Geophysical Research Abstracts
Vol. 19, EGU2017-8675, 2017
EGU General Assembly 2017

Determining the source locations of martian meteorites: Hapke mixture models applied to CRISM simulated data of igneous mineral mixtures and martian meteorites

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At present, martian meteorites represent the only samples of Mars available for study in terrestrial laboratories. However, these samples have never been definitively tied to source locations on Mars, meaning that the fundamental geological context is missing. The goal of this work is to link the bulk mineralogical analyses of martian meteorites to the surface geology of Mars through spectral mixture analysis of hyperspectral imagery.

Hapke radiation transfer modelling has been shown to provide accurate (within 5 – 10% absolute error) mineral abundance values from laboratory derived hyperspectral measurements of binary [1] and ternary [2] mixtures of plagioclase, pyroxene and olivine. These three minerals form the vast bulk of the SNC meteorites [3] and the bedrock of the Amazonian provinces on Mars that are inferred to be the source regions for these meteorites based on isotopic aging. Spectral unmixing through the Hapke model could be used to quantitatively analyse the Martian surface and pinpoint the exact craters from which the SNC meteorites originated. However the Hapke model is complex with numerous variables, many of which are determinable in laboratory conditions but not from remote measurements of a planetary surface. Using binary and tertiary spectral mixtures and martian meteorite spectra from the RELAB spectral library, the accuracy of Hapke abundance estimation is investigated in the face of increasing constraints and simplifications to simulate CRISM data. Constraints and simplifications include reduced spectral resolution, additional noise, unknown endmembers and unknown particle physical characteristics.

CRISM operates in two spectral resolutions, the Full Resolution Targeted (FRT) with which it has imaged approximately 2% of the martian surface, and the lower spectral resolution MultiSpectral Survey mode (MSP) with which it has covered the vast majority of the surface. On resampling the RELAB spectral mixtures to these two wavelength ranges it was found that with the lower spectral resolution the Hapke abundance results were just as accurate (within 7% absolute error) as with the higher resolution. Further results taking into account additional noise from both instrument and atmospheric sources and the potential presence of minor amounts of accessory minerals, and the selection of appropriate spectral endmembers where the exact endmembers present are unknown shall be presented.

References

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