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P21E-3021 Near- and mid-infrared reflectance mapping of Calcium-Aluminum-rich inclusions and applications for remote sensing of asteroids

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Abstract

The oldest known solar system solids, calcium-aluminum-rich inclusions (CAIs), and L-type asteroids share a spinel-like reflectance in the near-infrared (NIR), a broad 2-μm absorption and an absent 1-μm absorption. This NIR signature and unique polarimetric characteristics of L-type asteroids have led to the hypothesis that they may contain up to 30% of CAIs. However, few studies have investigated the combined near and mid infrared properties of CAIs. Here we present combined scanning electron microscopy (SEM), hyperspectral NIR reflectance maps, and FTIR mid-infrared (MIR) reflectance maps for 6 CAIs, representing fine-grained (fg) and Compact Type A (CTA) CAI types. These CAIs contain primary phases such as hibonite, melilite, perovskite, calcic pyroxene, and spinel as well as various alteration phases. Classification maps show that for the portions of CAIs examined, the aerial fraction of spinel ranges from 0-70% and the fraction of calcic pyroxene and melilite ranges from 0-100%. We found that NIR absorptions varied based on Fe content in spinel and CAI type with fg CAIs being spinel-like and CTA CAIs being featureless aside from H_2O/OH absorptions. Spectral variability in the MIR primarily depends on the spatial proportions of silicates (9-13.6 μm sharp maxima) and spinel (14 μm broad maxima). Phase classification maps created from our SEM and MIR data were used to determine the aerial fraction of spinel needed for the characteristic ~14 μm feature to 1) first appear and 2) to dominate the spectral signature. Classification maps show the appearance of the 14 μm broad maxima once 15-50% aerial fraction of spinel is reached, superimposed on spectra with silicate absorptions. Once ~70% aerial fraction spinel is reached, the spectral signature is dominated by the 14 μm maxima. The position of the ~14 μm maxima shifts to 15.2 μm with increasing FeO wt.%. These observations will be used to interpret infrared observations of L-type asteroids from the James Webb Space Telescope's (JWST) first observing cycle. The spectral signatures could be explained by spinel in the NIR, while in the MIR that same area would look like pure silicates. This possibility highlights the complexity of interpreting MIR data, since the processes controlling NIR and MIR features are fundamentally different.