Moissanite and chromium-rich olivine in the Luobusa mantle peridotite and chromitite, Tibet: Deep mantle origin implication

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The Luobusa ophiolite lies in the eastern part of the Indus-Zangbo suture zone, Tibet and contains the biggest chromitite deposit in China. In recent years, lots of ultrahigh pressure and highly reduced minerals were surprisingly discovered in the Luobusa mantle peridotite and chromitite. They indicate a deep mantle (> 300 km) origin contrary to previously SSZ origin thought (Yang et al., 2014). Here, we report our new discoveries of in-situ natural moissanite and chromium-rich included olivines in Luobusa. They also suggest a lower mantle or transition zone origin.

The moissanite occurs as a twinned grain in Cr-spinel hosted by enveloped dunite of a podiform chromitite in the Luobusa ophiolite (Liang et al., 2014). The moissanite is green in color, and has parallel extinction. Its Raman spectrum has shifts at 967-971 cm^{-1}, 787-788 cm^{-1}, and 766 cm^{-1}. The absorption peaks in the infra-red spectra are at 696 cm^{-1}, 767 cm^{-1}, 1450 cm^{-1}, and 1551 cm^{-1}, which are distinctly different from the peaks for synthetic silicon carbide.Chromium-rich included olivines were found in harzburgite, dunite, disseminated chromitite, nodular chromitite and massive chromitite respectively. These olivines are included by spinels or chromites with crystal shape of subhedral to hedral. No matter in what lithology, included olivines contain obviously higher Cr_2O_3 (0.1-1.49 wt %) and lower FeO than other olivines (Cr_2O_3 < 500 ppm). Especially, they contain the highest Cr_2O_3 content (up to 1.49 wt %) by far in the world and much higher than those in chondrite olivines (~ 0.7 wt %) (Dodd, 1975). Except for a weak negative correlation of Cr_2O_3 vs FeO, no other correlations of Cr_2O_3 vs MnO and of Cr_2O_3 vs MgO were observed. Aluminum is near background levels and minors of manganese (~0.1 wt%) and nickel (0.3~0.5 wt %) were detected in the chromium-rich included olivines.

Moissanite is one of the deepest mantle minerals known to reach the surface. All moissanite grains analysed thus far have very depleted carbon isotope compositions ($\delta^{13}C$ from −18 to −35‰), much lighter than the main carbon reservoir in the upper mantle ($\delta^{13}C$ near −5‰). They were suggested to form in the lower mantle since the ^{13}C-depleted carbon is supported by extraterrestrial carbon, and there have been no other explanations until now (Trumbull et al., 2009).

Although the substitution of chromium in olivine is controversial for a long time, most evidences proved that chromium in olivine is divalent and precipitate in high pressure, high temperature and extremely reducing conditions (e.g. Brenker, 2002). For those chromium-rich included olivines in the Luobusa ophiolite, Cr^{2+} is believed to be the controlled valence in the octahedral site of olivine since the in-situ moissanite in the same sample has been discovered. A possible vacancy substitution mechanism is proposed to explain the uncorrelated characteristic between Cr and other metal elements. Combing with many other findings of ultra-high pressure and extremely reducing minerals reported by previous studies, the chromium-rich olivines in the Luobusa mantle peridotite and chromitite might originate from mantle transition zone or lower mantle and their precursor phase might be wadsleyite or ringwoodite.

References

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