NIR SPECTRAL INVESTIGATION OF THE DELISLE/DIOPHANTUS CRATER REGION BY THE SIR-2 INSTRUMENT.

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Introduction: The Eratosthenian craters [1] Delisle (25.5 km diameter) and Diophantus (19 km) and their associated rilles have been the subject of several lunar morphology studies (e.g. [2]). In particular, Delisle has been employed to reconstruct the modification stage of impact craters and terrace slumping mechanisms [3]. Figure 1 hints at the geological complexity of the region surrounding the craters by the superposition of a Clementine (VIS) color ratio [4] map highlighting three major mineralogically diverse surface materials: Ti-Fe-rich mare (blue), mature highland (red/purple), and relatively fresh (green). We have analyzed and interpreted new high-resolution NIR data from the SIR-2 instrument [5] to map interpretative mineralogical variations across the region.

Sample analysis: Spectral properties of lunar surface materials are dictated by their compositional (mineralogy) and physical properties (e.g. grain sizes, space weathering processes) [6,7]. Remote sensing lunar science is built on the foundations laid by laboratory analysis of returned lunar samples supported by theoretical studies and direct measurements of the spectral properties of key minerals [8]. We used a Comparative Normalization Analysis (CNA, Bugiolacchi et. al, submitted) technique to emphasize spectral features and track absorption variations and characteristics focusing on 18 key mineralogical band centers (Fig. 2). Figure 3 (also Fig. 1) shows the interpretative mineralogical classification of diagnostic absorption features of the investigated spectra. Clearly, in this study we only offer a qualitative description of the *main* spectral signature of each sample: for instance, 'OPX' spectral type signifies a spectral 'shape' comparable to that of a 'OPX-rich' sample obtained in a laboratory environment. OPX might be the dominant spectral species but actually it could be present just as a minor mineral (for instance in plagioclase-rich regolith).

The upper surface materials of Delisle's continuous deposits are spectrally comparable to highland materials, i.e. Fe-poor and dominated by plagioclase (especially the southern region). The crater interior and part of the northern rim instead suggest the main mafic phase to be represented by olivine. Spectrally similar surface materials are also detected in correspondence with the fresh ejecta from a conspicuously bright small crater south of Delisle. Surface materials overlying crater Diophantus show significantly different signatures where pyroxenes, with varying calcic content, dominate the spectral characteristics. This general trend is punctuated by spectra of uncommon (for the region) mineral phases such as 'pure' anorthite and spinel. The former is only found north of the 'pyroxene-rich' southern region, which instead features, in two instances, spectral signatures associated with the latter mineral.

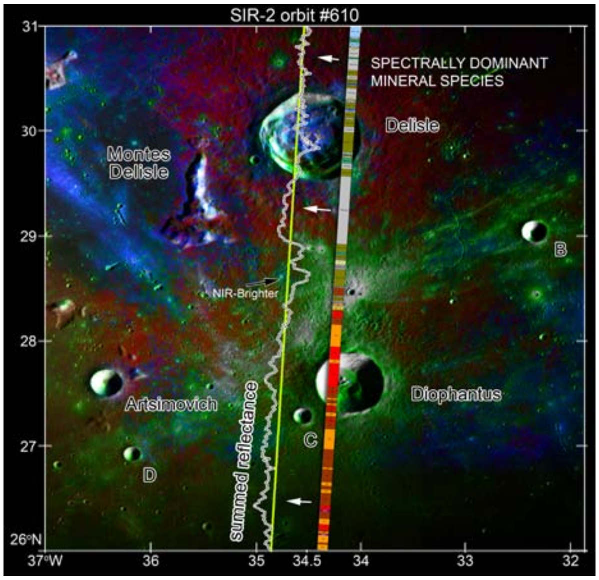

Fig. 1. Delisle/Diophantus lunar region. As reference, the orbital path also represents the average summed NIR reflectance. Clementine Color ratio map superimposed on Apollo 15 image collage (AS15-M series).

Discussion and Conclusions: Although the distance between craters Delisle and Diophantus is only around 50 kilometers, they differ considerably in the spectral characteristics of their exposed materials. The target area of Delisle impact probably comprised of highland materials (similar to the Montes Delisle to the west) which were excavated and scattered at great distance; [9] reckoned that at a distance of 30 km Delisle deposits comprises around 30% of the exposed materials. Olivine as the main mafic signature of the northern ejecta and crater interior's materials hints at a possible composition of the target's area materials rich in this mineral; this adds to the growing body of evidence from remote sensing surveys of a more significant presence of olivine close to or on the lunar surface prior to widespread mare floodings, at least around the equatorial region of the lunar nearside [10] and linked to the Imbrium event itself. South of about 28.3° N we observe a sudden change in spectral characteristics with stronger and concurrent 1 and 2 µm absorption features associated with the presence of pyroxenes. Ca-rich phases are the dominant species and this is typical of the average mare basalts materials now surfacing most of the region.

We associate the isolated distinct spectra with anorthosite and spinel with caution since these NIR signatures could be alternatively interpreted as (respectively): mature and/or shadowed materials (with highly subdued absorption features, here associated with the Diophantus Rille), and Fe-rich glass materials.

Finally, spectra with absorption features associated with olivine (i.e. “Olivine + PX”) could also belong to ‘impact glasses’, especially in samples with overall low VISNIR reflectance.

Clearly, there is still much theoretical and laboratory work needed to constrain and link spectral characteristics with mineral species. Nevertheless, the SIR-2 high-resolution NIR data and proposed interpretative method foster great potential for the development of an increasingly sophisticated and reliable mineralogical investigative tool.

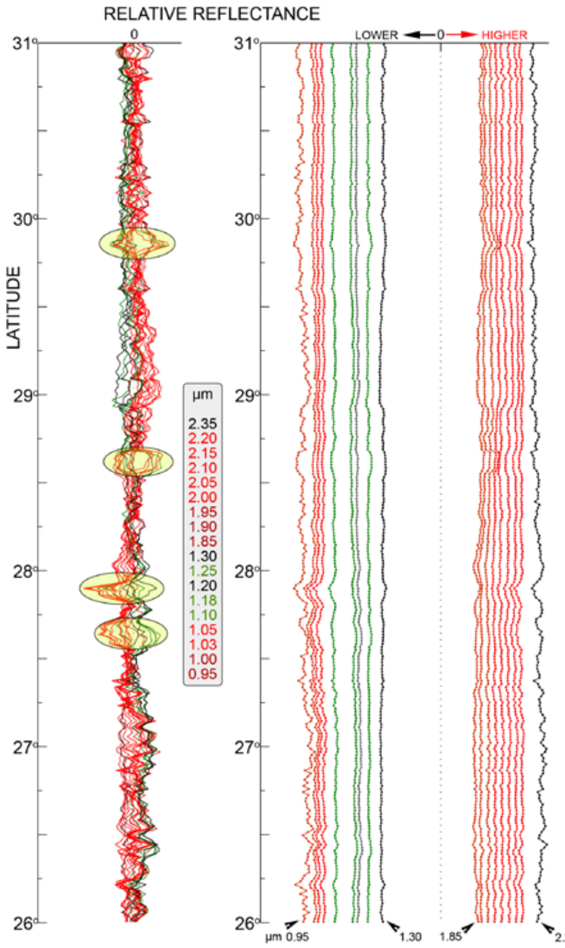

Fig. 2. Comparative Normalization Analysis (CNA) of 18 spectrally diagnostic band centers. The graph to the left represents a further normalization step to highlight the larger spectral variations within the sample pool.

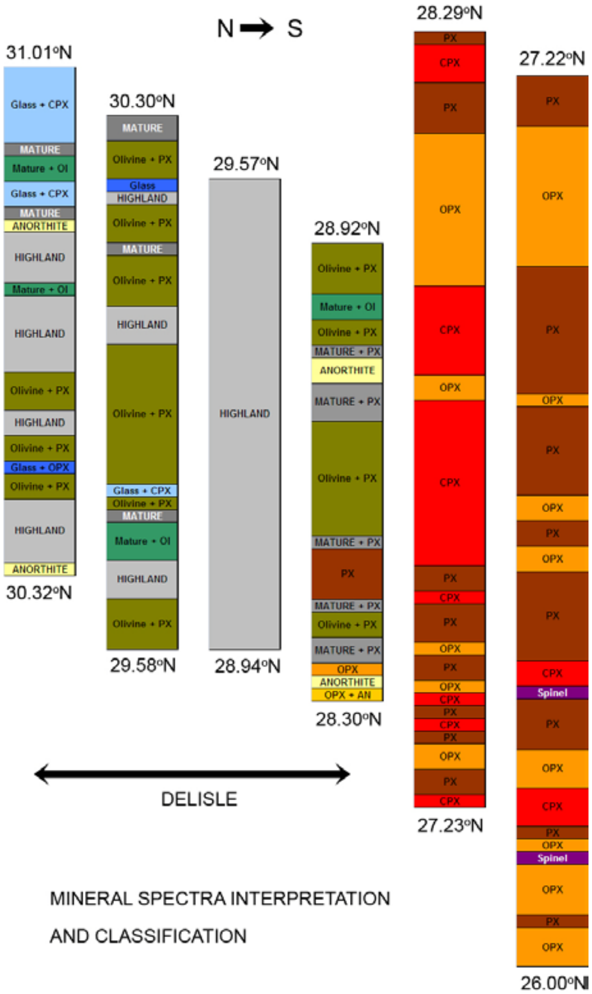

Fig. 3. Mineralogical and petrological interpretation of spectral absorption characteristics. Samples run continuously from north to south, but here are presented staggered in aid of clarity.

References:

[1] Neukum and König (1976) *LPS VII*, p. 2867-2881. [2] Lucchitta B.K. (1977) *LPS VIII*, p. 2691-2703. [3] Settle and Head III (1977) *JGR.*, *84*, 3081-3096. [4] Nozette et al. (1994) *Science*, 266, 1835-1839. [5] Mall U. et al. (2009) *Current Sci. 96, No 4.* [6] Adams and McCord (1971) *Science, 171, 567-871.* [7] Noble et al. (2007) *Icarus 192, 629-642.* [8] Pieters C. M et al. (2002) *Icarus 155, 285-298.* [9] Morrison and Oberbeck (1978) *LPS IX*, p. 3763-3785. [10] Yamamoto et al. (2010), *Nature Geoscience* 3, 533-536.