American Mineralogist, Volume 101, pages 726–734, 2016

Reflectance spectroscopy of chromium-bearing spinel with application to recent orbital data from the Moon

KELSEY B. WILLIAMS[1,*], COLIN R.M. JACKSON[2], LEAH C. CHEEK[3], KERRI L. DONALDSON-HANNA[4], STEPHEN W. PARMAN[5], CARLE M. PIETERS[5], M. DARBY DYAR[6], AND TABB C. PRISSEL[5]

[1]Department of Earth and Planetary Sciences, Washington University in St. Louis, 1 Brookings Drive, St. Louis, Missouri 63130, U.S.A.
[2]Geophysical Laboratory, Carnegie Institution of Washington, 5251 Broad Branch Road NW, Washington, D.C. 20015, U.S.A.
[3]Department of Earth and Environment, Boston University, 685 Commonwealth Avenue, Boston, Massachusetts 02215, U.S.A.
[4]Atmospheric, Oceanic and Planetary Physics, Oxford University, Clarendon Laboratory, Parks Road, Oxford, Oxfordshire OX1 3PU, U.K.
[5]Department of Earth, Environmental, and Planetary Sciences, Brown University, 324 Brook Street, Providence, Rhode Island 02912, U.S.A.
[6]Department of Astronomy, Mount Holyoke College, 217 Kendade Hall, 50 College Street, South Hadley, Massachusetts 01002, U.S.A.

ABSTRACT

Visible to near-infrared (V-NIR) remote sensing observations have identified spinel in various locations and lithologies on the Moon. Experimental studies have quantified the FeO content of these spinels (Jackson et al. 2014), however the chromite component is not well constrained. Here we present compositional and spectral analyses of spinel synthesized with varying chromium contents at lunar-like oxygen fugacity (f_{O_2}). Reflectance spectra of the chromium-bearing synthetic spinels (Cr# 1–29) have a narrow (~130 nm wide) absorption feature centered at ~550 nm. The 550 nm feature, attributed to octahedral Cr^{3+}, is present over a wide range in iron content (Fe# 8–30) and its strength positively correlates with spinel chromium content [$\ln(\text{reflectance}_{\text{min}}) = -0.0295$ Cr# $- 0.3708$]. Our results provide laboratory characterization for the V-NIR and mid-infrared (mid-IR) spectral properties of spinel synthesized at lunar-like f_{O_2}. The experimentally determined calibration constrains the Cr# of spinels in the lunar pink spinel anorthosites to low values, potentially Cr# < 1. Furthermore, the results suggest the absence of a 550 nm feature in remote spectra of the Dark Mantle Deposits at Sinus Aestuum precludes the presence of a significant chromite component. Combined, the observation of low chromium spinels across the lunar surface argues for large contributions of anorthositic materials in both plutonic and volcanic rocks on the Moon.

Keywords: IR spectroscopy, Cr in spinel, lunar and planetary studies, lunar remote sensing, experimental petrology, synthetic spinel, visible to mid-infrared, lunar highlands, dark mantle deposits