Metamorphic olivine: a vehicle to transfer volatiles to the deep mantle

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Oceanic lithosphere contains abundant serpentinites as hydration products of abyssal peridotites. Their subduction causes the dehydration of serpentine to form olivine at ~ 150 m depth. It is assumed that all water and fluid-mobile elements in serpentinites are released to the overlying mantle wedges. Studies of such secondary olivine in HP-UHP belts (West Himalayas, Zermatt in Switzerland, Voltri in Italy) show that this olivine has significantly different compositions from mantle olivine. Since olivine is stable under high P and T, secondary olivine together with abundant oxide inclusions are capable to transport volatiles and highly incompatible elements, such as HFSE, into the deep mantle.

Secondary olivine contains significant NiO in all three locations, ~ 0.3 % in Voltri and W. Himalayas and ~0.4% in Zermatt, but they do not positively correlate with MgO, likely due to a minor incorporation of Ni into magnetite and crystallization of Ni minerals, such as awaurite, during serpentinization. The contents of MnO are high (<0.43wt% in Voltri, < 0.3 wt% in Zermatt and W. Himalayas) compared to the contents (~ 0.1 wt%) of mantle olivine [1], because of preferential uptake of Mn in olivine over serpentine [2] during dehydration. Arsenic contents vary; 1-15ppm in the Himalayan olivine and 0.1-0.3ppm in the Zermatt olivine.The high values in the former reflect high As(V) in serpentine [3]. Other notably enriched elements in olivine include Li (<60ppm in Voltri; <1.3ppm in Zermatt), F (<137ppm; <1.9ppm) and B (<23 ppm; <8ppm). Co-existing antigorite contains Li (0.1ppm,<0.01 ppm), F (<2.5 ppm) and B (<10 ppm, <22 ppm). Their comparable concentrations in serpentine and olivine suggest that the serpentinite dehydration does not release much of these elements to the overlying mantle. Furthermore, the Voltri olivine contains high TiO_2,< 0.85 wt%, as Ti-clinohumite defects of olivine structure, which positively correlates with H_2O (<0.7 wt%). The compositional variation of olivine likely reflects that of serpentine, which in turn reflects the subduction zone environments.

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