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Early Archean alteration minerals in mafic-ultramafic rocks of the Barberton greenstone belt as petrological analogs for clay mineralogy on Mars

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Abstract

Characterization of terrestrial analog sites is critical for detection and determination of clay mineralogy in remote sensing studies of Mars aimed at geological, hydrological, and potentially biological investigations. In this study, we investigate a suite of hydrothermally altered early Archean rocks from the Barberton greenstone belt (BGB) of South Africa as potential petrological, mineralogical, and spectral analogs to hydrothermally altered metabasalts and mafic-ultramafic intrusions in the martian subsurface and impact craters. We present the first spectral imaging measurements on exceptionally well-preserved early Archean mafic-ultramafic rocks from the BGB, with the aim of studying their clay mineralogy and spectral signatures. Multiple spectral analyses were conducted on different sample textures (rock powders, crushed rocks, and rock slabs) appropriate for Mars rover and remote sensing exploration. Visible/near-infrared (VNIR) and mid-IR reflectance spectra were acquired on particulate samples, while VNIR spectral imaging data were collected on rock slabs. Mid-IR emission spectra were measured for the rock slabs and grains. Spectral features are compared from these different spectral techniques to identify the minerals present in the samples and compare macroscale vs. microscale detections. The measured spectra reveal absorption bands that correspond to clay mineralogy of the serpentine and chlorite mineral groups, consistent with petrographic observations, as well as magnetite, olivine, quartz, feldspar, and Al-phyllosilicate. The spectral data acquired in this study expand the reference spectra data set for remote sensing studies. The implications of this study are that rocks from early Archean greenstone belts, such as those of the BGB, serve as potential clay-bearing petrological analogs for hydrothermal environments on Mars.

Keywords: Barberton greenstone belt, early Earth, Archean metabasalts, Mars petrological analogs; Earth Analogs for Martian Geological Materials and Processes