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GEOMORPHIC MAPPING OF CRATER FLOOR DEPOSITS IN SOUTHERN MARGARITIFER TERRA, MARS

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INTRODUCTION

Mars has a complex geologic history involving impact cratering, volcanoes, fluvial erosion, and other processes. Previous findings show that the Margaritifer Terra region has experienced a lot of fluvial activity, erosion, transport, and deposition (*e.g.* Saunders, 1979; Parker, 1985; Grant, 1987). More recently, Grant and Wilson (2011; 2012) have provided further insight into water-driven activities within impact craters in southern Margaritifer Terra. They discuss how alluvial fans on Mars are concentrated on cratered highlands, and their results enhance Howard and Moore's 2005 study on cratered highlands on Mars which are concentrated in the southern Margaritifer Terra, southwestern Terra Sabaea, and southwestern Tyrrhena Terra.

While various areas in Margaritifer Terra have been mapped at greater detail than earlier studies (Williams et al., 2007; Fortezzo, 2009; Grant et al., 2009; Grant and Wilson, 2011, 2012), there remain additional cratered areas where detailed mapping will help our understanding of the geologic history of this region of Mars.

Specifically, a region of five craters (Figure 1) between previously mapped areas holds several interesting features such as alluvial fans and mass wasting deposits. By studying the shapes and ages of alluvial fans and their relationships to their host craters, it is possible to better understand the role of water in shaping these features. This study focusses on mapping this area of five craters to better understand the geologic history of the local region.

GOALS

This project was performed as an 8-week undergraduate summer research project with the goal of understanding how water shaped the surface of a small area in Margaritifer Terra. To do this the project included creating a geomorphic map through image interpretation and determining relative ages of features such as alluvial fans in connection to past effects of water

BACKGROUND

Interest in the geology of the Margaritifer Terra region began with the Viking program and has continued with recent missions, which continue to provide evidence that water once shaped the surface over large regions of Mars.

Detailed images of Mars were first transmitted through the Viking program. The first geologic map of the entire region of Margaritifer Terra used Mariner 9 data (1-2 km/pixel) to describe the area as smooth materials and mountainous areas surrounded by ancient, cratered highlands (Saunders, 1979).

Now with newer and more accurate mapping techniques, smaller areas can be mapped to explain the geology in more detail than over a larger area.

Figure 2 shows a portion of a map by Grant et al. (2009) where a heavily dissected area experienced impact, aeolian and fluvial processes throughout Martian geologic history. Their map indicates that the highland surface underwent severe impact and fluvial processes early in its history.

Some areas in that region show fluvial erosion, transport and deposition of material, and as the fluvial processes declined, two widespread volcanic and aeolian resurfacing events embayed, subdued, or inundated low lying areas. After the end of the fluvial activity, small impacts and aeolian resurfacing processes were the dominant resurfacing processes (Fortezzo, 2009; Grant et al, 2009)

There are various interpretations as to how fluvial features formed. One, in some areas of Margaritifer Terra, snow possibly concentrated in the rim depressions of the craters by aeolian processes (Grant et al., 2012). Runoff from melting snow could have given rise to mass wasting and landslides inside some craters. Alluvial fans can also hold clues to habitable conditions on Mars since water is responsible for the deposition of alluvial fans (Grant et al., 2012).

Acknowledgements

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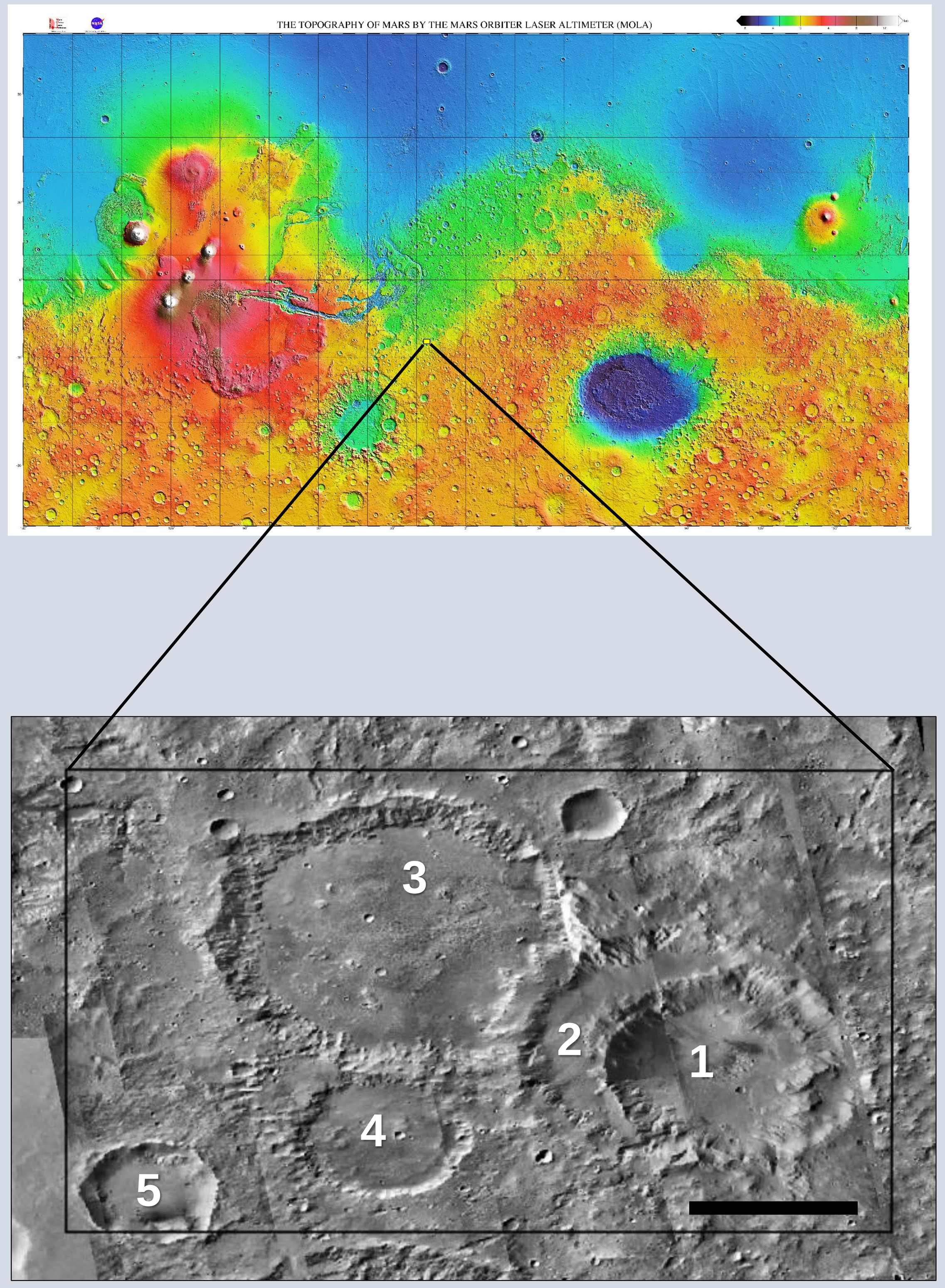
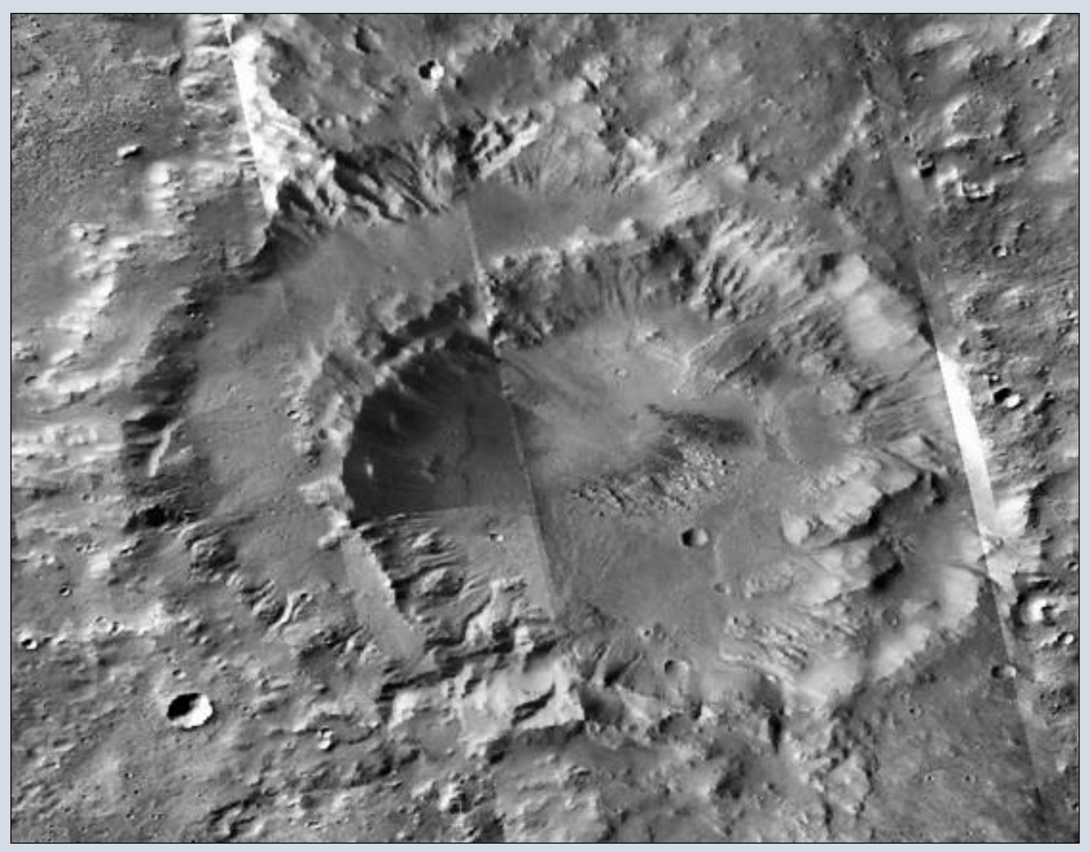


Figure 1. Location of five large craters in southern Margaritifer Terra. Numbers correspond to crater number used here. Scale bar is 25 km wide. Close up of Crater 1 is shown below.



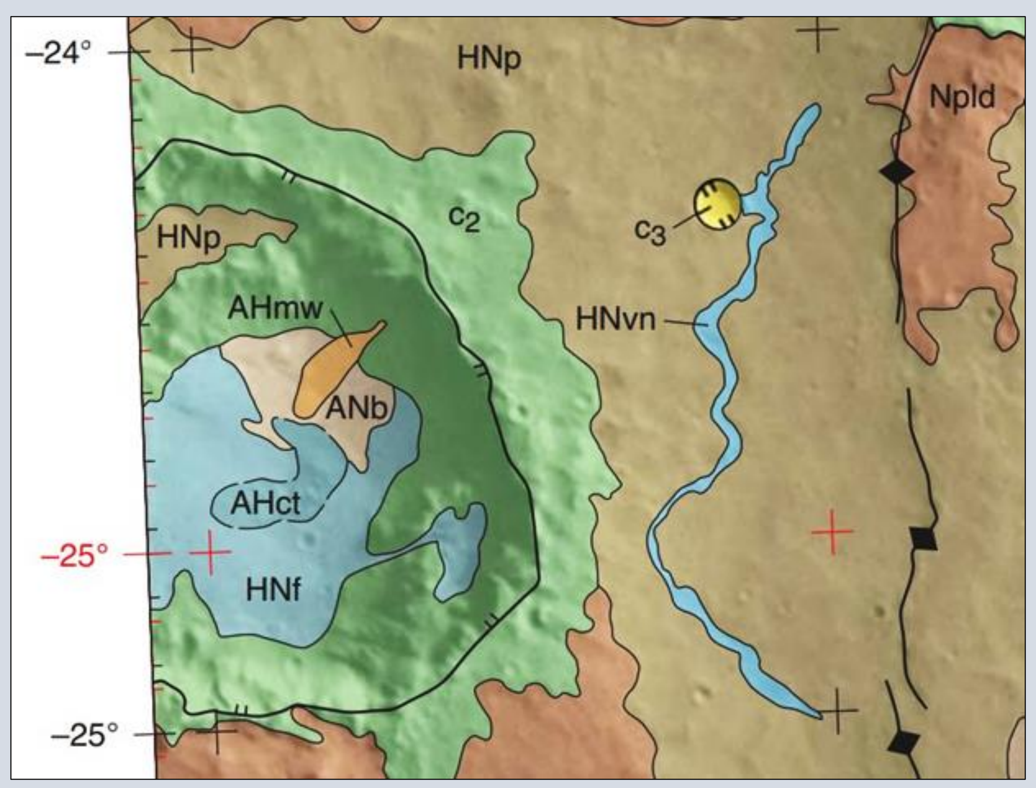


Figure 2. A portion of the Grant et al. (2009) map in southern Margaritifer Terra. The large crater on the left is Crater 1 in Figure 1.

METHOD

To understand how water affected the geologic history of southern Margaritifer Terra in an area that had not yet been mapped in detail, a study area bounded by 343.76 to 345.56 E longitude and -25.11 to -23.61 latitude was identified, mapped, and compared to existing literature and geologic maps of the region. This area was chosen because it is part of a larger ongoing mapping campaign in the Margaritifer Terra region, and there are several interesting geomorphic features within the craters.

Software

The Java Mission-planning and Analysis for Remote Sensing (JMARS) software was used to align images and other Mars data. JMARS is a geospatial information system (GIS) which provides information for mission planning and data analysis and can also be used for projects such as this. This project used multiple data sets to reveal the geologic history of the chosen area.

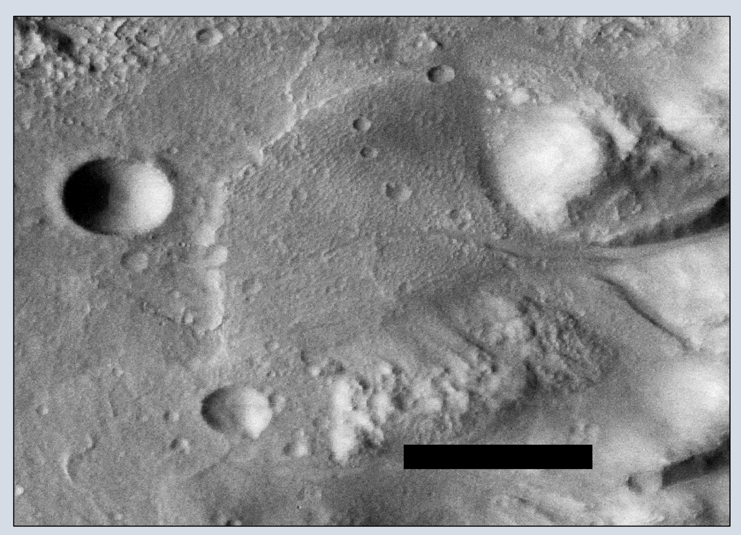
In addition, photogeologic analysis was used to create the map utilizing a variety of image datasets. These included data from the High Resolution Stereo Camera (HRSC) (10 m/pixel), Context Imager (CTX) (6 m/pixel), Thermal Emission Imaging System (THEMIS) daytime thermal infrared (IR) camera (100 – 230 m/pixel), THEMIS visible camera (~20 m/pixel), High Resolution Imaging Science Experiment (HiRISE) (1.3 m/pixel), and the Mars Obiter Laser Altimeter (MOLA) (128 pixels per degree) as described in Christensen et al. (2009). Image analysis was performed by comparing the geomorphology of features in the study area to geomorphology on Earth. Examples of several images used in this study are shown in Figure 3.

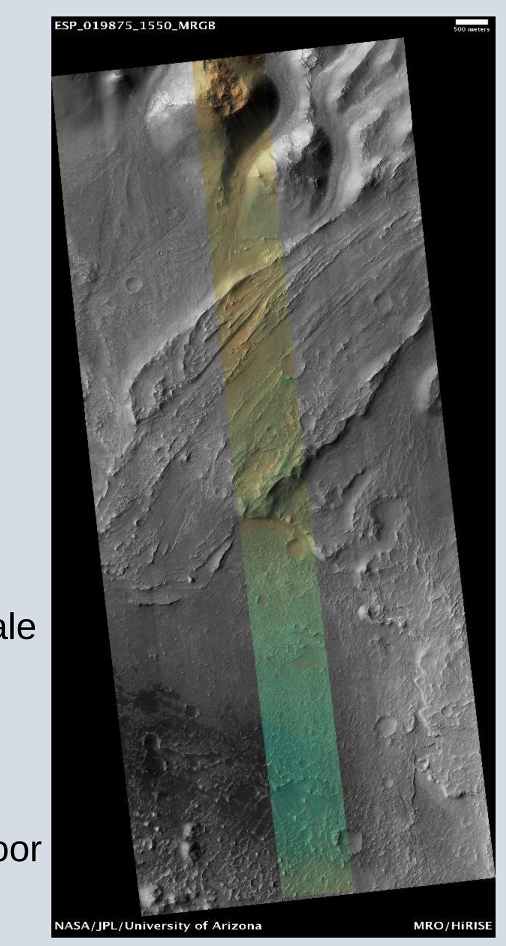
Geomorphic Map

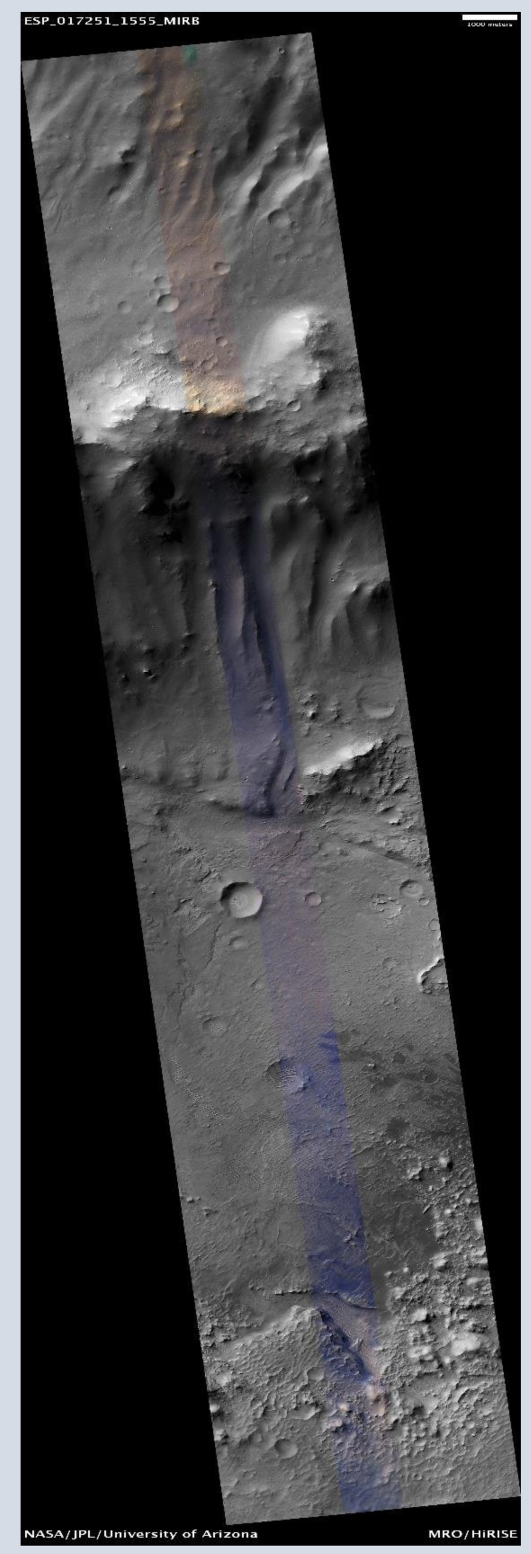
By viewing the images and topographic data sets, the geomorphology of the study area was analyzed to create a map (Figure 4) within JMARS. The layer manager in JMARS helped to add, delete and edit different layers needed to create the map. It helped to turn on the relevant layer maps, and the opacity bar helped to line up the polygons and images and to see layers under one another by changing the opacity. The layer manager also helped to plot topographic profiles and to make changes in settings as required.

The stamp layer was important for showing image locations on the surface of Mars. Different parameters such as latitude and longitude can be selected to study the chosen area. Each stamp was opened in a web browser to assess its usefulness, then selected stamps were rendered in JMARS to create the map base.

Shape layers in JMARS were used to draw points, lines, polygons and circles on the rendered images to identify important geologic features in formation of the map (Figure 4). The shape layer gives information about the shapes that were drawn such as the area of a polygon. The color of each shape was selected to match the geologic units in other peer-reviewed maps. Observations and interpretations of each unit type were compiled in the Description of Map Units.







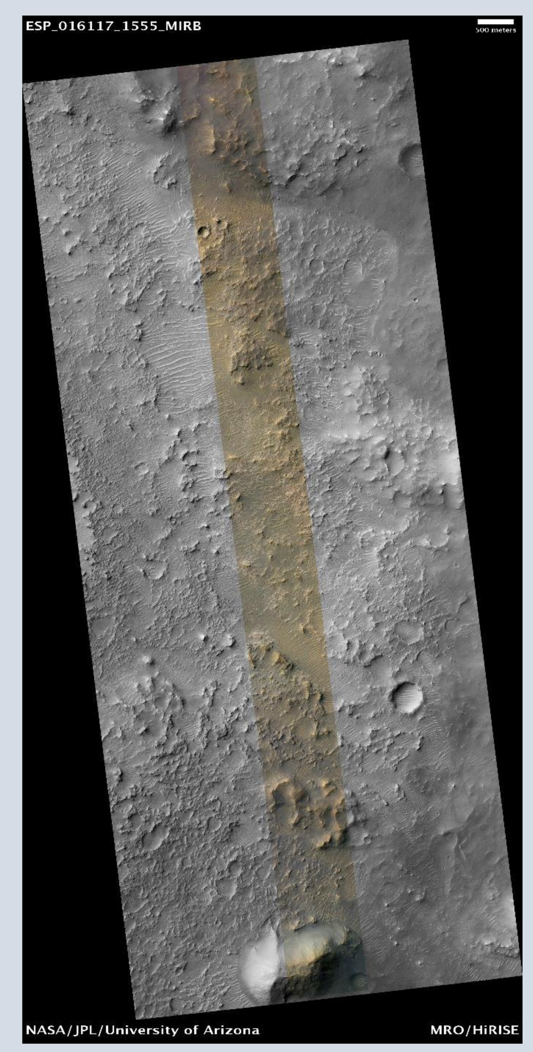


Figure 3. (above) Alluvial fan in Crater 1. Scale bar is 2.5 km. Themis image projected in JMARS. (Right) HiRISE image of landslide in Crater 1. Scale bar is 500 m. (Middle Right) Fluvial erosion featured on wall of Crater 1. Scale bar is 1000 m. (Far Right) Texture of floor in Crater 3. Scale bar is 500 m.

RESULTS

The area studied contains five large impact craters of various ages. Four of the craters appear to be moderately degraded and one appears to be well-preserved. A geomorphic map of the area was compiled in order to consider the nature and timing of surface processes within the five large craters.

The crater Dison, in the southwest corner of the map (Crater 5), is 20.7 km in diameter and has an alluvial fan emanating onto its floor from the southeast. The crater to the east of Dison (Crater 4) is larger and older, as it contains some of the ejecta from Dison. It also has a smooth deposit coating the northwestern part of its interior. This smooth material is interpreted to be an aeolian deposit blown in from the northwest. This smooth deposit is also seen in a larger crater to the north (Crater 3) and another crater to the east end of the map (Crater 1).

Crater 1 is 38.8 km in diameter and has four distinct alluvial fans of different ages spreading onto its floor as well as several fans that coalesce into a bajada along the eastern side of the crater. The older fans have steep fronts, which suggests that a lake existed in the crater when they formed. Younger fans do not exhibit steep fronts. The geomorphology of the fans suggests the presence of a crater lake during formation of the older fans but not during formation of the younger fans. One of the youngest features in this crater is a landslide on its eastern wall. This crater lies within an older, slightly larger crater (Crater 2), and all five of the large craters in the study area have gullies or rilles in their walls that indicate fluvial erosion.

Water appears to have ponded between Craters 2 and 4. The older valley network material in the northwest corner of the map probably connects to other larger channels toward the northwest.

Although some of these features likely formed from overland flow, some could be the result of rainfall or snowmelt. Snowmelt could have caused interesting geologic features such as channels, gullies, alluvial fans and landslides. Areas outside of the craters are mostly covered by an old plains unit, several areas of older cratered plateau material, and several younger impact craters and their ejecta. Overall, this area possesses an interesting combination of features that reveal the history of geologic processes that have shaped the surface including impact cratering, mass wasting, and fluvial erosion and deposition.