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Comparative Normalisation Analysis (CNA) of the Imbrium region using Near-Infrared data from the SIR-2 instrument

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Abstract

A Comparative Normalisation Analysis (CNA) method takes advantage of the two main strengths of the SIR-2 instrument: its high spectral resolution and, crucially, the uniformity and comparability between the spectral samples obtained during its 100 km altitude mission phase as part of the Chandrayyan-1 payload. The analysed data is classified according to spectral absorption characteristics and binned within ten chosen classes. Geographical distribution maps are produced and thence discussed in a geological context.

1. Introduction

A single spectrum sample representing the average reflected radiance of several square kilometres of a remotely sensed planetary body's surface, rarely, if ever, allows a reliable quantitative analysis of the mineralogical mix of its surface materials. Instead, a qualitative and comparative interpretation is often attempted, especially when a given spectrum's absorption characteristics closely resemble that from a laboratory-sourced or modelled mineral endmember (as in the case of planetary bodies with one predominant iron-rich mafic mineral, such as pyroxene or olivine). Problems arise when, as in most cases of evolved planetary surfaces, the absorption features are the result of complex admixing of several classes of diagnostic minerals, which often overlap and/or vary in their strengths of absorption, regardless of the prevailing mode. The CNA method we presented in [1] does not attempt a deconvolution of the prevailing diagnostic spectral types, let alone a modal mineralogical survey of each spectrum. Instead, the technique, through a process of double normalization and scaling, allows for the classification and grouping of spectral shapes whilst minimizing soil maturity and shadowing factors. The process relies on a custom database of 34 spectral shape models (sub-grouped into 10 dominant types, Fig. 1) based on laboratory data from both theoretical and actual mineralogical samples (inset Fig. 1).

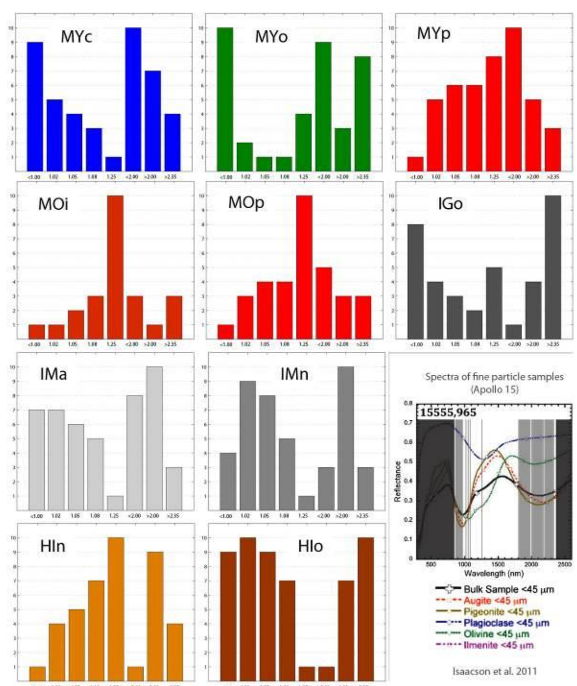

Figure 1. CNA predominant spectral types, following a double normalization process. Inset shows examples of laboratory spectra of bulk and fine components of a 'typical' lunar mare soil (Apollo 15). Grey bands highlight spectral range and position used by CNA for SIR-2 data (<1.00, 1.02, 1.05, 1.08, 1.25, <2.00, >2.00, >2.35 µm).

2. Discussion

Figure 2 shows the geographical distribution of the 10 spectral groups. It also lists the suggested nomenclature used for the groups (as in Fig. 1). Capital letters reflect the prevailing geological setting (e.g. 'M' for 'maria'), with lower cases instead the most prominent spectral signature, as derived from known mineralogical absorption characteristics (e.g. 1.05-1.08 μm, olivine, as per 'MYo'). Other classifications (e.g. younger, older) are derived either from published data, or the most likely petrology (e.g. impact glass, mix). This classification is somewhat arbitrary and speculative and should be revised as the analysis broadens to other lunar regions. Nonetheless, Fig. 2 shows the CNA method of being capable in differentiating presumed mineralogical differences apart from absorption strengths variations due to physical properties or exposure time of the surface materials. This is an important finding since the diagnostic spectral range is limited to the near infrared and devoid of the equally valuable UV-VIS information.

The Imbrium Basin shows three dominant spectral types (MYo, MYc, and MOi) with geographical distribution not only consistent with previous studies (e.g. [4]), but also adding further detail in spectral type differences ('M' map, Fig. 2). Top left map 'M' displays the distribution of five spectral signatures that represent most of the mare surface investigated. All are interpreted (spectrally) as high- to mid-Ca dominant pyroxenes and this is in agreement with petrologic models of mare basalts. Nevertheless, the geographical distribution of the units differ somewhat from other published work (e.g., [5]) and the question is raised as to whether the CNA method might be more sensitive to certain physical factors, such as soil maturity, as compared with, for instance, VIS colour ratios, or mineralogical abundances (predominantly olivine and/or ilmenite).

3. Conclusions

By 'sacrificing' the potential mineralogical quantitative information held in the NIR data, the CNA method nevertheless succeeds in sorting comparable spectral signatures into distinct groups, resulting in a new classification and mapping of surface materials.

Future work will expand on the geographical coverage of our method, including the lunar farside.

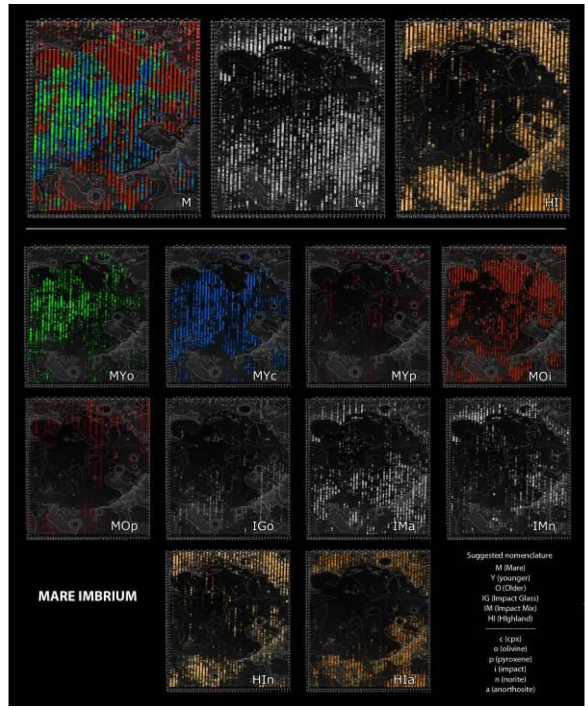

Figure 2. SIR_2 data as interpreted through the CNA grouping routine. Top three images are layers derived from the 10 spectral maps below to highlight comparable geographical settings.

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