CHARACTERISTICS OF IMPACT CRATER INTERIOR DEPOSITS IN NOACHIS TERRA, MARS. S.C. Mest, Planetary Geodynamics Laboratory (Code 698), NASA Goddard Space Flight Center, Bldg. 33, Rm. G310, Greenbelt, MD 20771, mest@kasei.gsfc.nasa.gov.

Introduction:

The martian southern highlands contain impact craters that display pristine to degraded morphologies, and preserve a record of degradation attributed to fluvial, eolian, mass wasting, volcanic and impact-related processes. However, the degree of modification by these processes and the amounts of material contributed to crater floors are not well constrained.

Impact craters (D>15 km) within Noachis Terra (20°-60°S, 20°-50°E) are being examined to better understand the degradational history and evolution of highland terrains. The following scientific objectives will be accomplished. 1) Determine the geologic processes that modified impact craters. 2) Determine the sources (e.g. fluvial, lacustrine, eolian, mass wasting, volcanic, impact melt) and relative amounts of material composing crater interior deposits. 3) Determine the spatial and temporal relationships between degradational processes on local and regional scales. And 4) develop models of impact crater (and highland) degradation that can be applied to these and other areas of the martian highlands. The results of this study will be used to constrain the geologic, hydrologic and climatic evolution of Mars and identify environments in which subsurface water might be present or evidence for biologic activity is preserved.

Methodology:

This research utilizes multiple data sets to accomplish the above objectives. Images (Viking Orbiter, MOC, and THEMIS vis and IR (day), HRSC) are being analyzed to characterize (a) the preservation states) and (b) interior deposits of craters. MOLA data and GRIDVIEW [1] are being used to estimate crater morphometry (e.g., diameter, depth, slopes), regional and local slopes, and thicknesses and volumes of crater interior deposits. Where possible, THEMIS infrared images and TES data are being used to characterize surface properties (e.g., emission, roughness) of crater interior deposits, and Mars Observer GRS is being used to observe the distribution of surficial hydrogen. These data sets will be used to produce detailed geologic and geomorphic maps of individual impact craters. Mapping could determine if the styles of crater modification were common regionally, such as by precipitation-driven processes or by a regional mantling unit [2,3] that contributes material to crater floors via erosion or mass wasting, or differ from crater to crater, suggesting mostly localized processes were (are) active. Relative age relationships for crater interior deposits will be determined by calculating crater size-frequency distribution statistics.

Observations:

Overall crater morphologies have been assessed for 732 craters (D>15 km) in Noachis Terra using Viking and THEMIS images and MOLA data, and have been designated a Type ranging from Type A (fresh, 58), Type B (degraded, 73), Type C (moderately degraded, 62), Type D (highly degraded, 362), and Type E (buried or exhumed, 177). These designations are similar to those defined by [4-7] and Barlow, and have been previously discussed [8,9].

Current analyses indicate that multiple processes were involved in degradation, infilling and subsequent erosion of impact craters in Noachis Terra. As remote sensing data provide better views of the martian surface, it is obvious that all large craters in this part of the highlands have been modified to some degree. At higher latitudes, lower elevations, and in close proximity to Hellas basin, all craters, even Type A craters, display subdued rims that appear mantled.

Surface Textures: Impact craters in Noachis Terra contain interior deposits that display a variety of surface textures. Some deposits can be attributed to a specific source, and textures to a specific style of emplacement or modification, but most deposits and surface textures are ambiguous in nature. Most materials exhibit varying degrees of “rugged”, “pitted” or “smooth” surface textures. Characterizations are based primarily on MOC and THEMIS vis image analysis; high resolution images provide the best method of characterizing surface textures and correlating textures to albedo features observed in lower resolution images.

Rugged surfaces formed by knobs, mesas, ridges, etc. and depressions. This texture could result from emplacement processes (e.g., volcanic flow) or subsequent modification (e.g., erosion). Most interior deposits in Noachis Terra display some variation of rugged texture, which include “stucco”, “knobby”, “platy” or “scaly”, and “brain”-like.

Pitted surfaces display shallow pits a few meters to tens of meters across; pits likely include impact craters, collapse depressions, or eolian scouring, and may have been subsequently modified. Most pitted materials are found at the highest-elevations within crater floors, such as on the tops of mesas or plateaus.

Smooth surfaces display minor changes in relief at MOC scale; may be hummocky on larger scales. Materials with smooth textures generally superpose rugged or pitted materials. The floors of depressions usually contain smooth materials; these occurrences are typically associated with dune features. An eolian origin for most smooth-textured deposits is likely.

Surficial Deposits: Data analysis, combined with surface texture characteristics, enables interpretations to be made about the nature of specific crater interior deposits and (or) the process of emplacement.

Mantling materials: Occurs in gullies and on rims and interior walls of most craters, especially south of ~40°S [2,3]. Deposits display knobby textures on rims and scaly/platy textures on walls and in gullies.

Mass wasting materials / Talus: Mass wasting materials are generally found at the base of crater walls and central peaks; may include mantling material that moved downslope. Deposits display transverse ridges and valleys, longitudinal grooves, and lobate and convex or scarp-edged terminations. Interior deposits displaying the “brain”-like texture (at MOC scale) usually cover most or all of the crater floors and are generally associated with transverse ridges and valleys (at THEMIS and HRSC scale), suggesting a mass wasting origin. Talus is found in most craters; rare in Type E craters. Most occur as narrow deposits at the base of crater walls and central peaks.

Alluvial fans / Fluvial deposits: Rare in this study area; generally small in area with small contributing areas incised in crater rim. Fluvial deposits resulting from rim erosion (gullies or a valley breaching a crater rim) also rare, despite the large numbers of gullies incised in crater walls. Deposits are difficult to identify due to modification, areal extent, and MOC coverage.

Eolian materials: Transverse dunes and dark eolian ridges are the most common eolian features in Noachis Terra. Transverse dunes usually fill low-lying areas (pits, small craters, among dark eolian ridges). Here, sediments form bright dunes in MOC. Most dunes are short, due to confinement by higher relief structures, and are oriented perpendicular to adjacent higher relief structures (crater walls, knobs, mesas, eolian ridges). Dark eolian ridges (~300 m high) form large dune fields on the floors of several large craters in Noachis Terra (e.g., within Proctor, Rabe) [10,11]. Barchan dunes are rare; usually found around dark eolian ridge fields, some isolated occurrences. All barchans are observed to be dark in MOC. The origins of wind-blown materials are difficult to assess, but the presence of these deposits indicates that eolian processes may contribute, or at least redistribute, significant quantities of sediments to interior deposits.

Impact crater ejecta: Clearly discernible from other materials (especially in THEMIS IR) if largely unmodified and (or) younger than underlying floor material. In MOC, the texture of ejecta is usually more rugged/blockier than other materials.

Gullies, Irregular Pits and Plateaus: Gullies are incised in the walls of craters of all morphologic Types, but rare in Type E craters. Gullies are incised in walls of all orientations, but generally densest in east-facing and north-facing walls. Some head at or near crater rims, suggesting erosion by precipitation-derived runoff [12-14], whereas other gullies originate at discrete layers along crater walls [15], suggesting seepage of groundwater. Many gullies are filled with "scaly/platy" materials similar to mantling material.

Several large craters in Noachis Terra (and other areas of the circum-Hellas highlands) contain features on their floors such as irregular pits and plateaus or mesas. Irregular pits are generally several tens to hundreds of kilometers across and up to 300 m deep. They are formed by circular to oblong depressions and (or) angular wall junctions. The walls of the pits are steep and display thick and thin layers. Most irregular pits are flat-floored, some contain knobs or mesas; pits act as sediment traps and thus many contain dune features. Plateaus, which also include mesas and mounds, are generally large features relative to the knobs that compose rugged textures. Mesas and plateaus are typically flat-topped and their surfaces display mostly "pitted" textures, whereas some display "smooth" or "rugged" textures. The walls of most mesas and plateaus are steep and some display thick and thin layers. Mounds are generally rounded; some display "pitted" textures and are bright in THEMIS day IR; some are "rugged" or "knobby" (central peak remnants?).

Discussion:

732 impact craters in Noachis Terra/Hellaspontes Montes (20-60°S, 20-50°E) have been identified, their morphologies categorized, and many (238) have been characterized in detail based on image coverage. Many highland impact craters in Noachis Terra exhibit evidence for modification (eroded and infilled) by multiple geologic processes. The morphologies of most craters and the deposits preserved on their floors suggest atmospherically-derived and (or) subsurface volatiles were involved, but not to the same degree as observed in the highlands north and east of Hellas Planitia [16-22]. Craters that contain similar features (irregular pits, plateaus, etc.) and (or) surface textures suggest either emplacement of similar materials (and sequences of materials shown by layering) and (or) the processes of emplacement and subsequent modification were widespread. It is the ongoing goal of this research to use all available Mars data to identify deposits associated with specific sources and determine the process(es) of their erosion and emplacement, quantify crater interior deposits (i.e., thickness, volume), and correlate crater degradation processes locally and regionally in order to spatially and temporally constrain volatile distribution as well as assess climate change on Mars.

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