GEOLOGIC MAPPING OF IMPACT CRATER FLOOR DEPOSITS NEAR THE LUNAR SOUTH POLE.

S.C. Mest[1,2], D.C. Berman[1], and N.E. Petro[2], [1]Planetary Science Institute, 1700 E. Ft. Lowell, Suite 106, Tucson, AZ 85719-2395 (mest@psi.edu); [2]Planetary Geodynamics Laboratory, Code 698, NASA GSFC, Greenbelt, MD 20771.

Introduction: In this study we use recent image, spectral and topographic data to map the geology of crater floor deposits in the region surrounding the lunar South Pole (60°-90°S, 0°-±180°). This study is part of a larger effort to map the geology of the Lunar South Pole quadrangle (LQ-30) at 1:2.5M scale [1-6]. The objective is to evaluate the nature (impact melt versus volcanic) and timing of impact crater fill deposits. Impact craters within this map area are important structures for (a) evaluating the regional stratigraphic history and (b) approximating the composition and structure of the Moon's lower crust/upper mantle. The overall objective of the regional mapping effort is to constrain the geologic evolution of the lunar South Pole with specific emphasis on evaluating (a) the regional effects of basin formation on the structure and composition of the crust and (b) the spatial distribution of ejecta, in particular resulting from formation of the South Pole-Aitken (SPA) basin and other large basins.

Methodology: This project utilizes ArcGIS to prepare data (e.g., image mosaics, topography, spectral maps) and map (e.g., contacts, structures) layers. The Clementine UVVIS 750-nm mosaic (100-200 m/pixel) is being used as the primary base to characterize geologic units from surface textures and albedos, identify unit contacts, and identify impact craters with diameters greater than 2 km; other mosaics and images (e.g., Lunar Orbiter, Clementine NIR and HIRES) are being used to complement the UVVIS base.

Regional Geology: LQ-30 exhibits ~16 km of relief. The near side consists predominantly of cratered highlands, is more heavily cratered and displays higher elevations than the far side. This difference is due to the overwhelming presence of SPA, which encompasses nearly all of the far side map area.

SPA is the largest (D=2600 km, ~18 km deep) and oldest (pre-Nectarian) impact basin identified on the Moon [7-9]. Models suggest that SPA formed by an oblique impact that excavated material from the upper crust [10,11] to the lower crust or upper mantle [12,13]. Galileo and Clementine multispectral data show enrichment in mafic materials [14-18] and LP-GRS data show enhancements in both Fe and Th [19-22] within the basin relative to the surrounding highlands. Although exposed materials within SPA have likely been altered by billions of years of geologic processes (impacts, space weathering, etc.) or buried by local mare and pyroclastic deposits, the materials exposed within SPA could be used to estimate the composition of the lower crust/upper mantle.

Mapping Results: Impact craters in LQ-30 display morphologies ranging from simple to complex [7,8,23]. LQ-30 hosts all or part of 46 impact features greater than 100 km in diameter that would have significantly affected the structure of the crust and redistributed large amounts of material across the surface.

The map area contains numerous impact craters with floor deposits that are distinct from surrounding plains and/or highland materials. Generically, most of these deposits likely consist of impact melt generated by each crater. However, some deposits, especially on the floors of some of the larger craters and basins (e.g., Antoniadi), exhibit low albedos and smooth surfaces and may contain some component of mare. Higher albedo deposits tend to contain a higher density of superposed impact craters. Unmapped crater floor deposits exhibit albedos that are similar to surrounding plains and highlands units, and generally occur in older, degraded craters, suggesting these floors are mantled, likely by younger impact ejecta.

Antoniadi Crater. Antoniadi crater (D=150 km; 69.5°S, 172°W) is unique for several reasons. First, Antoniadi is the only lunar crater that contains both a peak ring and a central peak, placing it morphologically between impact craters and multi-ring basins [7,8]. Second, it contains the lowest elevations on the Moon (-8.5 km), which provides access to lower crustal/upper mantle materials via its central peak and peak ring. Previous mapping [7] and preliminary mapping [24] show floor deposits consisting of dark smooth material near the center of the crater, and brighter more rugged floor materials between the peak ring and crater wall. Recent mapping shows that the dark material appears to embay the rugged material, as well as the peak ring and central peak structures. This indicates that the dark material was emplaced after the rugged material and may consist of mare, whereas the rugged material likely includes impact melt emplaced immediately following crater formation [7]. Clementine UVVIS data provides adequate resolution to derive general embayment relationships, but key diagnostic features (e.g., rilles, flow margins) are not visible. Clementine HIRES (~10 m/pixel) images, as well as LROC NAC (~50 cm/pixel, as they are released) can be used to assist in properly assessing unit relationships and identifying features that will enable units to be adequately characterized.

Preliminary crater size-frequency distributions for small craters (D<10 km) superposed on Antoniadi's ejecta blanket suggest an Upper Imbrian age, whereas craters greater than 10 km in diameter suggest a Lower Imbrian/Nectarian age [24]. It is important to note that Antoniadi's ejecta blanket also contains a significant number of secondary craters that are likely included in the counts and will affect age determination.

Schrödinger Basin. Schrödinger basin (76 ºS, 134 ºE) is one of the least modified lunar impact basins of its size. Schrödinger is believed to be Imbrian in age [6,7,25] and is likely one of the last major basin-forming impact events on the Moon, slightly older than the Orientale impact, which emplaced secondary craters on Schrödinger's floor [25]. The basin exhibits an outer ring (D=312 km) that defines its rim and an inner peak ring (D=160 km) represented by a discontinuous ring of mountains. Clementine-derived topography show the basin is ~8 km-deep with elevations of ~2.5 km (max) along the western rim and -5.5 km (min) on the floor [6].

Arcuate to linear fractures are prominent on the basin floor and occur concentric and radial to the basin rim. Most fractures bisect plains-forming units, but some bisect the peak ring. These features are a few kilometers wide, and tens to a few hundred kilometers long and appear similar to other floor-fractured craters on the Moon and Mars [26].

Our mapping has identified ten distinct units organized into three groups - Schrödinger Basin Materials, Schrödinger Basin Plains Materials, and Schrödinger Basin "Volcanic" Materials - and are described below.

Schrödinger Basin Materials: The oldest materials exposed in Schrödinger are *Schrödinger peak ring material* and *Schrödinger basin rim material* [6]. The peak ring material forms an incomplete ring of mountainous terrain around the center of Schrödinger. The basin rim material forms the topographic rim crest and interior wall of Schrödinger. These materials are interpreted to consist of pre-Schrödinger crustal materials uplifted following the impact event [6,12,27].

Schrödinger Basin Plains Material: The floor of Schrödinger is covered with plains-forming materials that display a variety of surface textures and albedos. *Schrödinger rugged plains material* appears to be the oldest plains material on the basin floor. Most exposures are found outside of the peak ring and form heavily cratered and knobby plateaus and massifs of moderately high albedo [6]. *Schrödinger hummocky plains material* occupies much of the floor along the northern and western walls within Schrödinger, and in the south where the peak ring is the most discontinuous. Hummocky plains display moderately cratered, low albedo surfaces with gently rolling topography [6]. The rugged and hummocky plains materials are interpreted to consist of impact melt [6].

Schrödinger smooth plains material, found just inside the peak ring, embays the rugged plains, peak ring and basin wall materials. The smooth plains display moderate to high albedo and contain few craters [6]. *Schrödinger mottled plains material*, found primarily in the center of Schrödinger, displays a smooth surface that is lower in albedo and less cratered than the smooth plains. The smooth plains and mottled plains materials are interpreted to be volcanic (mare) in nature, possibly erupted via floor fractures [6].

Schrödinger knobby plains material forms two high-albedo deposits along the southern basin wall. These deposits exhibit lobate edges, and clusters of rounded and elongated knobs. Knobby plains material is interpreted to be (a) impact ejecta, (b) basin wall materials emplaced by landslides, and/or (c) more rugged exposures of the rugged plains [6].

Schrödinger Basin Volcanic Material: Volcanic materials are concentrated inside Schrödinger's peak ring. *Schrödinger dark plains material* displays smooth, featureless, low albedo surfaces. Clementine UVVIS color ratio maps show these deposits are more mafic relative to other Schrödinger plains materials [6]. Within one deposit, a long (10s of kilometers) sinuous rille emerges from the mottled plains and terminates within the dark plains. Dark plains material is interpreted to be composed of fluid basaltic lavas [5,6].

The eastern part of Schrödinger, just inside the peak ring, contains a small (D=5 km) well-preserved ovoidal cone. The cone displays ~500 m of relief above the surrounding plains and is ~400 m deep from its floor to its rim [6]. The cone has been characterized as a "maar"-type crater [25] and a "dark-halo crater" (DHC) [28], and has been identified as the source of pyroclastic eruptions [25,28]. *Schrödinger dark material* forms a small deposit that surrounds and forms the flank of the DHC. This deposit exhibits a relatively smooth, lightly cratered surface with lower albedo than the surrounding plains [6]. Schrödinger dark material displays an unusually strong mafic band (950/750 nm versus 750 nm) in Clementine UVVIS data, but also displays similarities to lunar highland soils [28]. Based on the unit's relationship with the DHC and its spectral signature, Schrödinger dark material is interpreted to consist partly of mafic materials emplaced via pyroclastic eruptions originating from the DHC [6]. The deposit's spectral signature suggests contamination by feldspathic highland-type materials either by superposed crater materials and/or vertical mixing [28].

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