Reaction between olivine and nitrogen fluids at high pressure and high temperature

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Behavior of volatiles will contribute to understandings of the budget of light elements, evolution of the earth, geodynamics and so on. Among volatile components, behavior of nitrogen in the deep earth is still unclear. There could be a hidden nitrogen reservoir in the deep earth. We are going to test a possibility of a hidden nitrogen reservoir from high pressure and high temperature experiments.

San Carlos olivine or synthetic forsterite was loaded as a starting material in a diamond anvil cell with nitrogen as liquid or compressed gas. After applying pressure at approximately 5 GPa, a sample was heated using CO_2 laser or fiber laser. X-ray diffraction (XRD) patterns, SEM-EDS images, XPS spectra were obtained on the recovered samples.

XRD measurements on the recovered samples revealed the formation of enstatite ($MgSiO_3$) suggesting the decomposition of Mg_2SiO_4 into $MgSiO_3$ and MgO. This reaction is contrastive to the reaction occurring in H_2 fluid (Shinozaki et al., 2013).

XPS spectra revealed that nitrogen was detected from an olivine sample recovered from 5 GPa and 1700 K. Before Ar^+-sputtering, species assignable to NH_4^+ is dominant. Presumably, the sample surface is covered with adsorbed molecules. After Ar^+-sputtering, a broad band attributable to intrinsic nitrogen reacted with the mineral was observed. The present results suggest the formation of nitride species (N^{3-}) in a mantle-derived silicate mineral. This study proposes nitride as a hidden nitrogen reservoir in the upper mantle.