Westhill Mars Mission WM^2

The Effect of Elevation on Lobate Debris Aprons

I Introduction

Our project looked at seeing how elevation of lobate debris aprons effects the direction, area, and number of the feature in Eastern Hellas Basin, Deuteronilus Mensae, and Tempe Terra? This question will aid the human population in gaining knowledge about Mars for additional research and future exploration as well as the expansion of further study of Mars. The study of Mars is extremely beneficial to the scientific community and the history of the universe. People know little about this planet compared to Earth. Future generations may find information about Mars helpful for an even greater understanding.

Our hypothesis is that higher elevations on Mars will have smaller lobate debris aprons. Lower elevations, -2 km will have the greatest number of aprons based on prior evidence. More lobate debris aprons will face the poles due to decreased sunlight and heating.

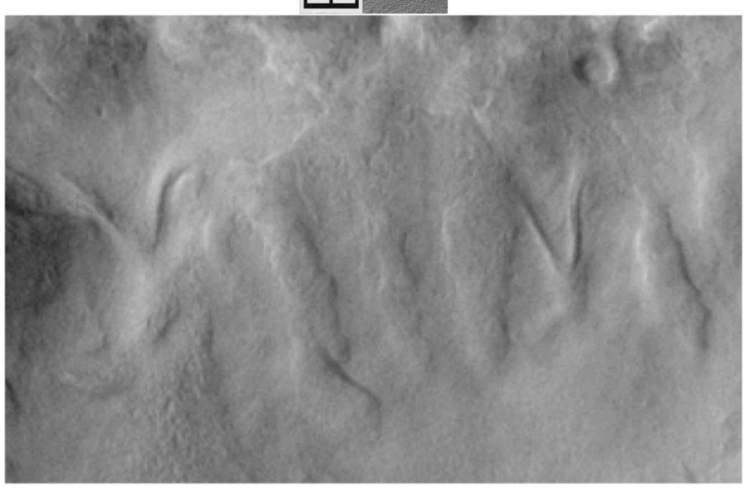
II Background

There are several definitions that are important in understanding the rest of our project.

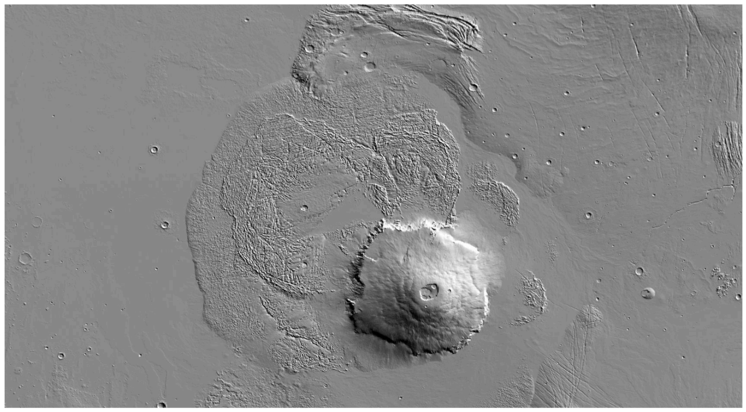
Lobate Debris Aprons (LDA)- glacier like formations that are found on Mars. They are like glaciers with a lot of rocks on top. They move slowly by rolling over themselves like a conveyor belt.
Fissure- A developmental break or fault in the base of a lobate debris apron.
Cold-based glaciers- a glacier without any liquid water underneath to give it lubrication to move easily across a surface.
Tharsis region- is an enormous volcanic plateau located on Mars' equator, at the western end of Valles Marineris.
Datum- the starting point for measuring elevation.

Sublimation- when a solid turns into a gas completely negating the phase of liquid.
Massif- the main mass of an individual mountain.
Dichotomous boundary- the divide between the low elevation of the northern hemisphere to the high elevation of the southern hemisphere.
Wet-based glaciers- when the glacier has a thin layer of liquid water as lubrication as it moves across a surface.

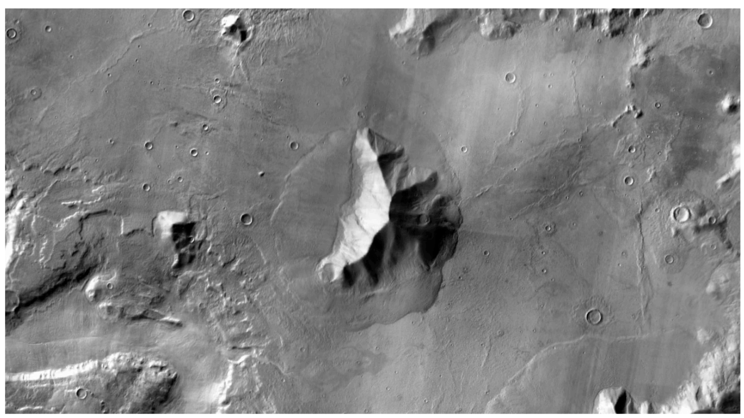
The top image below is a rock glacier which is when rock and debris is mixed together with ice and frozen CO_2 which then flows down a massif. The image on the bottom is one of the targets that we selected and it displays a few of these features.



This debris apron, near Olympus Mons, was formed when the ice underneath the debris sublimated and caused the rock and debris to flow down and produce a debris apron.

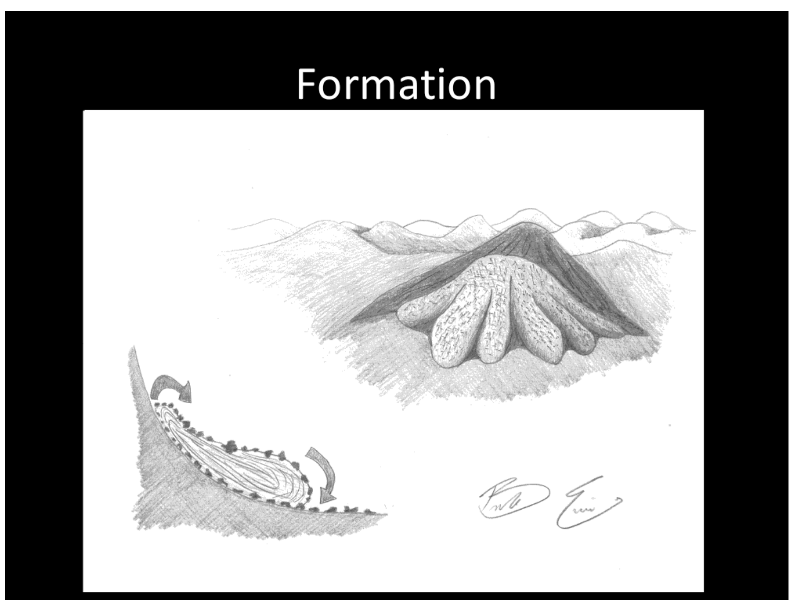


The debris apron displayed here is formed by frozen ice being covered by rock and debris, causing the ice to remain frozen under the debris.

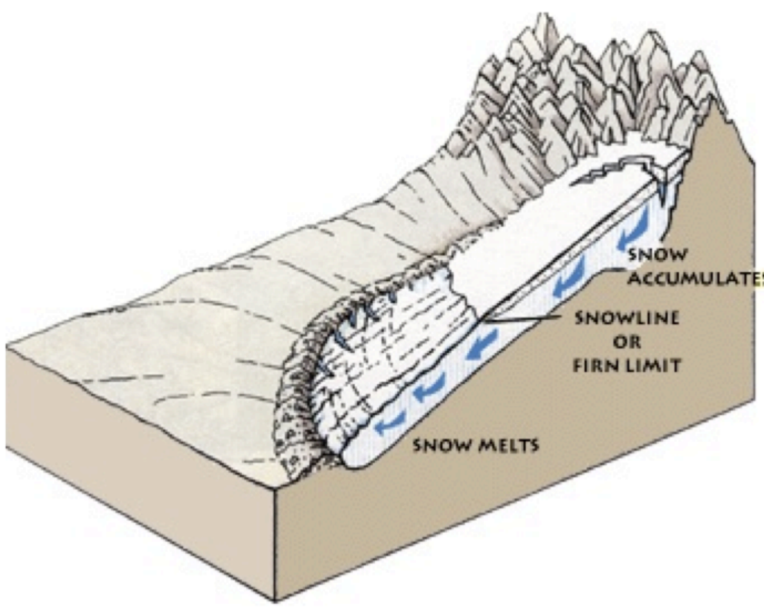


The lobate debris apron is a cold based glacier. As mentioned before, a lobate debris apron differs from a wet based glacier like here on Earth.

The lobate debris apron forms by rocks covering the ice. It is a cold based glacier in that the ice is frozen to the rocks at the base. As the rock/ice mixture flows downhill the whole structure rolls over itself like a conveyor belt depositing the rocks at the base in a linear moraine like deposit.



Glaciers on earth are wet based in that the weight of the ice produces enough pressure to melt the ice at the bottom allowing the glacier to slide down slope pushing rocks and debris from the base of the glacier to the end producing a moraine.

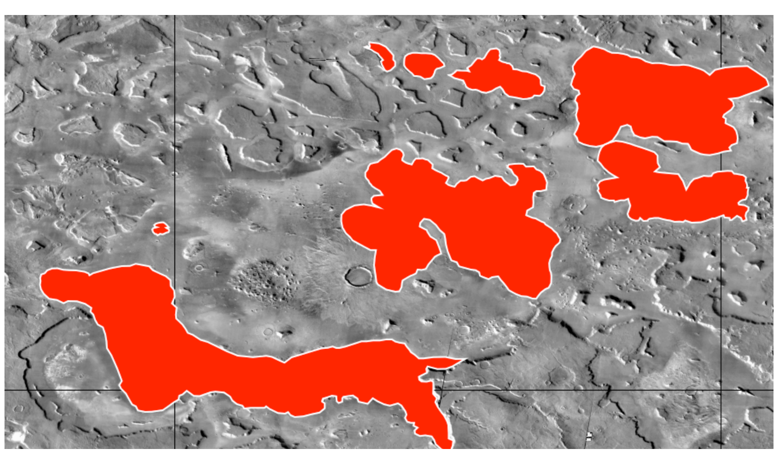


Glaciers on Earth are called, “wet-based” because of the way that the ice melts and travels to the bottom of the glacier to help it slide down the slope that it formed on. On the other hand, Ice sheets on Mars are believed to be, “cold-based” because the bottom of the ice sheet is frozen to the surface and only moves by folding over on itself. One specific feature that is seen in many places are Lobate Debris Aprons which are believed to be rock and dust covered ice sheets that have flowed out and left “aprons” around the massif. Scientists believe that flow lines on the surface of Mars that were created by the cold-based ice sheets when they folded over upon themselves were evidence of past glaciers on the surface and they also believe that there is no active glacial flow on the surface of Mars today.

III Methods

We used the Thermal Emission Imaging System or THEMIS aboard the Odyssey spacecraft, which is in orbit of Mars. Our group focused on specifically lobate debris aprons in the areas of Hellas, D. Mensae, and Tempe Terra. We chose to search for lobate debris aprons in these specific areas because they were in very different regions of Mars, which we believed may aid our results in concluding where lobate debris aprons are located.

We used tools such a JMARS to identify specific features by detecting their shape, size, and location.



As a control we set certain parameters in JMARS, we set the THEMIS quality to range between 4 and 7, measured the elevation to confirm the presence of a surface feature and measured the area perpendicular to the massif.
We focused on Hellas, D. Mensae, and Tempe Terra because these regions were different regions on Mars where we believed might have either many or a low amount of lobate debris aprons.

We used many THEMIS, CTX, and HiRise images to gather data on our question. These images were embedded and used within the JMARS program.

We recorded the size, shape, elevation, image identification number, and in which region the feature was present in order to come up with an explanation of why that feature was there and why there was either a low or high amount present in that region. We made measurements of elevation and size in order to determine where they were located and whether or not their location impacted their size. We used the tools built into JMARS in order to identify these factors.

We used the Mars THEMIS Image Gallery website in order to look at many THEMIS images of the regions that we were examining. After visually inspecting these images, we mostly used JMARS to determine our final results.
We used the image galleries on the Mars THEMIS website to visually inspect images within the region that we were studying and the type of feature that we needed to study as well.

IV Data

Deuteronilus Mensea High

Image ID #	Longitude (E)	Latitude (N)	Area (KM^2)	Direction
V26519017	75.513	30.812	494.267	2
V28840011				
B17_016272_2141_XI_34N294W	65.922	35.738	1594.679	1
P17_007543_2162_XN_36N294W				
V11669003	56.012	39.687	188.01	0

Deuteronilus Mensea Low

Image ID #	Longitude (E)	Latitude (N)	Area (KM^2)	Direction
V01435006	17.531	42.598	706.121	0
V10647015				
V30514005	16.469	43.461	261.16	0
V30514005	16.75	43.117	686.615	0
V29179010				
V2179010	17.154	43.377	267.802	0
V28630013	16.246	43.006	1128.886	0
V22066004				
V30514005				
V37339010				
V01435006				
V27170025	16.721	44.166	185.989	0
V11583002	17.305	44.652	394.602	0
V22303012	19.254	44.66	753.329	0
V21679008	19.762	42.967	129.068	0
V19545019	20.844	40.281	23848.47	0
V05442018				
V29054009				
V14216012				
V17049012				
V13592006	23.828	46.148	305.021	2
V36278027	24.512	46.012	607.101	0
V10748006	25.996	45.738	1944.194	0
V04568011				
V30152009				
V22078005	29.02	43.961	6381.232	0
V10709003				
V29815010				
V18097023				
V10135008	28.504	45.187	11299.04	0
V12893004				
V09798021				
V27494022				
V27806009				
V19536015	24.914	43.352	16749.97	0
V12631004				
V17573018				
V29029007				
V20019004				
V05441019	50.337	49.787	245.351	2
V27306021	55.422	53.814	52.223	0

Hellas High

Image ID #	Longitude (E)	Latitude (N)	Area (KM^2)	Direction
V26582008	79.209	-25.0832	1248.892	0
V32233005	101.3037	-36.2666	116.118	0
V15150002	98.264	-30.322	83.608	2
V09796007	103.027	-40.551	1394.951	0
V24522004	103.055	-40.503	356.739	1
V25932004	108.168	-42.805	1561.35	2
V25932004	108.277	-42.805	288.349	1
V23174005	108.305	-42.746	437.455	0
	103.305	-46.969	1356.603	0
	104.105	-47.5	1132.343	0

Hellas Low

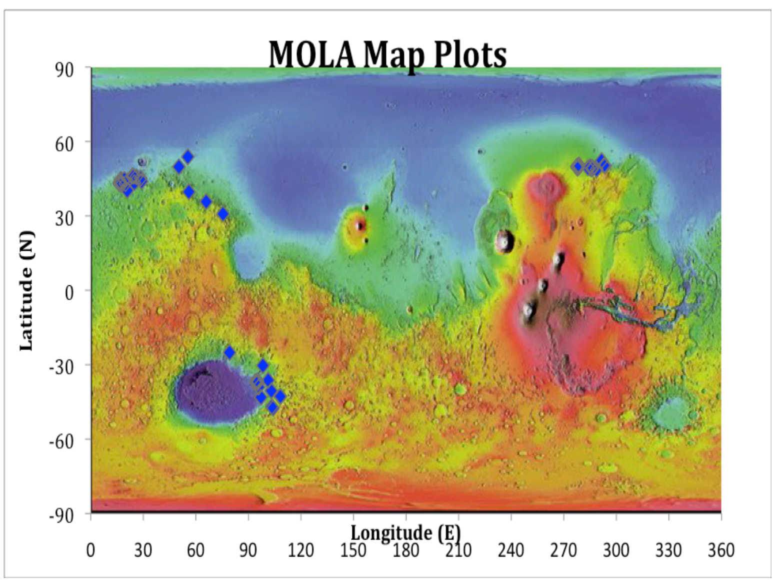
Image ID #	Longitude (E)	Latitude (N)	Area (KM^2)	Direction
P14_006593_14	94.65	-36.75	502.543	1
B19_016957_14	93.885	-36.828	573.144	2
P15_006738_14	95.211	-36.479	270.412	1
P15_007094_14	95.211	-36.479	171.076	1
V26232010	94.748	-37.66	392.971	0
P03_002202_14	95.822	-39.027	683.46	0
B18_016680_1:	97.121	-43.131	502.651	1

Tempe Terra High

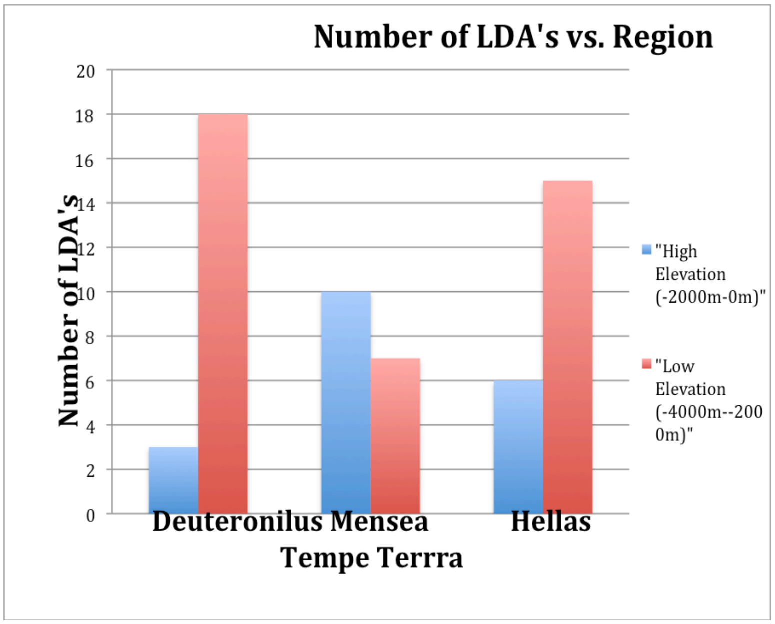
Image ID #	Longitude (E)	Latitude (N)	Area (KM^2)	Direction
P16_007166_22	277.719	49.285	446.721	0
P16_007166_22	277.6	49.588	238.569	0
P16_007166_22	277.992	49.59	74.488	0
B16_015908_23	278.371	49.523	425.507	0
NO IMAGE AVAI	292.969	50.352	164.482	0
NO IMAGE AVAI	293.593	50.197	473.907	0

Tempe Terra Low

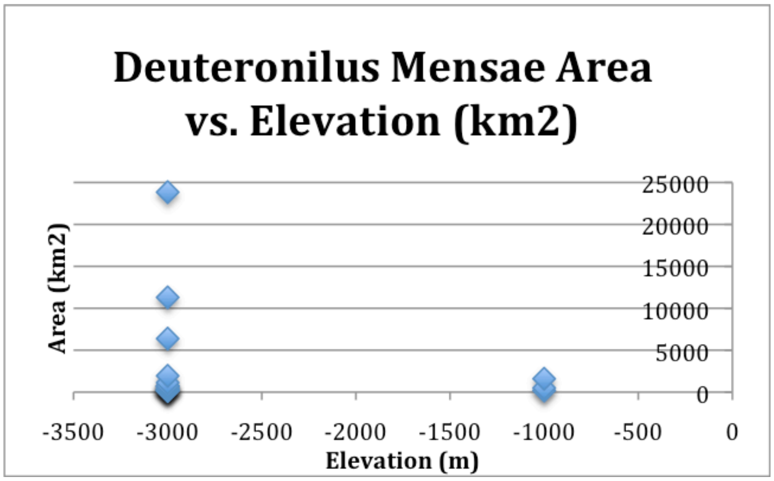
Image ID #	Longitude (E)	Latitude (N)	Area (KM^2)	Direction
V28309006	278.613	50.502	318.521	2
V26874016	277.5165	50.04	224.957	1
V29170005	278.002	49.986	95.574	2
V05895013	277.588	49.631	246.948	2
V28309006	278.389	50.236	65.087	1
V26886012	291.566	52.238	259.481	0
V29619010	283.854	49.416	233.208	2
V11424002	288.741	48.764	773.338	0
V19723005	285.346	0.129	168.005	0
V19723005	285.143	49.768	579.511	0
V27872005	285.496	49.426	246.181	0
V10176012	285.604	49	234.817	0
V04559002	285.973	49.277	70.366	0
V13533005	286.412	49.51	413.145	0
V10463007	286.309	48.9	198.394	0

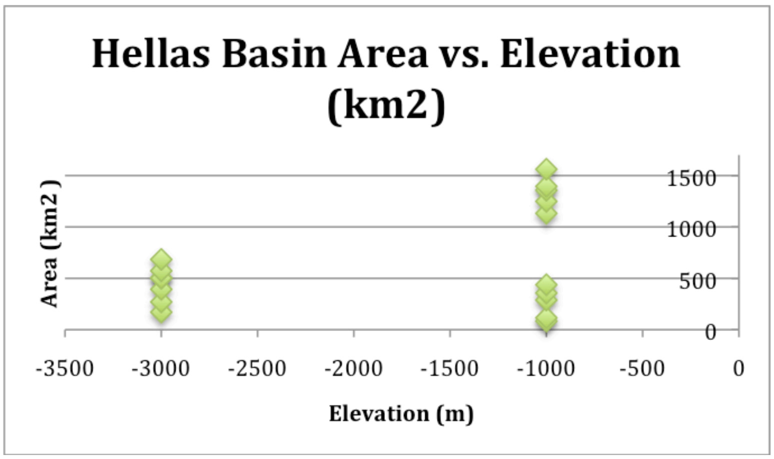


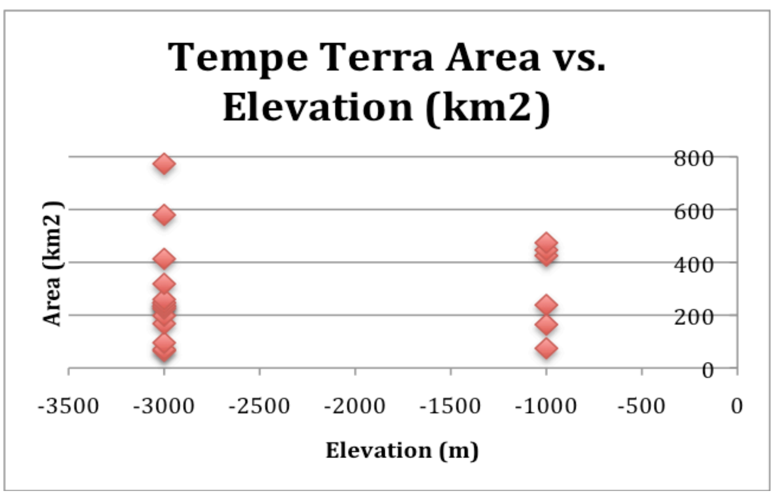
We targeted 3 distinct regions, that scientist have noted them for their levels of glacial like features such as Massifs and Lobate Debris Aprons, Hellas, Tempe Terra and Deuteronilus Mensae.



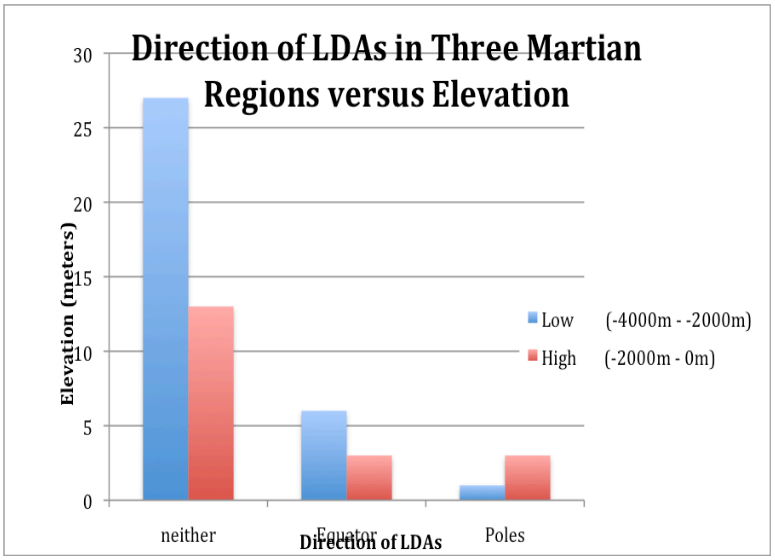
We found that there were a similar total number of debris aprons in each region. With generally, more lobate debris aprons in the lower elevation range -2km to -4km. The patterns in Tempe Terra and Deuteronilus Mensae regions are similar in that lower elevations had many more lobate debris aprons. We grouped this count in ranges.



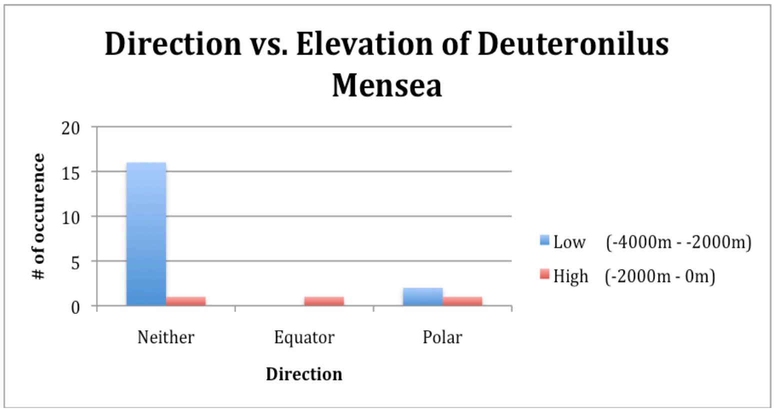


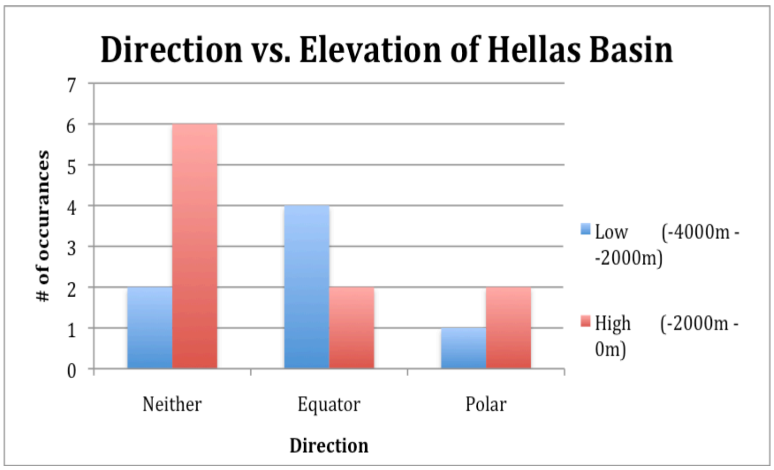


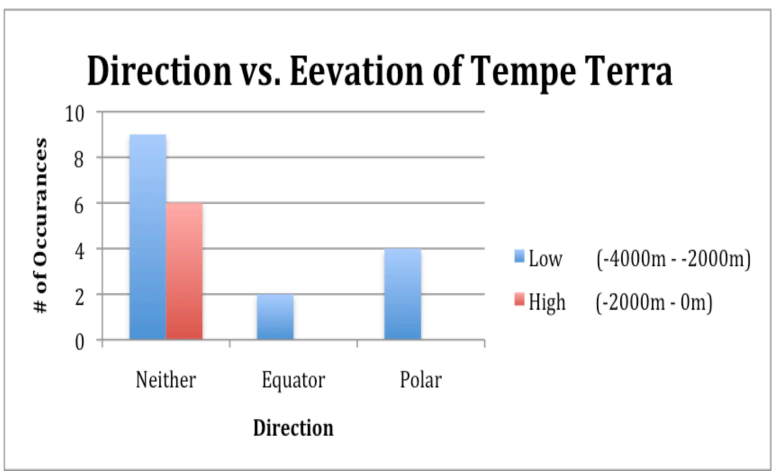
Since we cannot show a range of points on the graph the points were placed in the middle of the range. Many points are evenly distributed. These graphs brought about many more questions especially in the Hellas Basin, due to a lack of time we had to reduce our search area, but there was a large break in the data. We found larger areas of lobate debris aprons generally at lower elevations, with the largest lobate debris apron found off the side of Olympus Mons. Our data collection was very controlled as we only looked at specific places, where we knew we would find large amounts of lobate debris aprons.



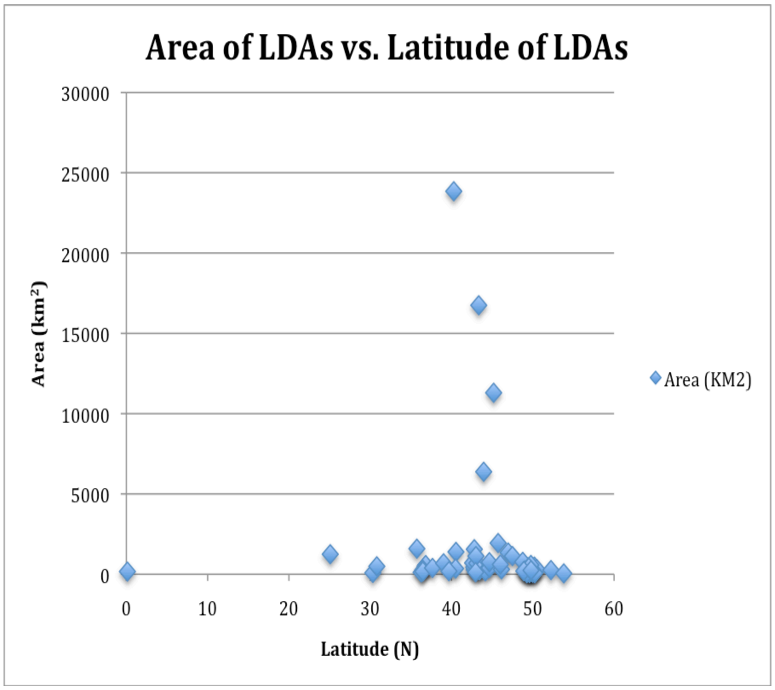
This graph shows all of our locations and data placed together. We only classified if the lobate debris aprons were distinctly moving toward the poles or equator. Ones that went east or west were not counted as well as the ones that go all the way around the massifs. We determined that further research with more specifics on east and west facing lobate debris aprons would be helpful. Although we do not have enough information, if more data points were gathered there might be a greater correlation between the number toward the poles and equator.



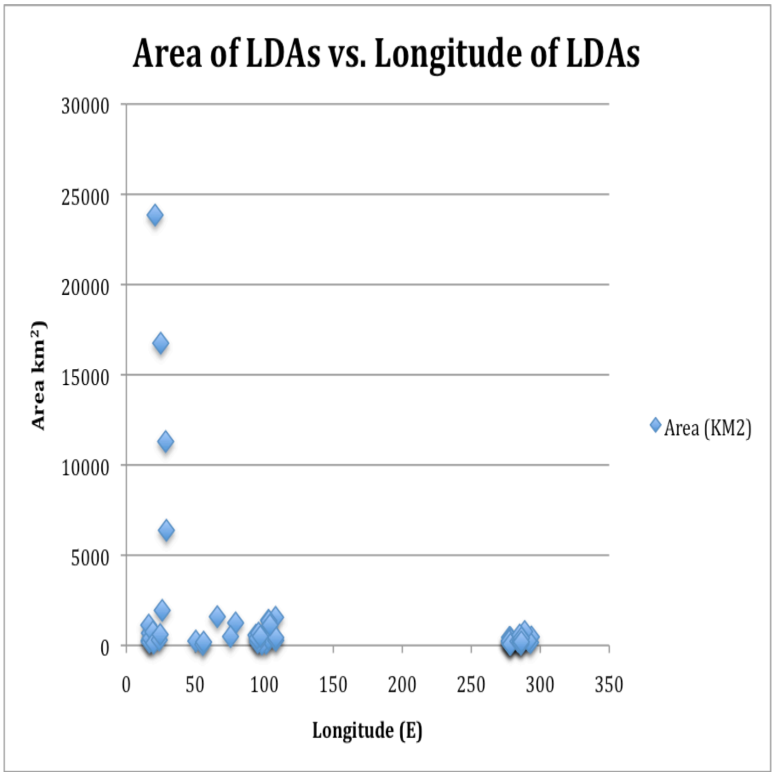




The three graphs break down the data by individual areas. Generally the data shows that the lobate debris aprons are not pointed toward or away from the poles. When the axis of Mars shifted, the direction of the lobate debris apron could be affected by shadows



Most data points are between 35-55 degrees latitude, although this is somewhat biased as we chose to look between 30 and 60 degrees. We believe this is due to the ice age where the ice migrated toward the equatorial regions when the axis shifted. Most of the larger lobate debris aprons as well as massifs were found in Deuteronilus Mensae region. Many were northern facing. This leads to the possibility of a different slope than the other regions, or maybe a difference in type of rock or shielding by the rocks during the ice age to prevent sublimation. Also the location is closer to the poles indicating that the area may have received less sunlight.



This graph shows similar results as the previous graph. Again our data is biased due to our limiting our search to certain locations. It reinforces our desire to look further into the Deuteronilus Mensae region at the rock type, locations, and other factors that might result in debris aprons.

V Discussion

After discussing areas where these lobate debris aprons may be found we looked at three locations. These locations include the eastern rim of Hellas, the northern and eastern portions of Deuteronilus Mensae and Tempe Terra. One of the controls for the experiment was that the regions studied were from datum to -4km. Each of these locations contained similar changes in elevation. While collecting this data we also looked for other features such as u-shaped valleys in order to support that we were indeed encountering lobate debris aprons in our research. Each of the three areas in our study were broken down into two ranges -2km to -4km and datum to -2km. The count for the number of lobate debris aprons were done in these ranges. Patterns in Tempe Terra and D.

Mensae are similar in that the lower elevations had many more Lobate Debris Aprons.

In these regions we also collected data concerning the size of the Lobate Debris Aprons. We calculated the Maximum, Minimum, mean and median for the Debris Aprons in the region. Upon viewing these graphs, we a student scientist developed many new questions, especially concerning the Hellas Basin where there was a huge gap between the elevation and area of the large and small Lobate Debris Aprons. As a general conclusion the larger Lobate Debris Aprons were located at the lower elevations. Possible factors with this could have do with Mars's atmospheric pressure and gravity. The largest Lobate Debris Aprons were found off the side of Olympus Mons. Our experiment was very controlled due to the fact that we studied places where we knew we could find large amounts of Lobate Debris Aprons.

Initially, we classified the Lobate Debris Aprons by which direction they were facing either polar, equatorial or other. Although some Lobate Debris Aprons were specifically facing one direction others could not be classified because of our research collecting was not specific enough. Many were found to either go east, west or to circle the entire Lobate Debris Apron. A direct correlation was not encountered. A direction and elevation correlation with each of these three areas could not be found.

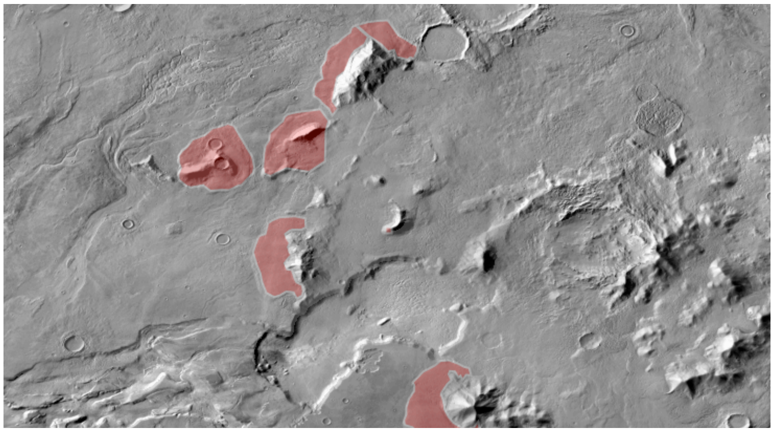
Interestingly when the area of Lobate Debris Aprons was compared with the Latitude of Lobate Debris Aprons most Lobate Debris Aprons were found between 35 to 55 degrees latitude. The ice is believed by scientist to have migrated during Mars's ice age in which the axis turned dramatically. This information was known by scientists previously, but our research further supports their evidence. There are many factors that could have caused this relationship and many are still unknown and need further research.

Error and Bias

Some of the bias encountered during our research pertains to the nature of our research, as well as the time frame during which our research was carried out. Due to time constraints, all of our research was focused on three specific regions of Mars that were believed to be prime locations for the occurrence of lobate debris aprons. These areas being Tempe Terra, Deuteronilus Mensae, and the Eastern flank of the Hellas Basin all fall within 30° to 60° from the equator and were chosen based upon preliminary research that suggested them as ideal for finding lobate debris aprons. Another bias that could have an effect on the results of the research is the fact that all of the lobate debris aprons that were recorded fall within the elevation ranges of 0 meters to 2000 meters and -2000 meters to -4000 meters. This is the result of a group consensus to cut the sample size due to the tight timeframe in which the research was carried out within.

Beyond bias that has occurred as a result of how our data was collected, further bias has occurred as a result of the type and the nature of data that we have included in our research. For example, the apparent direction of each lobate debris apron was recorded either flowing toward the polar caps, not flowing toward, or having no clear direction of flow. The fact that we recorded the direction of the flow of the lobate debris aprons in this manner leads to the assumption that they are glacier related, and perhaps that their flow was influenced by a period of advancing polar ice caps, which then retreated leaving pockets of smaller glaciers that became lobate debris aprons. This idea is supported by the research of others in the science community, but remains unconfirmed as of yet. Another issue with the manner in which the direction of the lobate debris aprons was recorded was the fact that all of the regions in which lobate were observed were areas with a grade. It is likely that grade played a role in the flow of the lobate debris aprons, but the direction of the lobate debris aprons relative to the grade of the area in which they were located was not recorded.

Further error was found in how each of our sub-research teams recorded data. In order to cover each of the targeted regions we divided each region into the high altitude range (0m to 2000m) and the low altitude range (-2000m to -4000m) and assigned each sub-research team a region and an elevation range. Each team was responsible for locating lobate debris aprons within their region and elevation range, and recording the image ID# of the THEMIS image used, the latitude and longitude, the area of the lobate debris apron, and the direction of the flow of the lobate debris apron. When recording the area of the lobate debris aprons it was decided that the massif that produced the lobate debris apron would be included in the measurement of the area. This decision was made to resolve the issue of the exact boundary between many of the massifs and the corresponding lobate debris aprons being difficult to define. This decision was based on the idea that the area of a lobate debris apron is typically relative to the size of its corresponding massif. During the analysis of the data collected it was noticed that some of the groups did not understand this decision and included only the lobate debris apron in some of their area measurements.



VI Conclusions

Our science question: How do lobate debris aprons affect direction, area, and number of the feature in E. Hellas, D. Mensae, and Tempe Terra?

We concluded: Generally there are more lobate debris aprons in a lower elevation. Pole magnetism has no effect on direction of lobate debris aprons. Lower longitudes tend to have very large aprons. For Tempe Terra and D. Mensae, lower elevations means larger lobate debris aprons, but for Hellas, the opposite is true. In the elevation of -1000, there are 2 distinct groups of lobate debris aprons --very large and very small--with nothing in between. There were some outliers in size at 35 degrees latitude--abnormally large in surface area.

Here are some ideas for future research:

Find out what causes the very large lobate debris aprons.

Possible explanations include gradient differences difference in amount of sunlight each receives, and difference in rock type.

Find out why there are only very large and very small lobate debris aprons at the elevation -1000.

Figure out which way the lobate debris aprons that were said to go in the direction "neither north nor south" go in--east, west, or all directions.

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Targeted Images