CLASSIFICATION OF DEPRESSION TYPES ON MARS. K. S. A. Coleman[1] and J. A. Tullis[2], [1] W. M. Keck Laboratory for Space Simulation / Arkansas Center for Space and Planetary Sciences, 202 Old Museum Building, University of Arkansas, Fayetteville, Arkansas, USA, [2]Department of Geosciences / Center for Advanced Spatial Technologies, University of Arkansas, Fayetteville, Arkansas, USA; <kxs03@uark.edu>

Introduction: As the days of human exploration of Mars draw closer, knowledge of the red planet's geology has accelerated primarily through remote sensor and *in situ* robotic investigations. Despite these advances, many essential questions remain unanswered. Water is critical to Earth's geology and it is certainly a key in uncovering Earth-Mars geologic analogies. This study will classify depressions found on the Martian surface in an attempt to identify solution-dominated features. If these structures could be visually identified using remote sensing image analysis, their presence would strongly support the existence of evaporites on Mars.

Literature review: In 1976, T.A. Mutch *et al.* released The Geology of Mars creating the original classification of impact craters, defining four basic types: simple, complex, rampart, and buried [1]. Mutch *et al.* defined the transition diameter between simple and complex craters as occurring between 15 and 20 km. Gatto and Anderson (1975) examined Earth Resources Technology Satellite (ERTS-1) imagery and recognized a similarity between thermokarst terrain near the Brooks Range in northern Alaska and fretted Martian terrain [2]. Costard and Kargel studied impact craters retaining an ejecta blanket comparing Martian and lunar impact ejecta morphology. By studying the method of formation of rampart craters, they determined that Schultz and Gault's suggestion of atmospheric entrainment was not feasible [3].

The Mars Crater Morphology Consortium (MCMC), created in 1997 by David Roddy, addressed the necessity of integrating the existing inventories of Martian impact craters into one system [4]. Numerous workers including Barlow, Bradley, Roddy, Costard, and Kuzmin had created databases of their individual research into Martian craters. Because the research investigations covered different aspects of the Martian environment, the datasets have different extents and are produced from various raw data formats such as Viking photomosaic maps, Mars Digital Imaging Maps (MDIM) and Mars Global Surveyor (MGS) data. Integrating the various formats and characteristics tracked is a feat best accomplished within a geomatics (e.g. Geographic Information System or GIS) environment. In an effort to make the data available to the planetary science community, the Consortium decided to merge existing datasets using ArcInfo GIS [4].

In 2001, Zisman presented a method of evaluating sinkhole risk based on 11 characteristics found during subsurface investigations [5]. Althought these will be useful once in situ resources exist to test the subsurface, only remote sensing images of Mars can currently be used to search for water impacted closed depressions.

Study: The objective of this study is to identify the presence or absence in representative areas of water impacted geologic formations. In order to complete the objective, it is necessary to 1) develop an improved classification system of closed depressions found on the Martian surface, and 2) develop methods for analyzing Mars remote sensor imagery using commercial geomatics software.

Analysis of Mars geology requires an understanding of comparable terrestrial and lunar geology. The following is a discussion of the depression types found in current literature, which are, or may be, analogous to Martian geologic structures. There are many different types of depressions mentioned in the relevant literature: impact craters, annular moats, volcanoes, thermokarst, quasi-circular depressions, chaotic terrain, out flow channels, and collapse structures. Each of these types of depressions has characteristics that can be used to identify it from others using Mars remote sensing imagery. The classification system created in this project is based on that of previous works, but differs in that it accounts for the correct gravity measurements of Mars and adds classifications that are called for by observations of Mars' surface features. This classification addresses impact craters, volcanic craters, and collapse structures collectively as depressions. The following list of crater types and morphological characteristics shows how depressions are divided into separate classes. The depression type classes created are based on the characteristics discussed in the literature on impact craters.

Results: Currently, a total of 3,276 closed depressions present in two study areas (the first a rectangle 75ºN to 15ºS latitude and 265ºE to 270ºE longitude and the second a rectangle 15ºS to 75ºS latitude and from 60ºE to 65ºE longitude) have been analyzed topologically and classified based on previous research as shown in Table 1.

Simple craters have a bowl shape, a raised rim, smooth walls and floor, and are generally less than 6.5 km in diameter. The ejecta from impact craters has the same appearance as lunar impact ejecta with a non-cohesive character and many secondary craters [5]. The morphology of the ejecta indicates emplacement from above by ejection along quasi-ballistic trajectories [5].

Complex craters are generally greater than 6.5 km in diameter with a planimetric shape that varies from circular to polygonal. Their upturned edges enclose flat floors which are created as the steep bowlshaped crater walls collapse under the influence of gravity forming a complex structure in the inner basin that may include a central peak.

Table 1 Depression classification and characteristics with number found in the search area.

Crater Type	Characteristics	#
Simple crater	Raised rim and bowl shaped crater with smooth walls and floor	2705
Complex crater	Raised rim and straight sides with flat floor Sometimes a central peak	99
Rampart crater	Ejecta fluidized Resembles mud flow	69
Rampart collapse	Collapse structure on a rampart	14
Buried crater	Crater filled or with upturned edges eroded away	313
Collapse structures	No raised rim	0
Volcanic crater	No raised rim Concentric craters at peak of topographic high	2
Linear collapse	No raised rim Sediments collapse into void	14
Undefined depression	None	23

In extremely large complex craters with diameters above 100 km, the central peak is sometimes replaced by concentric rings. These craters have not previously been segregated into a separate category, but the concentric rings validate doing this because it reduces statistical variation.

Rampart craters are impact craters in which the ejecta indicate emplacement as a cohesive surface flow. The internal morphology of a rampart crater is determined by its size because rampart craters occur in every size range across the entire planet.

Rampart collapse occurs as the ramparts lose their water content because water filling the pore spaces within the rampart supports the structure. As water drains from the rampart, pore spaces empty reducing pore strength. The ramparts create a relatively smooth sheet over the Mars surface except where the presence of a raised feature inhibits the flow of fluidized sediments. Rampart collapse can be identified as low areas of collapse within a rampart crater.

Buried craters are one of the previously described impact craters that have been filled over time with sediment. They can be identified by a circular shadow on the surface. Their upturned edges may have been eroded away or the internal depression may be partially or completely filled with sediments.

Volcanic craters are not of impact origin so they do not have upturned edges. They lie at the top of local topographic high areas. The volcanic craters identified in this study area exhibit complex structures similar to those formed by the coalescing of several craters over a moving center.

On Earth, collapse structures occur in the form of sinkholes in limestone, dolomite, and similar evaporites through a complex interaction of soil, rock, and groundwater.

Linear collapse structures are linear structures covering hundreds of kilometers that resemble fault bound collapse structures on Earth where sediments have winnowed into the fault.

Conclusion: Solution donimated geologic formations, such as karst topography and sinkholes, have not been conclusively identified to date in this effort, but analysis continues. Anomalous depressions that do not fit into previous classification systems are being categorized for future study.

References:

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