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The effect of oxidation on the mineralogy and magnetic properties of olivine

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ABSTRACT

Although nucleation of magnetite and/or hematite along dislocations upon oxidation of olivine has been observed by many workers, the effect of oxidation on the magnetic properties of the sample with specific mineralogical alterations has not been studied. Therefore, we investigate this problem using a set of time series 1 bar oxidation experiments at 600 and 900 °C. Results show rapid olivine oxidation and alteration at both 600 and 900 °C, forming magnetite and hematite associated with a change from paramagnetic to ferromagnetic behavior after oxidation. Magnetite and hematite nucleate along dislocations and impurities in the crystal structure, along with surface coatings and within cracks in the crystals.

Fresh, unaltered mantle xenoliths containing magnetite have been interpreted as having formed in cold tectonic regimes in the mantle, rather than through oxidation during or after ascent. Mantle xenoliths rapidly ascend through the mantle with estimates of the ascent of up to 90 km/h (3 GPa/h) based on the diffusion profile of water in mantle olivine. The rates correspond to xenoliths ascending through the mantle over hours and not days or weeks. Our results show that olivine oxidation and alteration can occur in days to weeks at 600 °C and within minutes at 900 °C. Therefore, if the xenolithic material is transported to the surface in a cold magma (at temperatures ≤600 °C), then the timescale of ascent is likely not long enough for oxidation to cause magnetite formation or a ferromagnetic signature to occur. However, if the material is transported in a hot oxidized basaltic magma (with temperatures ≥900 °C), then oxidation can cause magnetite formation and a ferromagnetic signature.

Keywords: Olivine, oxidation, hematite, magnetite, magnetic properties, xenoliths