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"Impact Craters in Martian Polar Regions" - Age Estimation, Climatology and The Search for Life

I) INTRODUCTION & BACKGROUND

My aim in this section is to provide a background on cratering and the reasons why the study of cratering is important. I also discuss why the study of cratering particularly in Martian polar regions is of specific importance and special interest. A short note on current work in this area is also included.

Every solid body in the solar system experiences impact cratering. An impact crater is produced when a projectile, traveling at a very high velocity, hits the surface of a solid body such as a planet or natural satellite forming a large hole in the ground. The study of impact craters is very important in order to gain an understanding of the history and properties of the body on which the impact has occurred. On Earth, this is made very difficult by the erosion that occurs as a result of both the weather and geological activity, and so relatively few craters can be well studied. In contrast, the Moon has no weathering, so craters there are well preserved. Mars on the other hand, has experienced significant bombardment. The southern hemisphere is more heavily cratered than the northern hemisphere. Winds are the main erosional force on Mars and wind blown soil and dust erode craters over time. Further, geological activities as well as the presence of surface water at the time of impact influence the structure of the craters. Features of Martian craters such as shape, size and relative density provide valuable information about the *Age, Geology and Climatology* of different regions on the surface of Mars as outlined below.

Craters on the Martian surface accumulate with time. The older a surface, the more impacts it has experienced. We can rank surfaces, or geologic units, on any planet in order of age by noting that the more impact craters it has, the older it is. If we can estimate the rate of crater production (for example by using the known rates measured for the moon from Apollo exploration), we can then count up the total number of craters and calculate the actual age of the surface in millions of years. Such calculations indicate the southern polar regions of Mars to be significantly older than the northern polar regions.

The shape of an impact crater will have been heavily influenced by the type of rock that the projectile hit. The crater will look very different if it struck a very hard surface rather than a softer, powdery surface. Similar to craters on other celestial bodies, Martian craters can also be degraded by slumping of crater rims (i.e., landslides), subsequent impacts, lava flows, and ejecta from nearby impacts. In addition, Martian craters may be weathered by water and the atmosphere. The study of crater geometry provides us with an insight into Martian geological processes related to water, wind and volcanism. In addition, the study of the relative shapes of impact craters as well as the variation in the number of craters of different diameters constrains the climate history of Mars.

The Polar Layer Deposits (PLD) of Mars are especially important for study because they are among the most exotic planetary landscapes anywhere in our solar system, and have been revealed in unprecedented detail by the images taken by the Mars Global Surveyor (MGS). The layered terrain in these regions may hold the secret of the planet's climate history for the past 100 million years.

The advancement of technology has led to better visuals of the polar regions of Mars. This has inspired a variety of mathematical models of surface cratering, age estimation and climatology. Current work in this area involves statistically correlating data obtained by multiple techniques to arrive at an accurate model for age estimation and climatology. Latest THEMIS[6] imagery obtained exhibits anomalies in the MOLA[4] depth/diameter profiles and age relationships, in the South PLD as noted in the Murray et al. AGU 2004 poster.[1]

II) OBJECTIVES

Outlined below are some of the core objectives of my SURF project. Approaches to achieving these objectives are detailed in the section that follows. I intend to use these objectives as guidelines rather than limiting factors for areas of work.

I) Utilize data obtained from the Mars Orbital Laser Altimeter (MOLA) and the Mars Orbiter Camera (MOC) instruments aboard the Mars Global Surveyor (MGS) to determine crater characteristics and notice geometrical patterns and variations. Additionally, employ data obtained from the Thermal Emission and Image Spectrometer (THEMIS)[6] aboard the Mars Odyssey orbiter. THEMIS is a visual and infrared imaging system with unique capabilities of multi-spectral coverage and ice and water detection. Utilize available information on moon cratering and correlate this information with the cratering on Mars to determine the relative age differences in polar regions and between the north and south deposits, as well as an absolute age estimate by mathematical modeling techniques.

II) Study the variation in geometric shapes and structures of the craters, especially noting ejecta, raised rims and terraced walls in order to understand the climate and geology of the Martian surface. The surface age for the polar layers obtained is used as a reference age for the polar processes and as a key factor in constraining the global climate history of Mars.

III) Utilize a mathematical model in order to study the properties highlighted above. Techniques of Fourier Analysis, statistical data correlation and other parameter based modeling tools can be applied in generating models of PLD evolution.

III) APPROACH

This section describes some of the techniques that will be used in order to achieve the set objectives and better understand Martian polar regions.

The latest Mars Observer Camera (MOC) high-resolution imagery, Mars Orbiter Laser Altimetry (MOLA) topography data and Thermal Emission Imaging System (THEMIS) images must first be analyzed in great detail in order to identify the density of craters of a given size in a particular region. Variations in the number of craters of a given diameter in a particular region can be plotted. Also variations of crater rim height with depth and crater diameter with depth can be studied [2]. Particularly, the data obtained can be compared to theoretical results generated by isochron dating, and a suitable age where the data sets exhibit strong positive correlation can be obtained. The improved imaging capabilities provided by the THEMIS system has helped reveal a more complex geological history of the South PLD than that previously revealed by the MGS data. A major unconformity separating older and younger regions was also discovered [1]. This information makes a strong case for using THEMIS data more extensively to study the age relationships and geometrical characteristics of polar regions.

Further, the polar layers are seen to have a characteristic rhythm in arrangement that can be modeled using Fourier analysis [3]. Understanding the arrangement of theses layers is a key to unlocking the record of Martian climate changes and relative ages of these various layers. The age data obtained by this technique can be compared with cratering data in order to observe correlation.

The MOC and MOLA images will provide a distinctive data source for these functions. Additionally, the THEMIS high-resolution multi-spectral images will provide unique detailed profiles of the PLD's. I have worked with images, image transformations and compressions using Fourier Analysis this semester and I plan to utilize some of the skills developed, especially the attention to fine detail, to perform these tasks.

IV) BROADER PICTURE

This section attempts to address how cratering studies fit in the broader picture of Mars exploration and the quest for life on Mars. Crater populations on Mars have direct implications on age and geological history, as well as climatology of regions of Mars as previously discussed. The study of crater distribution also provides an idea of the terrain of Martian regions. Additionally, the North Polar Layered Deposits (PLD) of Mars are of fundamental climatological importance because they represent the largest actively exchanging reservoir of Martian water, water being essential for the sustenance of life. Thus the study of crater populations in the North PLD of Mars will provide justification for using this region as a potential landing site for Mars Rovers. The nature of topography will also indicate the feasibility of landing in this region. The THEMIS images obtained of the South Polar Layered Deposits as interpreted in the Murray et al. AGU 2004[1] poster make this region also an important area for detailed observation and further analysis. Further, there are indications that craters might serve as suitable prospective locations for the search for life forms on Mars [5].

V) REFERENCES

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