American Mineralogist, Volume 89, pages 1557–1560, 2004

LETTER

Comparative planetary mineralogy: V/(Cr + Al) systematics in chromite as an indicator of relative oxygen fugacity

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ABSTRACT

We have been developing oxygen barometers based largely on the behavior of V, which can occur in four valence states (V^{2+}, V^{3+}, V^{4+}, and V^{5+}), and record at least 8 orders of magnitude of f_{O_2}. Our first efforts in measuring these valence proportions were by XANES techniques in basaltic glasses from Earth, Moon, and Mars. We now address the behavior of V valence states in chromite in basalts from these bodies with a technique that uses the electron microprobe. Our first insights into this new technique resulted from running electron probe traverses across spinel grains from core to rim on grains that show zoning from chromite to ulvöspinel. The zoning profiles showed the normal trends of core to rim decreases of Cr, Al, and Mg, and increases of Fe, Ti, and Mn. However, the behavior of V was very different for Moon and Earth, with Mars in between. In terrestrial basalts $V^{4+} > V^{3+}$, in lunar basalts $V^{3+} > V^{4+}$, and in martian basalts V^{3+} and V^{4+} are both significant. The trends (core to rim) for the Moon show a strong positive correlation of V and Cr and negative correlation of V and Ti. For the Earth, the trends are just the opposite, with a strong negative correlation for V and Cr and a strong positive correlation of V and Ti. Chromite in martian basalts showed trends somewhere in between. We found that a convenient way to display these data for chromite is a plot showing the relative V/(Cr + Al) ratios. These ratios nicely reflect the oxygen fugacity ranges for Moon, Mars, and Earth.