MULTISPECTRAL ANALYSES OF KOVALEVSKAYA CRATER ON THE LUNAR FARSIDE.
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Introduction: Kovalevskaya crater is a well preserved complex impact crater located on the lunar farside highlands (31°N, 230°E; D = 113 km). Eratosthenian in age, the crater is located ~ 85 km northwest of the Cordillera mountains within the Orientale basin [1]. Kovalevskaya crater (Fig. 1) has a well preserved crater rim, terraced walls, and a flat crater floor with a central uplift that appears to be partially slumped (Figs. 1, 2). The inner crater floor is filled with smooth materials. Ejecta materials superimpose nearby older craters. The release of high resolution multispectral data from the Lunar Reconnaissance Orbiter (LRO), and Chandrayaan-1 multispectral instruments presents new opportunities to observe and assess both the spectral characteristics and morphology of Kovalevskaya crater in great detail. We present preliminary results from the synthesis and analyses of Clementine, Chandrayaan1-M^3, Lunar Orbiter Laser Altimer (LOLA), and LRO-Camera data.

In this study we characterize, map, and assess the distribution of impact materials, particularly impact melt deposits beyond the crater floor. Such melt deposits are proposed to be a secondary phase of ejecta emplacement that occurs during the crater modification stage [2]. Therefore, locating and characterizing impact melt deposits relative to Kovalevskaya crater can provide details on the emplacement mechanisms involved in impact cratering.

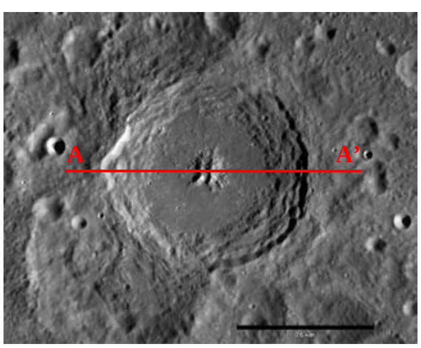


Figure 1: *LRO-WAC view of Kovalevskaya crater. Red line highlights topographic context of Fig. 2.*

Figure 2: *Topographic expression of the crater derived using LRO-LOLA altimetry data.*

Methods: Proximal impact materials are mapped using the LRO-WAC global mosaic and NAC image products (Fig. 3). Impact melt deposits are identified primarily based on their visible characteristics - smooth, low albedo deposits that show obvious contrast when compared to their immediate surroundings, and deposits that do not have a volcanic source of origin.

Further characterization of the impact melt deposits is conducted using a fusion of spectral, and topographic details together with morphology. Data integration is conducted using ISIS v.3 [3]; ENVI; JMars for Earth's Moon [4], and ArcGIS software packages. Maturity of surfaces and the iron weight distribution is inferred from Clementine UV-VIS data derived composite maps draped over LRO-WAC data (Fig. 4a, b). An RGB spectral parameter composite map (Fig. 4c) is generated from M^3 data, providing integrated band depth (IBD) values at 1 µm, 1.3 µm, and 2 µm (calculated using the algorithms of [5,6]) for assessing the mineralogy. Sampled spectral profiles are acquired using the 85-band Chandrayaan-1 Moon Mineralogy Mapper (M^3) UV-VIS-NIR data (Fig. 6). Each of the geological units identified in Fig. 3 are spectrally sampled to determine preliminary compositional information of the impactite materials associated with Kovalevskaya crater.

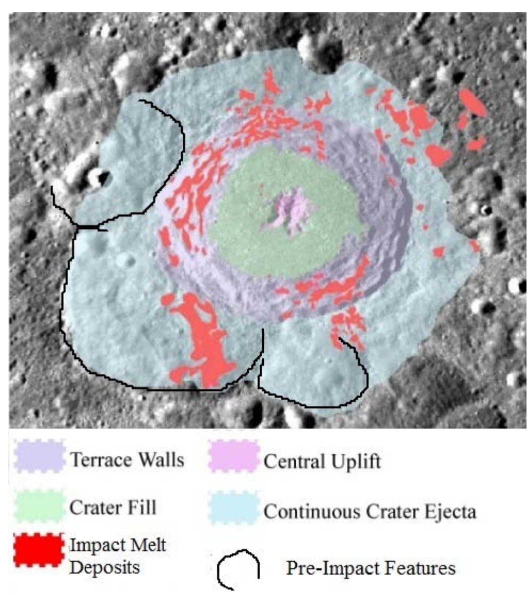
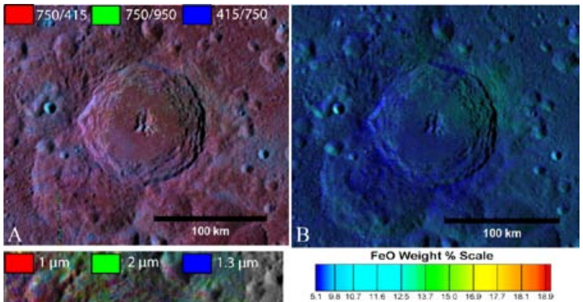


Figure 3: *Geological sketch map highlighting impactite units present.*



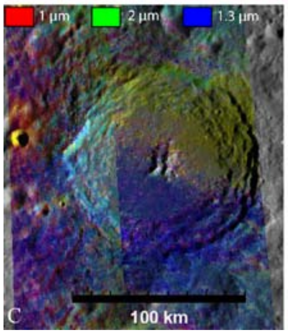


Figure 4: *A) Clementine derived false colour composite map. B) Clementine derived iron weight percent distribution composite map. C) M^3 derived IBD spectral parameter map.*

Results: The extent of impact related units within Kovalevskaya crater is shown in the geological sketch map (Fig. 3). The crater floor of Kovalevskaya is filled with smooth, low albedo deposits, presumably impact melt, with very little hummocky terrain. Impact melt deposits beyond the crater floor (Fig. 3) occur as thin veneers or pooled deposits filling low-lying depressions. They occur draped over central uplifts, within terrace surfaces, or overlying crater ejecta (e.g. Fig. 5). Impact melt deposits are found at a maximum distance of 97 km beyond the crater rim (~2 crater radii).

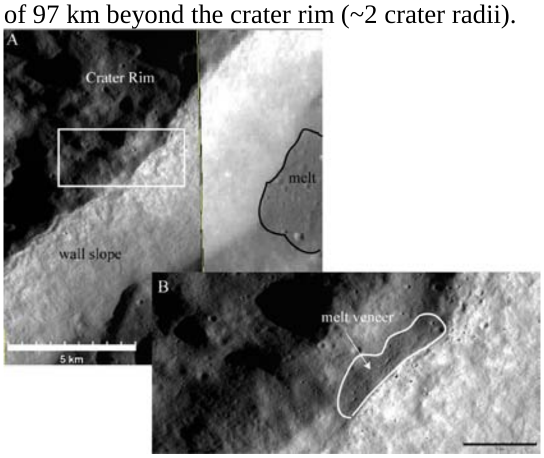


Figure 5*: View of the west crater rim near a wall terrace (31°N, 228°E). (A) LRO-WAC mosaic overlaid by LRO-NAC M178488703LC. Smooth melt deposit overlies the terrace surface to the lower right. White box outlines location of 5B. (B) Thin melt drapes over crater rim in contrast to the near-by rough wall slope, and crater rim.*

The presence of mafic material is discernable in the spectral data (Fig. 4). A high concentration of iron-rich material in the north east quadrant of the crater interior can be seen in the Clementine colour ratio (yellow in Fig. 4a) and iron (light blue in Fig. 4b) maps, and the M^3 IBD spectral parameter map (yellow in Fig. 4c). Sampled spectral profiles (Fig. 6) of the morphological units within the crater indicate the presence of both low and high-Ca pyroxenes, and plagioclase feldspar. The non-ubiquitous distribution of mafic material alludes to the complexity of the target subsurface.

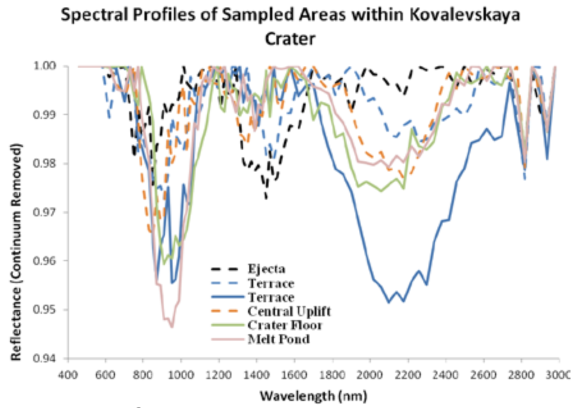


Figure 6*: M^3 derived spectral profiles of sampled geological units within Kovalevskaya crater. There is a strong mafic presence in the north (solid lines) when compared to the south (dashed lines).*

Discussion: Impact melt deposits are recognized well beyond the crater floor of Kovalevskaya (Fig. 3). However, the spectral characteristics of the identified impact melt deposits are not spectrally distinguished from the target rocks they formed from. This suggests that the impact melts emplaced beyond the crater floor of Kovalevskaya are composed of the same materials as the crater floor melts, consistent with the suggestion that melts can be emplaced as a secondary ejecta layer phase during the crater modification process [2]. Furthermore, the presence of pre-existing topography as seen around Kovalevskaya may also affect the distribution of late-stage impact melt deposits. The collapse of the crater walls during the crater modification stage would make it easier for the impact melts to escape from the transient cavity and be emplaced beyond the rim.

The diverse distribution of mafic minerals within Kovalevskaya could be the result of either 1) the redistribution of material excavated from a mafic rich region and emplaced over Kovalevskaya during later lunar impact events, or more likely, 2) the presence of mafic rich material within the target subsurface. It is unknown at this point if Kovalevskaya crater lies within any older, degraded impact basin of any type to explain the presence of mafic-rich deposits to the north east section of the crater terraces and floor. Further assessment is required.

References: [1] Scott et al. (1977) *U.S.G.S.* Map I-1034. [2] Osinski et al. (2011) *EPSL*, 310, 167–181. [3] Gaddis, L. et al. (1997) *LPS XXVII*, 1226. [4] Christensen, P. R. et al. (2009) *AGU*, IN22A–06. [5] Mustard, J. F. et al. (2011) *JGR*, 116, E00G12. [6] Donaldson Hanna, K. et al. (2012) *LPS XXXXIII* , 1968.