite deposits in China. Recently, we discovered an in-situ SiC phase inclusion in Cr-spinel from dunite in the Luobusa ophiolite. It occurs as rectangular interpenetration twin and only the central part was preserved well. The size of the whole crystal is about 20 µm and the well-preserved part is only 5µm. The Fourier Transform Infrared Spectrometer and Laser-Laman analyses revealed that the SiC phase crystal is moissanite in stead of synthetic silicon carbide. The occurrence of primary moissanite directly suggests that the inclusion and its hosting mineral- Cr-spinel were generated under the UHP condition over 6 GPa (200 km). In addition to the moissanite, some fine-grained olivines included in the Cr-spinel from hurzburgite, dunite and chromitite were also analyzed by electron microprobe. They are significantly richer of Mg and Cr elements than other olivines. Previous studies have suggested that the extreme Mg-rich (Mg# = 97~ 98) olivine inclusions have abnormal small unit cell parameters and bond lengths, which indicate the UHP and HT contidion in the deep mantle [1]. The higher Cr content in these olivine inclusions might suggest a high solubility of Cr oxide in the host olivine in the deep mantle, and this point could be further proved by mineral exsolutions in olivine described below.

Abundant mineral exsolutions were found in coarse-grained olivines from dunite and nodular chromitite. They could be divided into two types: a majority of spinel-group mineral lamellae and a minority of clinopyroxene lamellae. The spinel-group mineral lamellae mostly occur as brown rectangular lamellae under the polarizing microscope and show as white thin rods under the backscattered light. Their element contents of Mg, Fe, Cr and Al are quiet different from each lamella. Some are Cr-spinel with 46 wt% ± Cr2O3, 32 wt% ± total FeO, 10 wt% ± Al2O3 and only 7 wt% ± MgO. But others are more Cr-bearing magnetite with more than 70 wt% total FeO. The rest of them are intermediate with varied Mg, Fe, Cr and Al contents. The clinopyroxene lamellae occur as narrow leaf shape with pale green under the polarizing microscope and as gray white lamellae in the backscattered image. Most of them are diopside and others are sodic clinopyroxene. In many cases, these two-type lamellae came into a close intergrowth. These substantial exsolution lamellae suggest a high solubility of Cr, Ca, Si, Al and Na in the host olivine or its precursor.

Previous studies have suggested that these kinds of exsolution lamellae in olivine were generated during cooling process from relatively high temperature condition [2, 3]. However, we noticed that the presence of moissanite in the same sample indicates the ultra-high pressure and extreme low oxygen fugacity. This kind of condition could be in favor of Cr stabilizing in coordinated sites of olivine as divalent [4] rather than trivalent as thought before. Experiments [5] proved that Mg, Fe, Si, Ca, Na and Al could stabilize in one mineral under the UHP and HT condition. Also, we observed that these exsolution lamellae only occur in coarse-grained deformed olivines but not in any fine-grained recrystallized olivines. Combing with previous researches about deep mantle origin for Luobusa mantle rocks [6], we present that some part of mantle peridotite and chromitite came from deep mantle over at least 200 km and those exsolution lamellae in coarse-grained deformed olivines might suggest an UHP precursor under an extreme reducing environment. We need to further identify those deep mantle sources from the MOR magmatism and to consider the multi-stage evolution for the Luobusa mantle rocks.

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