

LETTER

**Direct determination of europium valence state by XANES in extraterrestrial merrillite:
Implications for REE crystal chemistry and martian magmatism**

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ABSTRACT

The relative proportion of divalent and trivalent Eu has proven to be a useful tool for estimating f_{O_2} in various magmatic systems. However, in most cases, direct determination of the Eu valence state has not been made. In this study, direct determination of Eu valence by XANES and REE abundance in merrillite provide insights into the crystal chemistry of these phosphates and their ability to record conditions of magmatism. Merrillite strongly prefers Eu^{3+} to Eu^{2+} , with the average valence state of Eu ranging between 2.9 and 3 over approximately six orders of magnitude in f_{O_2} . The dramatic shift in the REE patterns of merrillite in martian basaltic magmas, from highly LREE-depleted to LREE-enriched, parallels many other trace element and isotopic variations and reflects the sources for these magmas. The behavior of REE in the merrillite directly reflects the relationship between the eightfold-coordinated Ca1 site and adjacent sixfold Na and tetrahedral P sites that enables charge balancing through coupled substitutions.

Keywords: Merrillite, europium, martian basalts, XANES, REE