College Heights Christian School
Mars Student Imaging Project Proposal

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Introduction

After researching a wide variety of topics related to Mars, the following question was derived: Are multilobed crater ejecta found in low lying areas, double lobed crater ejecta in higher elevations, and craters with no lobes at the highest elevations, indicating the location of permafrost?

This topic was chosen based on existing photographs of lobed crater ejecta, which correspond with apparent flooding areas. One theory to explain the existence of lobed crater ejecta is the presence of permafrost under the surface of Mars. This project will provide additional information concerning the subsurface of Mars.

Background

Examination of Martian landscape shows a dry and barren wasteland utterly incapable of supporting liquid water. Despite this, there are numerous indications of water previously existed on the planet. Among these are striations in rock formations, winding gullies, ancient shorelines, lobed ejecta blankets from craters, and what appear to be dry riverbeds (Boyce 12-13).

One formation on Mars reflecting the past presence of water is the vast variety of channels. The origin of these channels is a topic of much controversy. Some scientists believe that these channels were created by water, and others claim that lava flows were responsible for these channels. There are three categories of channels that exist on Mars. The first type are small runoff channels located in old densely cratered terrain. Second, former tributaries, now called outflow channels, may have originated from global flooding. The third type of channels, called fretted channels, are found in flat-floored valleys and increase as they flow downstream. The majority of the outflow channels are located around the Chryse basin. These channels generally emerge from rocky terrain, which seem to have previously collapsed. Running downstream several hundred kilometers, the flow into the plains of Chryse Pantitia. The general dimensions of these channels have been defined as tens of kilometers wide and more than a kilometer deep. The areas that contain densely integrated channels provide the most evidence for the water-origin theory of the channels. Due to their complex nature, it is highly unlikely that lava or wind could create this network of channels. Forming channels this intricate would require erosion on an extremely large scale (Caplinger Channels).

During recent years there has been a great deal of research concerning the existence and history of water on Mars – if Mars was once wet, where is the water now, what has happened to it? Currently, the low atmospheric pressure allows gases and liquids to escape from the atmosphere and surface. This, scientists believe has caused much of the surface water to simply leave the planet. Another theory explaining the absence of water is that the water seeped into the ground, particularly near the polar ice caps, where it is frozen beneath the surface. This would explain the possible existence of a layer of permafrost found beneath the surface of certain regions of Mars (Raeburn 58).

Permafrost, also referred to as pergelisol, is defined as being subsoil consisting dirt and water that is permanently frozen. On Earth, it is commonly found in the soils of the arctic areas of Alaska, Canada, Greenland, and other northern countries, preventing the growth of plants. The growth of permafrost is slow and gradual; it takes place during long winters and extremely short summers. When the water content in the soil is at a higher level, the permafrost becomes "thicker and richer" (Bliss 289).

Many features of the Martian surface are consistent with features on Earth associated with permafrost, suggesting that Mars still has much water in frozen form under the surface. As early as the 1970's, images from The Viking Landers gave evidence of ancient oceans, especially in the northern hemisphere. Current research has continued to add to the body of evidence suggesting Mars was once wet. Permafrost is more likely to have formed in the regions of such oceans and potential basins as Hellas and Argyre (Ogawa 1).

A possible indication of the presence of permafrost on Mars is the ejecta from the well-known craters that exist on Mars. A crater is formed from an object impacting the surface of a celestial body. There are thousands of fluidized craters, those which form multi-lobed ejecta, in the Southern Hemisphere of Mars. The density of the craters is much lower in the Northern Plains than in the Southern Uplands. This is a direct result of the Northern Plains being younger (Mars Craters). There are several stages involved in the formation of a crater. The first stage is the Compression Stage, which is the initial impact between the surface of the planet and the projectile, deforming both. The second stage is the Excavation Stage. This occurs when a projectile strikes the surface of a planet, and a shock wave is emitted. This shock wave dislodges particles into the atmosphere creating what is called an ejecta blanket. The third stage is the Modification Stage, which changes the shape of the crater after it has been formed. These changes are primarily caused by erosion and infilling (King 82-87).

The ejecta blanket, which forms during the excavation stage comes from the outer edges of the crater when it was first impacted, expelling only a small amount of debris from the center of impact (Boyce 203-204). The actual expelled particles are known as target rock. There are different types of ejecta, fluidized, such as single lobed, double lobed, petal ejecta, and pancake ejecta (Caplinger). It is suggested that lobed ejecta blankets are formed due to the melting if the permafrost at impact. The water that is melted is mixed with soil particles and generates a muddy-like pattern.

Purpose

The purpose is to determine if lobed ejecta are more common in low-lying areas that would correspond with pre-existing oceans or outflow channels. This could be further evidence suggesting the presence and location of permafrost under the visible surface of Mars.

Hypothesis

If there is water locked in permafrost beneath the surface of Mars, then when photos of craters are compared, larger and multiple lobed ejecta will be seen in regions that were once outflow channels caused by floods or the remnants of past oceans.

Experiment Design

Control Group

For the experiment, a basis for comparison has been selected. The control craters, one double lobe, one single lobe, and one with no lobe, are the following images:

V07091014 THEMIS: Double lobed crater

101553002 THEMIS: Single lobed crater, -30.1N, 231.9E

V07098001 THEMIS: Crater without lobed ejecta – -45.893º N, 158.734º E

Another image used to locate these craters was the topography map of Mars, which shows what areas are low in elevation.

http://ltpwww.gsfc.nasa.gov/tharsis/Mars_topography_from_MOLA/

Experimental Group

After obtaining our image of a crater with lobed ejecta, this basic procedure, described step-by-step, will be followed.

1. Select a crater with a lobed ejecta, in a low-lying area, and similar in diameter to the control craters.

2. Measure the diameter of the crater.
3. Calculate the area of the crater.
4. Draw a best-fit circle encompassing the maxima ejecta
5. Measure the diameter of the circle, and calculate the area
6. Draw a best-fit circle encompassing the minimum points of the ejecta.
7. Measure the diameter of the circle, and calculate the area.
8. Average the two areas: minima and maxima of ejecta, this will approximate the area of the lobed ejecta.
9. Subtract the area of the crater from the area of the lobed ejecta. This represents the surface area of the ejecta.

Analysis

In order to evaluate the data collected, similarly sized craters will be compared. Craters from areas of higher elevations, that do not display lobed ejecta, will be used as a control. The area of the ejecta of the control group directly relates to the size and speed of the projectile upon impact. The craters that have lobed ejecta, also chosen as controls, are of similar size, and the area of their ejecta will be calculated. Presumably, larger ejecta would be formed when a larger amount of permafrost is melted. Once calculated, the area of the experimental group will be compared with those of the original controls. The approximate elevation of the craters will also be taken into consideration. If the area of the study crater's ejecta is similar to the single lobed control crater, it would indicate that the permafrost is present but not to as great of an extent as that which created multi-lobed ejecta. The results will allow researchers to identify another location that would likely have frozen water under the surface.

Conclusion

The information collected has indicated that water may still be present in the form of permafrost under the surface of Mars. It has shown that when projectiles hit the planet in low-lying areas, they form rampart craters. By doing this project, the researchers intend to show that low- lying regions of Mars contain more water under the surface, which generates lobed ejecta with a larger surface area. In contrast, craters formed at higher elevations would have ejecta a smaller surface area (formed by smaller quantities of water) and would not form lobed ejecta.

One of the big questions surrounding Mars is concerning water, since many believe the presence of it would permit life to exist on Mars. The presence of water would also provide a potential fuel source, as well as providing a way that plants can be grown, both necessary for manned space exploration of the planet. The area of study proposed will provide further evidence of water by confirming that low-lying areas are closer to the permafrost than higher elevations, and, more importantly, it would aid in the mapping of this underground water resource.

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