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Hematite and magnetite precipitates in olivine from the Sulu peridotite: A result of dehydrogenation-oxidation reaction of mantle olivine?

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Abstract

Analytical electron microscopic observations have been carried out on a garnet peridotite from the Maobei area, Sulu ultrahigh-pressure terrane. The results showed that olivine in this garnet peridotite (5.3–6.6 GPa; 853–957 °C), contains precipitates of chromian magnetite and chromian-titanian hematite at dislocations and (001) faults. Specific crystallographic relationships were determined between these precipitates and the olivine host, viz. $[101]_{Mt}//[001]_{Ol}$, $[110]_{Mt}//[0\bar{1}1]_{Ol}$, and $[0\bar{1}1]_{Mt}//[011]_{Ol}$; and $[0001]_{Hm}//[100]_{Ol}$ and $[10\bar{1}0]_{Hm}//[001]_{Ol}$. These oriented oxides are not associated with silicate/silica phases and therefore cannot be accounted for by the mechanism of olivine oxidation. It is postulated that these magnetite and hematite precipitates most likely have resulted from dehydrogenation-oxidation of nominally anhydrous mantle olivine during rock exhumation. In view of the contrasting diffusion rates of H and Fe in the olivine lattice, it is suggested that the formation process might actually take place in steps. Hydrogen diffusion with concomitant quantitative oxidation of Fe^{2+} to Fe^{3+} in olivine occurred early during initial rock exhumation and was followed by slow Fe diffusion forming magnetite/hematite at stacking faults and dislocations within the olivine lattice. Two requirements are essential under such a scenario: an ample amount of H content of the olivine, and an appropriate exhumation rate, probably in the range of 6–11 mm/year, of the host rock. It is also noted that such dehydrogenation-oxidation processes may hamper a correct estimate of the actual *P*-*T* conditions and mantle oxidation state based on mineral chemistries present in mantle eclogite/peridotite. The present study demonstrates that oriented mineral inclusions may not necessarily form through exsolution processes sensu stricto, but may form through a series of more complicated reaction mechanisms.

Keywords: Magnetite, hematite, olivine, dehydrogenation-oxidation, UHP peridotite