GEOLOGY OF CRATER MILLOCHAU, TERRA TYRRHENA REGION OF MARS. S.C. Mest[1] and D.A. Crown[1,2], [1]Department of Geology and Planetary Science, University of Pittsburgh, Pittsburgh, PA 15260, scmst25@pitt.edu; [2]Planetary Science Institute, 620 N. 6th Ave, Tucson, AZ 85705.

Introduction: The martian highlands preserve a long and complex history of degradation by fluvial, eolian, and mass wasting processes [1-8]. The effects of these processes are best observed on impact craters that characterize the ancient highlands. Previous studies of highland terrains - Margaritifer Sinus [9,10], Ismenius Lacus [11,12], Arabia Terra [13], and Promethei Terra [14,15] - have shown that craters display pristine to highly degraded morphologies. Some craters exhibit distinctive interior deposits, suggesting infilling by sedimentary and (or) volcanic deposits. Several studies [e.g., 16-20] have suggested that large impact craters on Mars may have contained standing bodies of water that could have been ideal environments for life to persist.

Studies of Terra Tyrrhena [3,21-27] suggest large amounts of fluvial erosion and deposition occurred during the early part of Mars' history, followed by remobilization of sediments by eolian activity. Crater Millochau (21.4¡S, 275¡W) is a large (~114 km diam.), highly degraded crater in Terra Tyrrhena that displays a complex geology representative of many of the above-mentioned processes. Detailed analysis of crater Millochau is part of a larger project being undertaken to document the history and characterize the geology of Terra Tyrrhena [26,27]. Due to its size, degree of modification, and apparent age, the geologic record of Millochau could represent a large part of martian history, recording changes in degradational style(s) and (or) climatic changes, as well as serve as a proxy for craters of similar age to understand the degradational history of this part of the highlands. This study intends to (a) characterize the complex geologic and geomorphic terrains within Millochau, (b) determine the origin(s) and ages of floor deposits, and (c) investigate degradation processes that might have affected Millochau and other craters in the region.

Regional Geology: Geologic mapping in Terra Tyrrhena (13-30¡S, 265-280¡W) is allowing detailed characterizations of the highlands to be made, including impact crater morphologies, dissection by fluvial valleys, and formation of intercrater plains. Much of the region records a long history of impact cratering and modification. The geologic history of this area may have been influenced by the Hellas basin as well as by other buried impact basins [28,29]. Erosion of highland materials is believed to have been widespread during the Late Noachian Epoch and continued throughout the Hesperian Period, resulting in deposition of plains-forming materials. An extensive network of valleys, as well as several smaller networks, dissects the study area. Subsequent eolian activity remobilized sediments and deposited them on valley and crater floors, as well as in low-lying areas of the plains, and in many places form large sets of parallel dune features.

Geology of Millochau: Crater Millochau is ~114 km in diameter and 2.3 km deep (lowest point in the northeast part of Millochau). Viking, MOC, and THEMIS images reveal a variety of features that suggest Millochau may have undergone a more complex geologic history than other large infilled craters in the region. MOLA topographic data are being used to observe the distributions of geologic materials and features within Millochau with respect to elevation.

Millochau has no ejecta blanket, which has either been eroded and (or) mantled by the local plains unit and eolian sediments that cover this part of the highlands. The rim of Millochau is quite discernible, however portions of it are more degraded than others. The northeastern and southwestern parts of the rim appear the most rugged, standing ~400-800 m above the surrounding terrain (~1500-2200 m above the crater floor). The remainder of the rim appears degraded by impact cratering and other processes. The eastern rim of Millochau is shared with another large (~50 km diam.) crater and forms a gap ~600 m above Millochau's floor. A second gap occurs along the southern rim of Millochau and is less than 200 m above the crater floor. Due to the presence of valleys on the southern exterior flank of Millochau and numerous gullies along the interior wall, this gap may have been formed, or at least modified, by fluvial erosion, as well as eolian processes. The southern wall of Millochau appears to contain a higher concentration of gullies than the northern wall, which is steeper than the southern wall. Unlike other large craters on Mars [16-20], Millochau does not have obvious inflow and outlet valleys and apart from the "gaps" does not appear to have been breached in any way. Therefore any water entering Millochau most likely traveled via the gullies, through the subsurface, or by direct precipitation.

The floor of Millochau, just north of center, is raised as much as 400 m above the surrounding floor. The material on the surface of this 'plateau' is similar in appearance to the pitted material (**mp** - discussed below) that covers most of the crater floor. The plateau is bounded on its northern and eastern edges by a scarp, and slopes gently to the south where it grades into the surrounding floor. The plateau could be the remnant of a central peak, but its degraded morphology raises questions as to the nature of its degradation. Furthermore, the presence of pitted material on its surface suggests an environment, or process, in which deposition of material would have been widespread in Millochau, including on the plateau.

Millochau contains three distinct deposits that form the Crater Millochau Assemblage: pitted, etched, and dune materials. Five high-resolution MOC images and one THEMIS (visible wavelength) image allow these deposits to be identified and characterized separately from crater floor material that fills other craters in the region. Etched and dune materials are exposed in a series of depressions that form the scarp boundary of the north-central plateau. Layers of variable thickness are observed within this scarp and in knobs found within the depressions; the layers presumably represent materials that were emplaced on the floor of Millochau.

Pitted material (**mp**) shows a heavily pitted and cratered surface and constitutes most of the floor material in Millochau. High-resolution Viking images show low-relief scarps cutting through the pitted material, which also appear to serve as contacts between pitted material with slightly different albedos. Darker albedo material appears to contain more craters than light albedo material, but size ranges of craters are similar for all pitted material. The presence of many small (<1 km diam.) impact craters is similar to that observed in the plains surrounding Millochau and suggests these units may be similar in age. Pitted material could include sedimen-

tary, volcanic, and impact related (ejecta, impact melt) deposits. Pits on the surface of the deposit are due to a large number of poorly preserved impact craters and collapse features. Scarps within the deposit could be either erosional (from fluvial processes), tectonic (i.e., from collapse of the deposit or faulting) in nature, or the edges of deposits.

Etched material (**me**) forms rugged and irregular surfaces and contains numerous scarps and knobs. Some knobs are capped with pitted material suggesting they are remnants of floor materials that have not been eroded. Layers of variable thickness are exposed along some scarps and knobs indicating possible deposition of sedimentary materials and (or) volcanic activity occurred early in Millcohau's history. Few fresh craters are observed within etched material, but some exposures appear to contain craters that are in the process of being exhumed. Etched material is interpreted to be exhumed crater floor materials; collapse of overlying materials and (or) erosion (fluvial and eolian) are believed to be the main processes operating to expose these deposits (sedimentary, volcanic, and impact materials).

MOC image E01-01209 shows the surface of etched material contains numerous positive relief lineations. The lineations generally connect patches of smooth material with similar albedo. Some interconnecting lineations are visible as ridges within the smooth material. Most lineations occur parallel to each other but some are orthogonal and form irregularly shaped polygonal depressions. The depressions tend to be filled with bright albedo material and (or) dunes. Currently it is unclear what the nature of this surface is, but possible scenarios include (1) erosion of smooth material by fluvial or eolian processes, (2) deposition of smooth material and lineations subaqueously or as eskers, (3) emplacement of volcanic material as dikes and flows with subsequent exposure, or (4) some sort of soft sediment deformation.

Dune material (**md**) occurs in isolated patches that fill low-lying parts of pitted and etched materials. The material that forms these deposits is generally darker in albedo than the underlying materials and forms large sets of long- and short-wavelength dunes, similar to those described by Edgett [30]. The long-wavelength dunes (~40-170 m; avg.=70 m) tend to be oriented east-west (long axis) and many span the widths of the depressions in which they occur. Short-wavelength (~10-30 m; avg.=20 m) dunes are short (long axis) and narrow. Short-wavelength dunes tend to be oriented parallel to the long-wavelength dunes, but some are perpendicular and are found between long-wavelength dunes; they are also usually oriented perpendicular to the slopes of topographic highs (knobs and scarps). From MOC images, it appears that most short-wavelength dunes superpose the long-wavelength dunes indicating they are either younger and (or) more mobile. Dune material is interpreted to consist of sediments eroded from other interior floor deposits, as well as crater wall and rim materials, and redistributed within low-lying areas by eolian processes.

In addition to the Assemblage units, Millochau also contains dark-albedo material located along the base of the interior wall. This material has been mapped as talus [26,27] and most likely consists of sediments shed from the crater wall by rock slides and falls, but may also include sediments eroded by fluvial processes and transported via the gullies, as well as other volatile-related mass movements.

Summary: The geology of crater Millochau is being studied as part of a geologic mapping project in the highlands of Terra Tyrrhena. From Viking, MOC, and THEMIS images, it is observed that the crater contains several distinct units, or geomorphic terrains, that may represent different environments of formation or possibly climates. Multiple layers, most of which are relatively thin, within knobs and scarps suggests emplacement of sedimentary and (or) volcanic materials over a fairly short time. Furthermore, extensive dune fields, and the presence of lineations and layering suggests some of the material filling Millochau is easily eroded and mobile and is most likely sedimentary in nature.

Crater size-frequency distributions are being compiled to constrain the relative ages of the geologic units in Millochau and determine the timing and duration of geologic activity [26,27]. Finally, TES and THEMIS spectral data are being used to further constrain the spatial extents of materials and (or) the physical properties of their surfaces.

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