The oxidation of olivine and implications for mantle magnetism

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The crust-mantle boundary has long been accepted as a magnetic boundary with a nonmagnetic mantle overlain by a magnetic crust [1]. Recent investigations into the magnetic properties of unaltered xenoliths have questioned whether certain parts of the upper mantle could be magnetic [2] [3]. However, mantle xenoliths could become magnetic during ascent through oxidation, decompression, or contamination with the magma that brought them to the surface. Kohlstedt et al. [4] showed that oxidation of olivine can nucleate magnetite and/or hematite along dislocations ('olivine decoration'); however, these experiments were not analyzed for their magnetic properties. Therefore, we are investigating the effect of oxidation on the magnetic properties of olivine and if oxidation alone can produce the magnetic properties seen in some mantle xenoliths.

Here we present oxidation experiments on gem quality olivine crystals from San Carlos and China. Following the previous experimental work [4], experiments have been conducted at 900°C and 600°C, in air, and from 12 minutes through 26 days. Olivine crystals were analyzed for their magnetic properties before and after oxidation. The unoxidized olivines exhibit no detectable ferromagnetic signal above 10^{-10} Am^2 (the detection limit of the vibrating sample magnetometer).

The initial results of the oxidation experiments show a darkening of the olivine crystals and the formation of a dark black and red outer crust. The longer the experiments were run, the darker the olivine became. Some olivines fractured during the experiment, consistent with an increase in volume due to oxidation. After oxidation, there was a change to a ferromagnetic signature and the hysteresis properties with increasing time. Mineralogic analyses are ongoing to confirm the nature of the oxidized minerals.

[1] Wasilewski P.J. et al. (1979) *GRL* **6**, 541-544. [2] Ferré, E.C. et al. (2014) *Tectonophysics* **624–625**, 3-14. [3] Friedman S.A. et al. (2014) *Tectonophysics* **624–625**, 15-23. [4] Kohlstedt D.L. et al. (1976) *Science* **191**, 1045-1046.