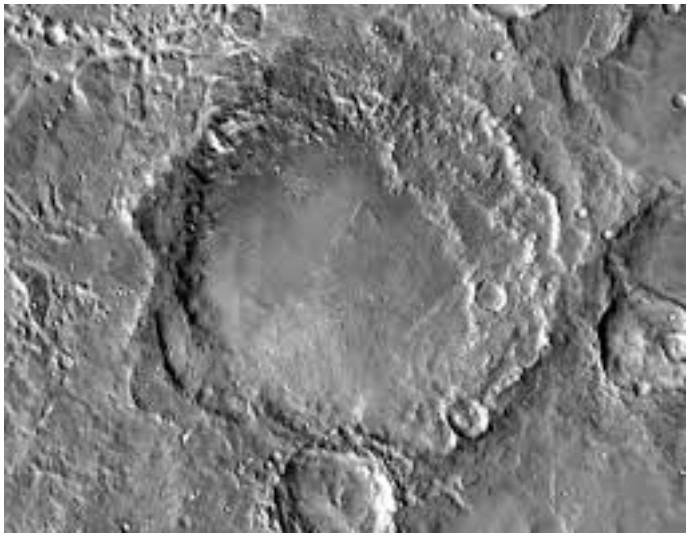
The Wilson School
5th Grade
MSIP Final Report
Spring 2013

Are there other craters similar to the McLaughlin Crater on Mars?



I. Introduction

Science Question:

Are there other craters similar to the McLaughlin Crater on Mars?

Importance & Interest:

This question is important because if we find another crater like McLaughlin Crater, there will be more probable evidence of water on Mars. If there is another crater like McLaughlin Crater, then there might have been several ground water fed lakes on Mars, which would prove there was water on many parts of Mars. It is important and interesting because there may be craters in which rovers, orbiters, or scientists have not yet explored that are like McLaughlin Crater. Scientists say that water and life are most likely found in deep impact craters, which is when meteorites crash into Mars. McLaughlin Crater is an example of a deep impact crater. It also has evidence of a groundwater fed lake, which is most likely where microbial life would have existed on Mars (Natural History Museum, 2013). We find this question very interesting and can possibly contribute to the research of unlocking the mystery of knowing if life once existed, or currently exists, on Mars.

Hypothesis:

If we can find another crater with similar characteristics to the McLaughlin Crater, then there is evidence that water once existed in that area of Mars.

The McLaughlin Crater

The McLaughlin Crater is located at 21.9°N and 337.63°E, and is 57 miles in diameter and 1.4 miles deep (Szondy, 2013). The crater was named after Dean B. McLaughlin who is an American astronomer who studied Mars craters (McLaughlin (Martian Crater), 2013).

(Image Credit: Dean B. McLaughlin, University of Michigan, n.d.)

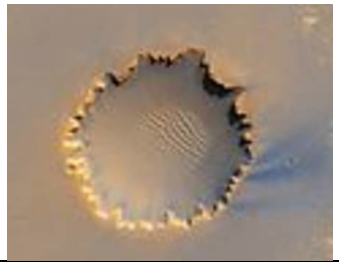
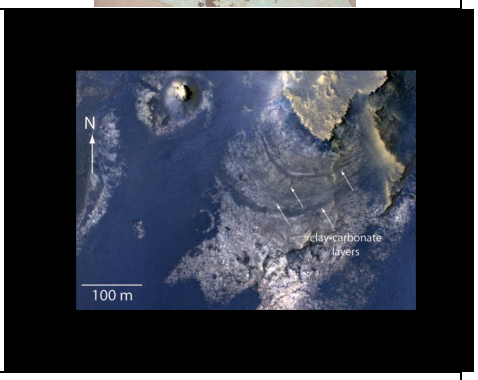
Today the crater is bone dry even though it is believed that it once held a lake fed by ground water (Choi , 2013 January 21). There are no obvious large cracks or openings in the crater rim. Because of this, scientists believe that the water originated from under the surface and that the water did not flow in from outside the crater. Additionally, scientists found gullies in the rim of the crater, which were possibly created from water pouring in from the crater walls (Plait, 2013).

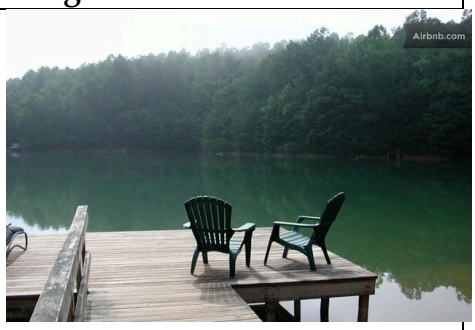
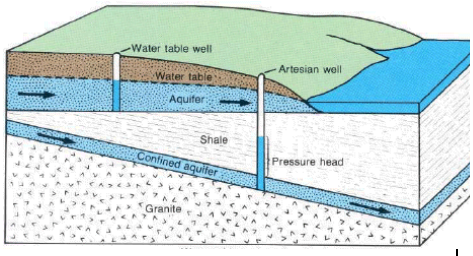
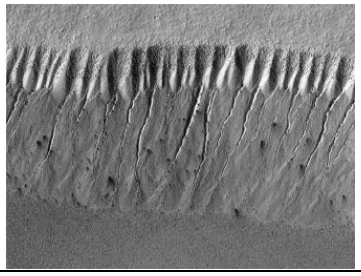
The crater shows new evidence of a wet underground environment. The Mars Reconnaissance Orbiter found evidence that water came from beneath the surface 3.7 billion - 4 billion years ago and remained so long that carbonate related clay minerals formed. Clay-carbonate is formed by water. The crater also shows sedimentary rocks, and has layered flat rocks at the bottom of the crater, which are clay and carbonate minerals. There are small channels inside the crater indicating an ancient lake surface (Choi, 2013 January 20). According to David J Geaney of Mars Travel:

> "This new discovery of clays and carbonates in McLaughlin Crater has added even more hope that life once, or maybe still does, exist on Mars. The presence of carbonates in particular indicates that the lake likely had low-acid content because carbonates generally do not remain preserved in high-acid environments. Life as we know is most likely to exist in low-acid environments, so having this knowledge makes scientists think this crater and the underground tributary channels may be the ideal place to search for evidence of past and/or present life" (Mars Travel, 2013).

Because of this evidence, some scientists think that there might have once been life in the McLaughlin Crater. As a result, the McLaughlin Crater is the best evidence for water and life on Mars. (Webster, G., Fischer, A., & Brown, D., n.d.).

Important Vocabulary

Word	Definition	Image
Crater	A bowl-shaped depression in a surface made by an explosion or the impact of a body, such as a meteoroid (Free Online Dictionary - Crater, n.d.).	
Clay	Moist sticky earth; mud (Free Online Dictionary - Clay, n.d.).	
Carbonate	A salt or an ester of a carbonic acid. (Free Online Dictionary - Carbonate, n.d.).	
Sedimentary rock	Rock formed from consolidated clay sediments (Free Online Dictionary – Sedimentary Rock, n.d).	
Conglomerate rock	Made up of parts from various sources or of various kinds (Free Merriam-Webster Dictionary – Conglomerate Rock, n.d).	

Word	Definition	Image
Spring-fed lakes	The geological definition of a spring is a place where water appears at the Earth's surface on its own. Springs are caused by rain and snow [A] seeping into the ground [B] and collecting in fractures and fissures in the bedrock, creating underground "holding tanks" called aquifers [C]. As the water passes through the fine particulate matter (sand, clay and other minerals) it is naturally filtered and purified. A spring occurs where a fissure in the bedrock breaks the surface at a point lower than the waterline of the highest point in the aquifer. The naturally higher water pressure forces the purified water up through the ground where it collects in pools or runs downhill (Anatomy of a spring, n.d.).	
Ground water	Water that exists below the water table in the zone of saturation, ground water moves slowly in the same direction that the water table sloops (Google Dictionary, n.d.).	
Gully	Trench cut into land by the erosion of an accelerated stream of water (Britannica Online Encyclopedia - Gully, n.d.).	

Where can places like McLaughlin Crater form on Earth?

Clay-Carbonate

Clay and carbonate form sedimentary rocks. The rocks are found all around the United States except for a few states (Conrad, 2011). This is important because these minerals have been linked to microbial life on Earth (Natural History Museum, 2013).

Spring-fed lakes on Earth

There are many spring-fed lakes on Earth. According to the Minnesota Department of Natural Resources, most lakes on Earth receive some ground water as its water source. Because ground water flows into the lake, when one swims, one may notice part of the lake feeling cooler. "Lakes also lose water to ground water sources. Most lakes have both [ground water flowing in and out]; some ground water flows into the lake and some lake water flows into the ground water system or aquifer. Variations in precipitation patterns can cause the amount in or out to change significantly" (Minnesota Department of Natural Resources, n.d.). Even though spring-fed, or ground-fed lakes are found on Earth, many of Earth's lakes also have water from surface-area runoff and an outflow other than through the Earth's crust (USGS, n.d.).

Images of McLaughlin Crater

McLaughlin Crater showing clay-carbonate layers

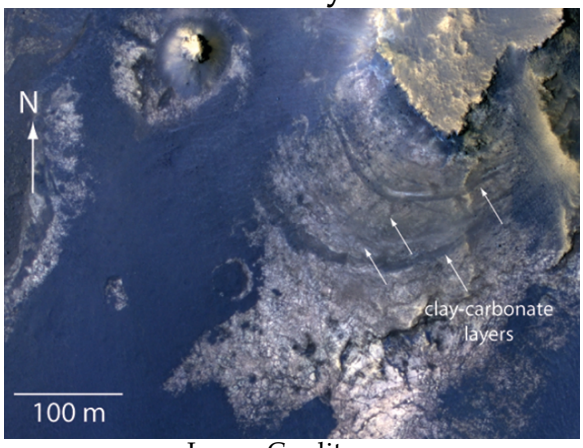


Image Credit: http://photojournal.jpl.nasa.gov/catalog/PIA16710

McLaughlin Crater

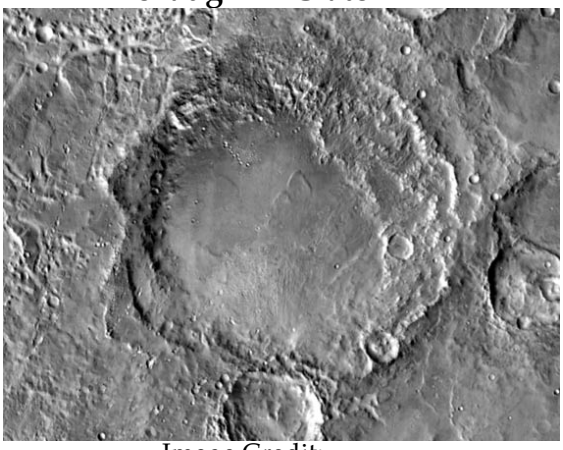
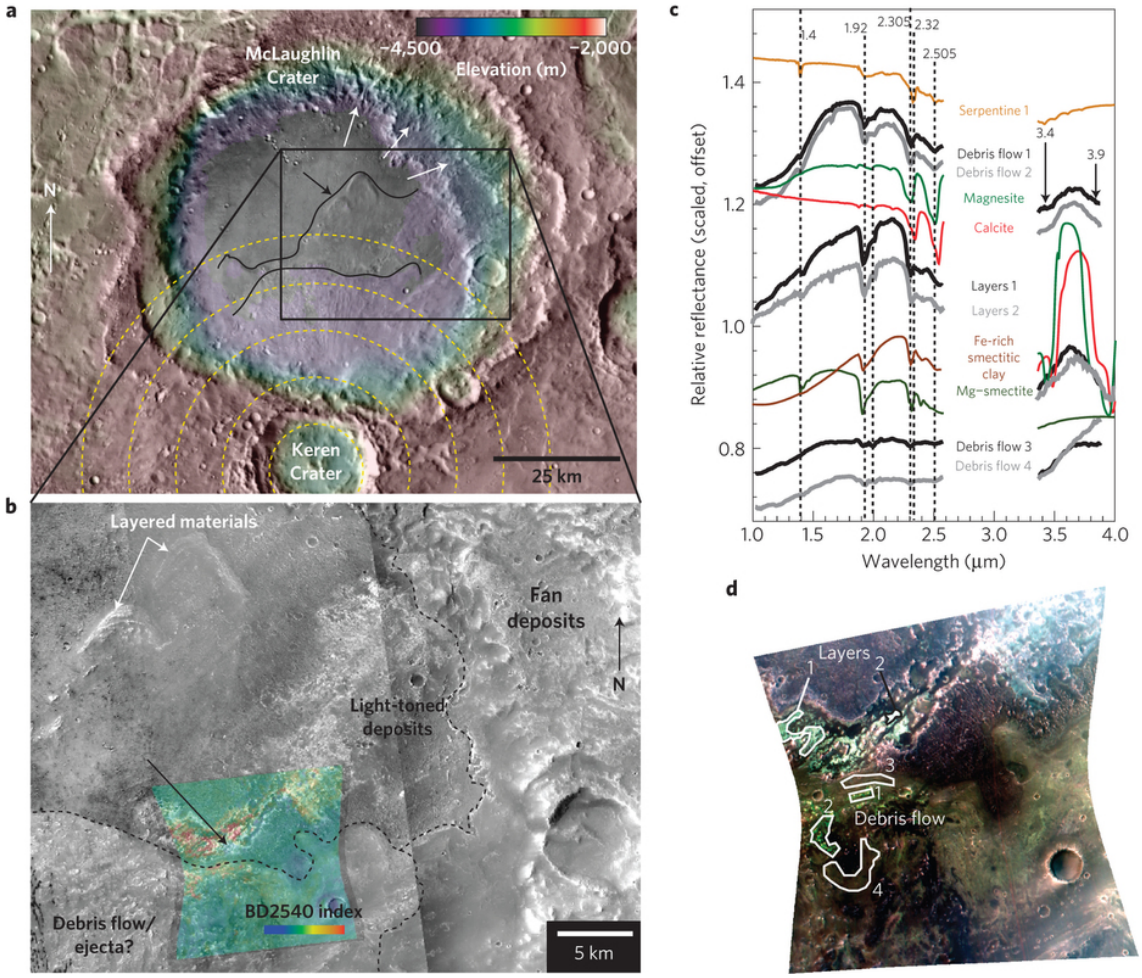


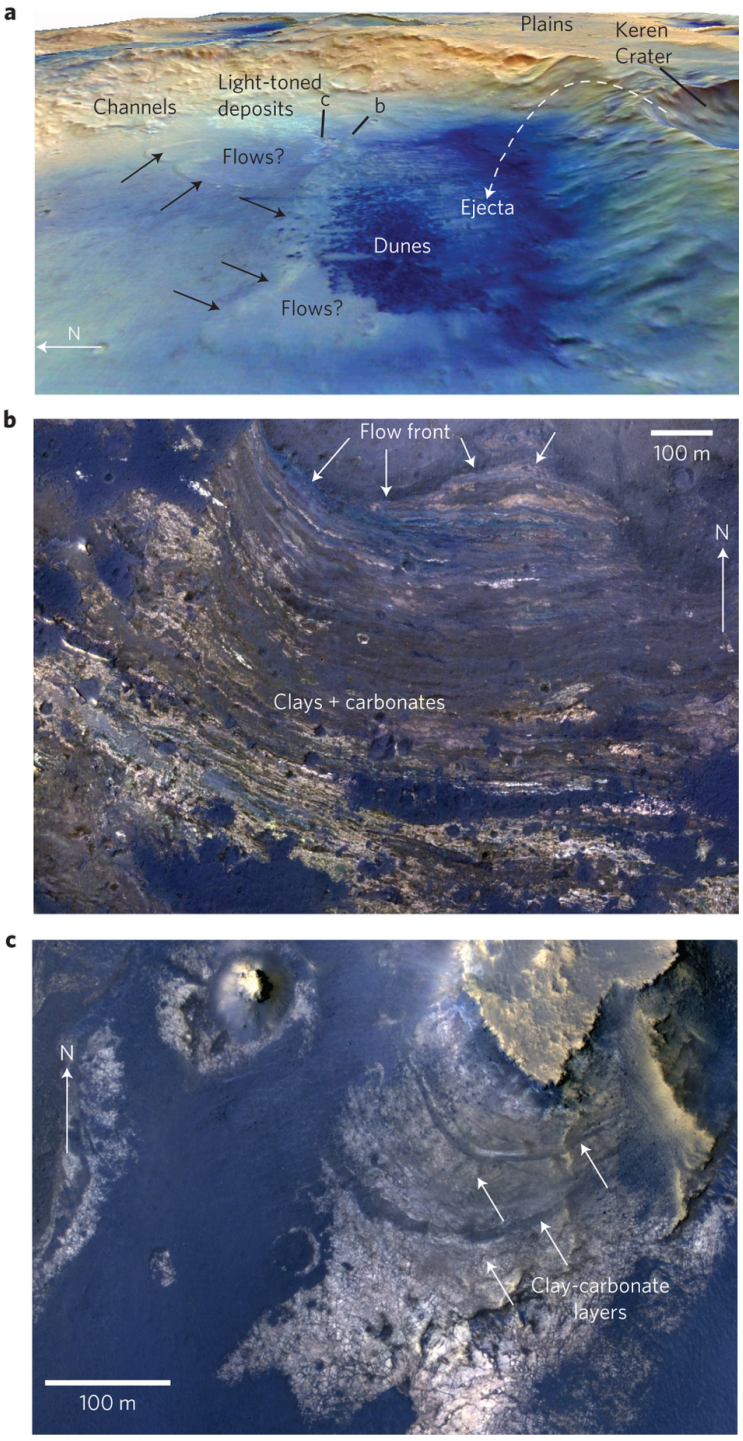
Image Credit: http://www.slate.com/blogs/bad_astronomy/2013/01/21/water_on_mars_evidence_of_an_ancient_lake_on_mars.html

Mineralogy and Geomorphology of McLaughlin Crater



"MOLA data are shown in **a** with channels indicated by white arrows and possible debris flows marked by black lines and arrows. Yellow lines mark crater radii from Keren Crater. **b**, CTX data show the occurrence of light-toned deposits and putative debris flows on the crater floor, as well as the location of CRISM image AA5A (**d**). The BD2540 index measures absoprtion (warm colours) related to carbonate and clay minerals. **c**, CRISM spectra extracted from regions of interest in **d** are shown as offset ratio spectra compared to laboratory spectra of relevant minerals" (Michalski, J. R., Cuadros, J., Niles, P. B., Parnell, J., Rogers, A. D., & Wright, S. P., 2013).

Geology of McLaughlin Crater



"**a**, Colour image data from the High Resolution Stereo Camera (HRSC) draped onto elevation data from the same instrument show the locations of features discussed in the text, including possible flow fronts indicated by black arrows. The locations of **b**,**c** are indicated. **b**,**c**, Contain image data from the High Resolution Imager for Mars (HiRISE) showing altered sediments within lobate flows (**b**) and layered rocks in the floor of the crater (**c**)" (Michalski, J. R., Cuadros, J., Niles, P. B., Parnell, J., Rogers, A. D., & Wright, S. P., 2013).

Sand Dunes on floor of McLaughlin Crater

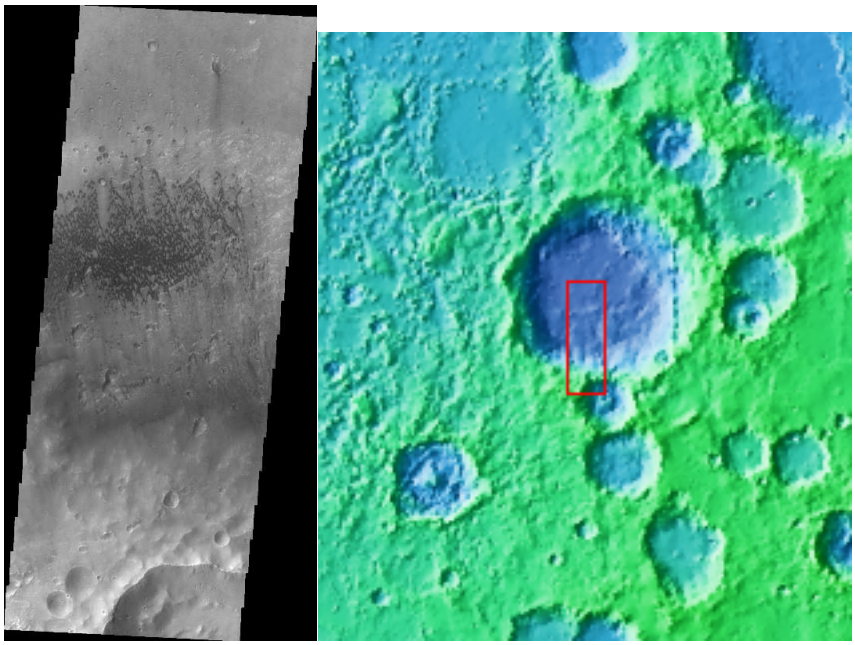


Image ID: V35980016 (http://themis.asu.edu/zoom-20100318a)

III. Methods

Procedure to Collect Our Data

1. Our class decided that we wanted to research water on Mars. Through our research, we narrowed our focus to the latest research on the McLaughlin Crater. We voted on McLaughlin crater as our control.
2. We wrote our question and hypothesis. We also decided that we needed to list what features we would compare to McLaughlin Crater.
3. We broke into groups to research craters that we would like to investigate. We researched craters on Mars that could have possibly held water. We used the JMARS application and and Mars Odyssey THEMIS website (http://themis.asu.edu) to find THEMIS images of interest.
4. We decided to pick our favorite eight craters to compare to our control. We also found a crater on the Martian surface that had not yet had a THEMIS image taken of it. We were granted permission to take a THEMIS image of "our crater." This was added to our crater list to compare to our control.
5. We wrote our proposal in groups and combined it in the end. We turned this into a PowerPoint and presented it to Arizona State University for feedback. We also received "our crater" image.
6. In our groups, looked at the 9 craters individually to compare to our control and analyze. We looked at depth, rim condition, evidence of gullies, evidence of layered rock, and evidence of clay carbonate. We used JMARS to find this data.
7. We compiled our discovered data in a chart and presented our group research to the class for confirmation that our data was correct.
8. We then analyzed our data and answered our science question. We then completed our final written report and will present it to Arizona State University and to a NASA scientist.

Images of Interest

We have been looking more closely at other craters on Mars to see if they have any similar characteristics as the McLaughlin Crater. As a class, we have been looking at the following craters using THEMIS images and CTX (when available) in our attempt to research and answer our question.

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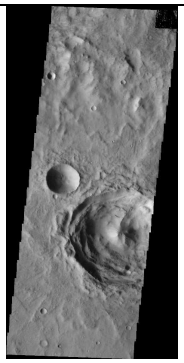
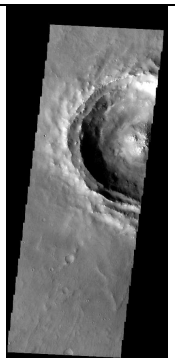
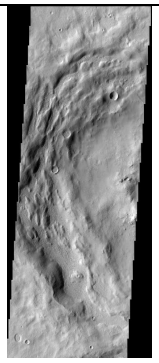
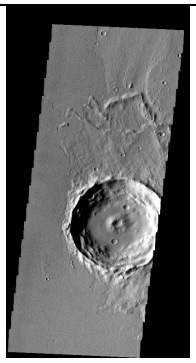
THEMIS Image				

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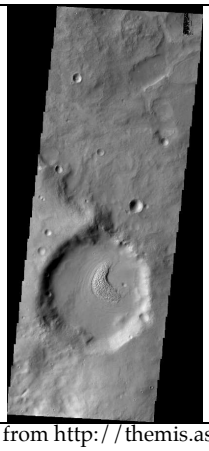
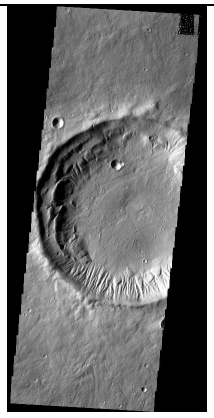
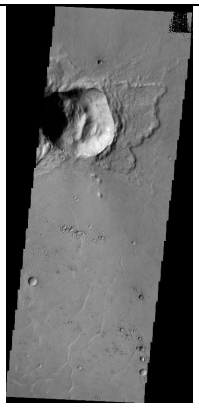
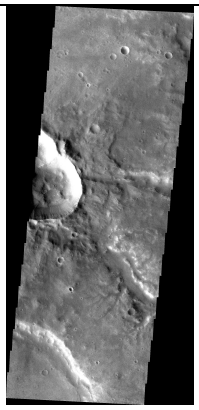
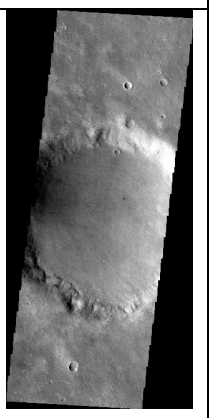
THEMIS Image					

All images taken from http://themis.asu.edu/image_of_the_day

These are all images of craters from various places on Mars. We have looked at craters that are in different areas because we wanted to know if the whole planet had water, not just if one section had it. The exact features we have been looking at are: no obvious large cracks or openings in the crater rim, gullies in the rim of the crater, sedimentary rocks, and layered flat rocks at the bottom of the crater. We have also looked at the depth of each crater to determine if it is large enough to have held water as a lake. We have also looked at the mineral composition of the crater to look for clay and carbonate minerals.

Controls

Our control is McLaughlin Crater. In McLaughlin Crater, we looked at its depth, its gullies, its rim condition, its layered rock on the floor, and its measurement of clay carbonate levels since these conditions suggest that water may have once existed there.

- We looked at the depths of our craters so that we could see if it is deep enough to hold water. The McLaughlin Crater is 1600 m deep.
- We looked for evidence of gullies because it is believed that the water in McLaughlin Crater came from underground. If the water came from outside of the crater, there would probably be no gullies.
- McLaughlin has a rim that does not have evidence of large cracks or openings. We looked at the rim condition because if the rim of a crater shows cracks, then the water probably wouldn't have come from under ground but from the outside and caused erosion to the rim of the crater.
- We looked for evidence of layered rock on the crater floors because McLaughlin Crater has layered rock on the floor. Water, over time, creates layered rock when it carries sediment from other rocks and builds up on the crater floors or walls.
- We looked for evidence of clay carbonate because the McLaughlin Crater has clay carbonate on its floor. Clay carbonate forms with a mixture of water and an ester of carbonic acid, which is a strong piece of evidence of water.

What we looked for in our craters

- Depth (We used the elevation tool from the MOLA shaded relief to measure.)
- Evidence of gullies (We used the CTX image or THEMIS image if there were no CTX images available.)
- Rim condition (We used the CTX image or THEMIS image if there were no CTX images available.)
- Evidence of layered rock on the floor (We used the CTX image or THEMIS image if there were no CTX images available.)
- Clay carbonate (We used the Mineral Composition TES Carbonate layer in JMARS to look at and measure the area with the most clay carbonate.)

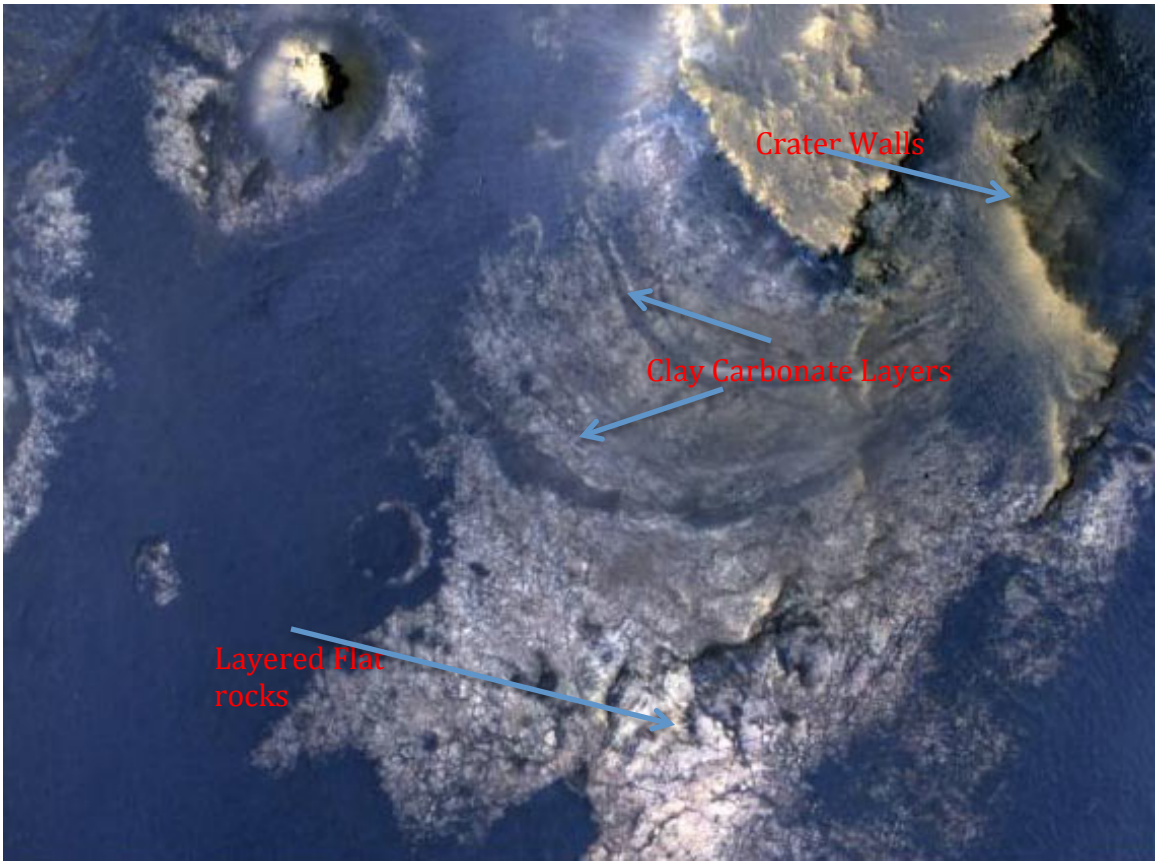
IV. Data

We looked at a total of 9 craters to compare to the McLaughlin Crater. With each image, we looked for the following:

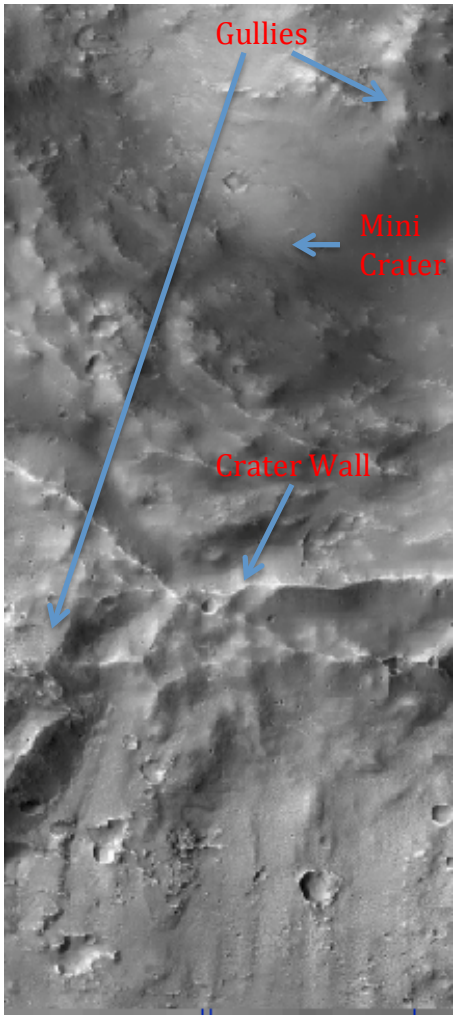
- Depth
- Evidence of gullies
- Rim condition
- Evidence of layered rock on the floor
- Clay carbonate

We have the following information about each crater.

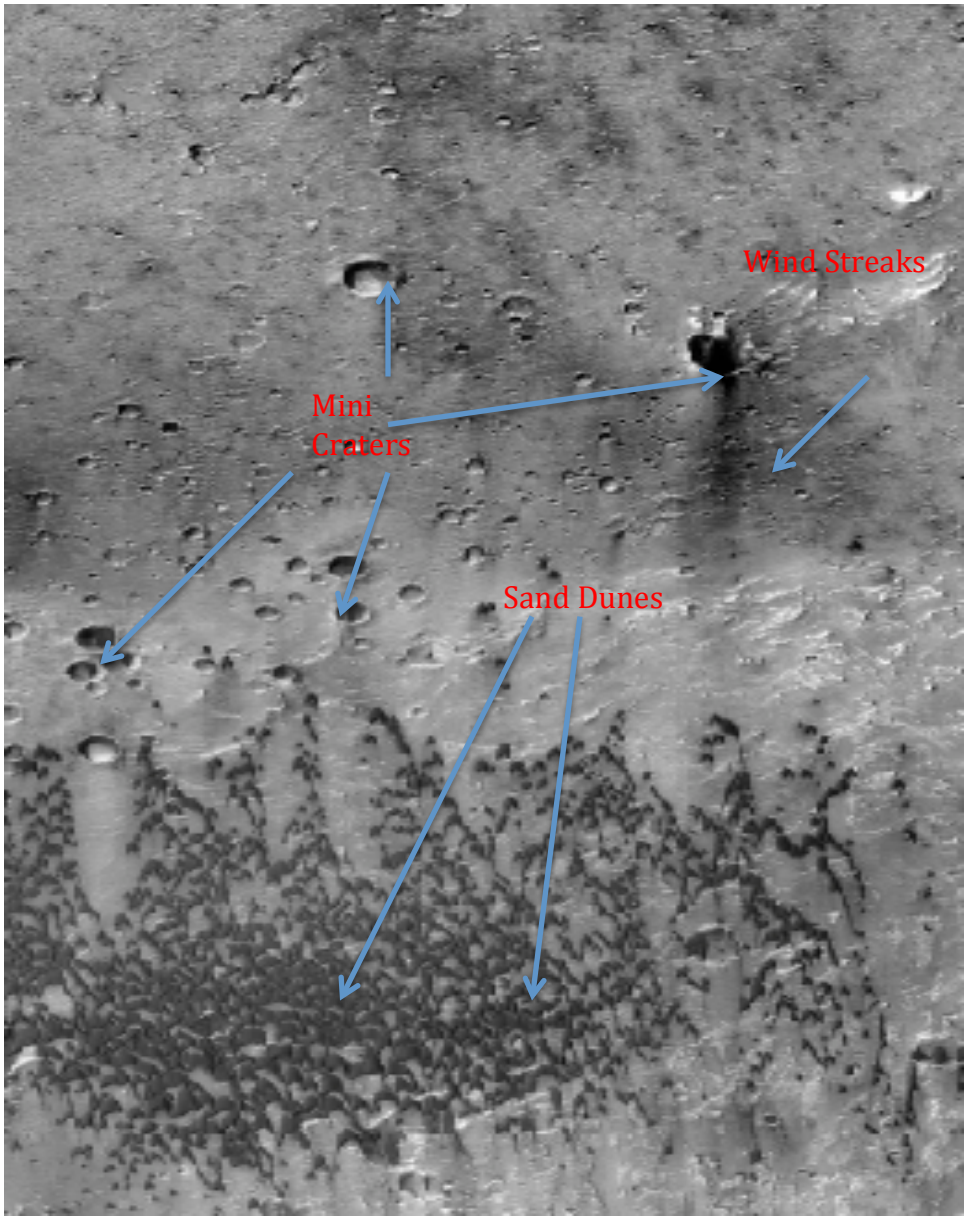
1. McLaughlin Crater (Our Control)



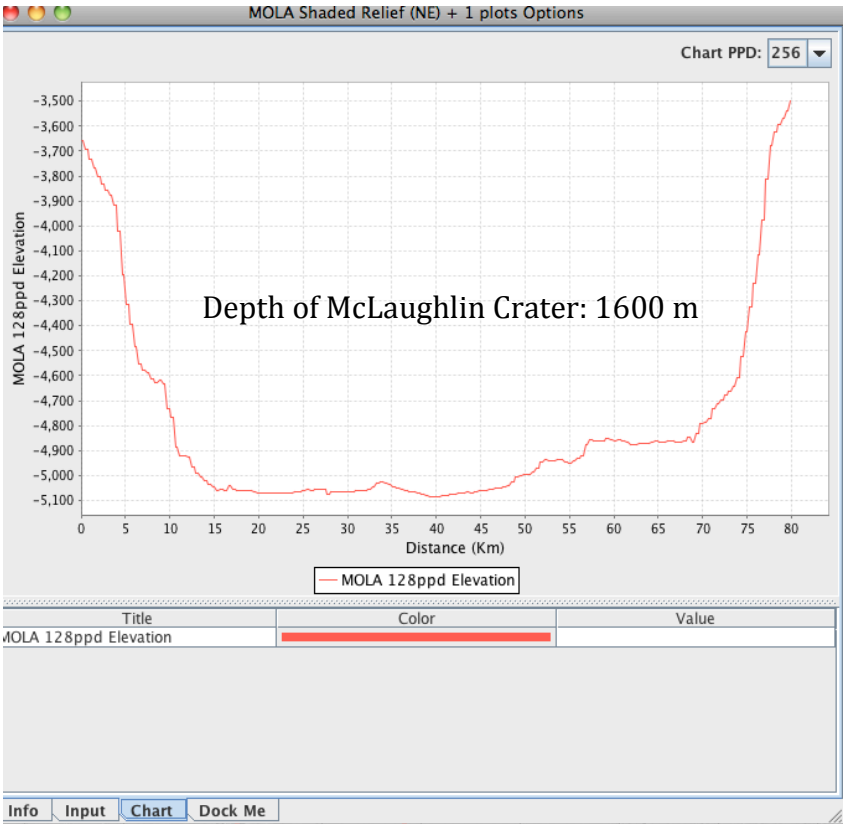
Internet Image



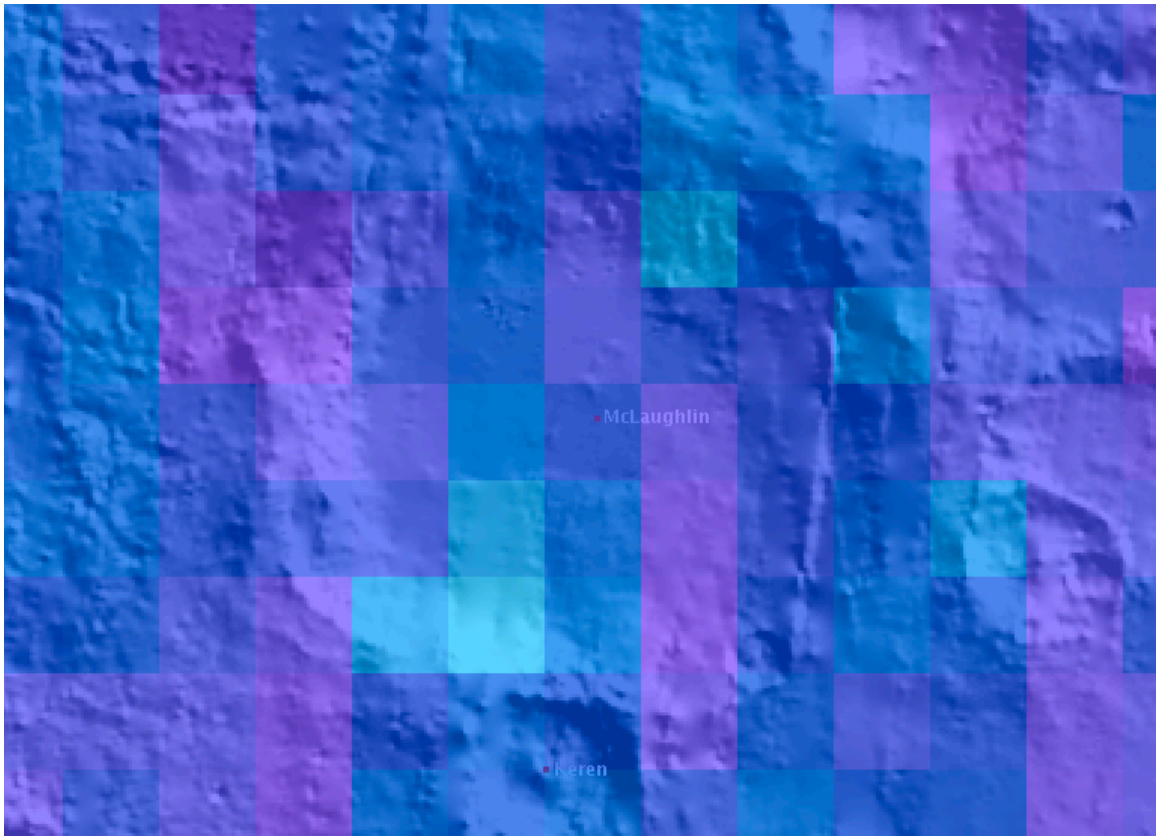
CTX image



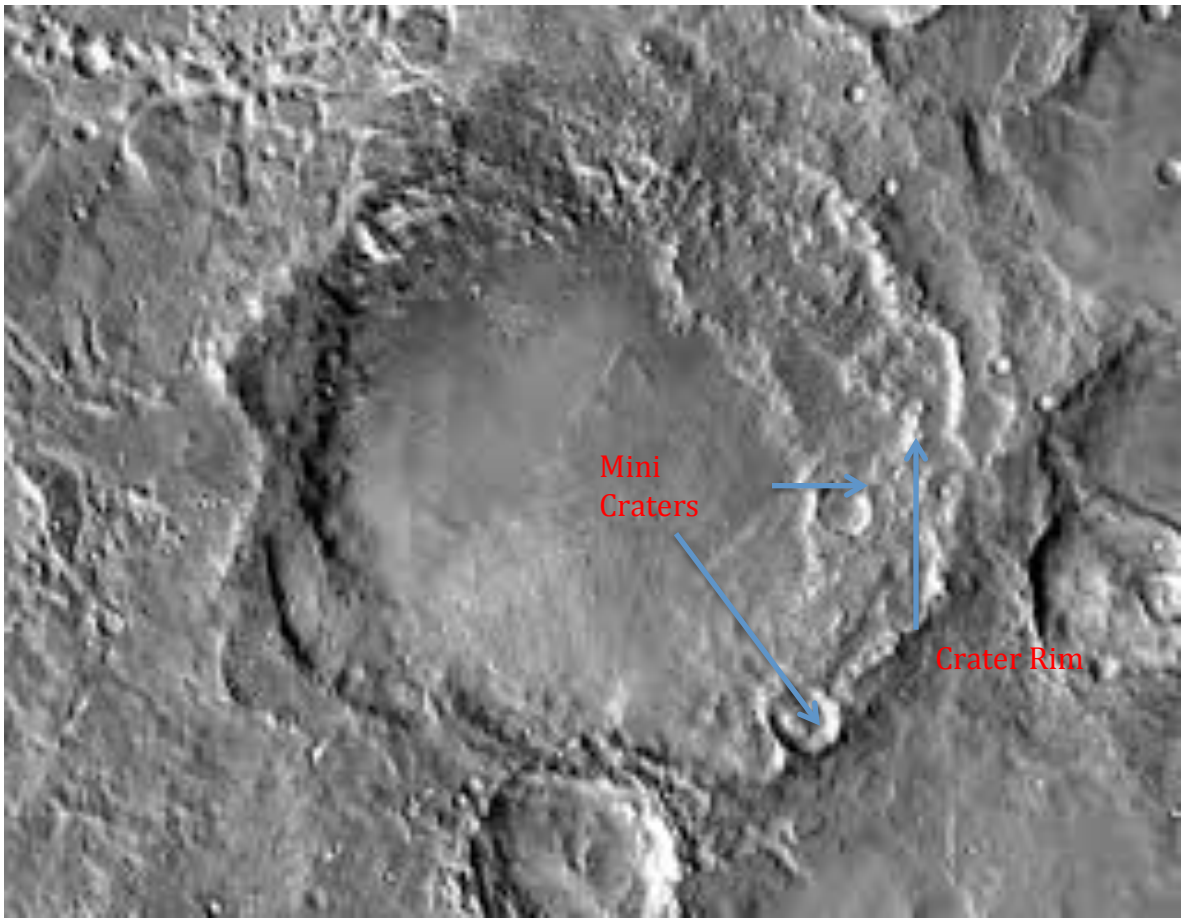
CTX Image



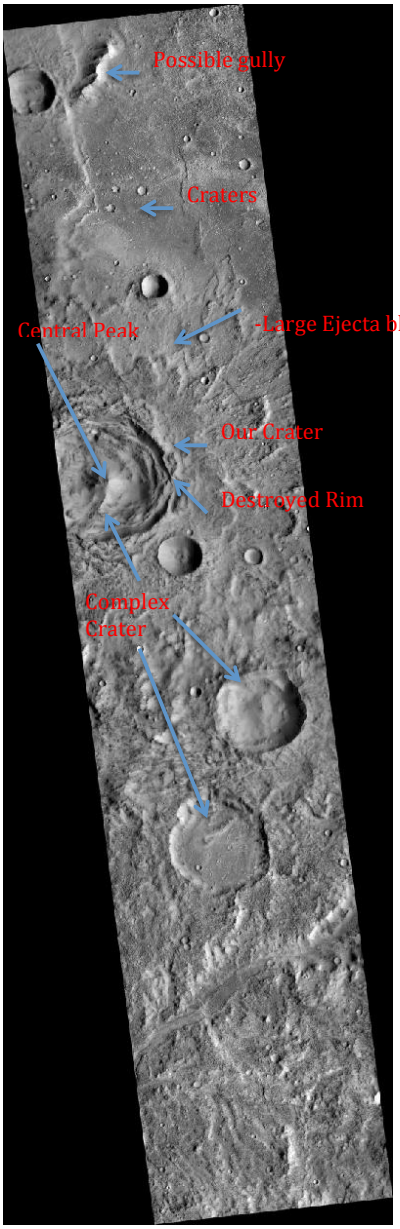
Mineral Composition
TES Carbonate

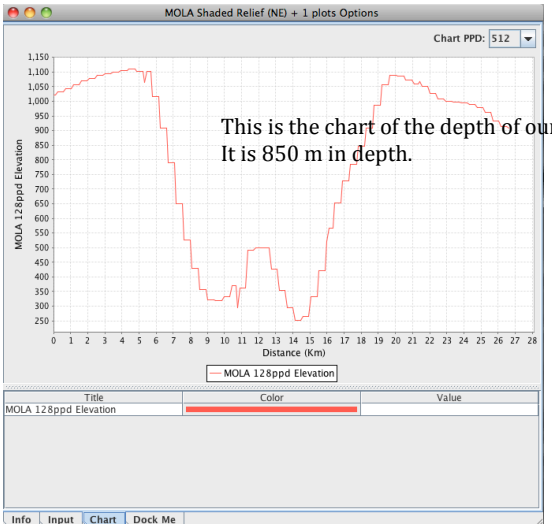


McLaughlin Crater Rim



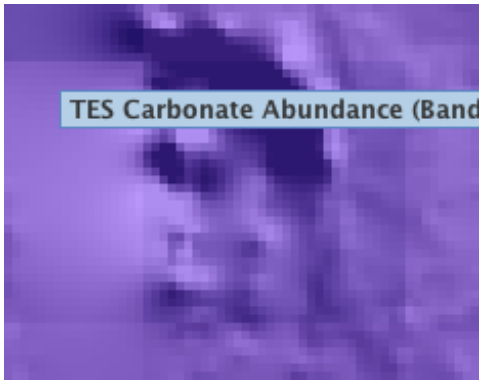
2. Crater V31968004



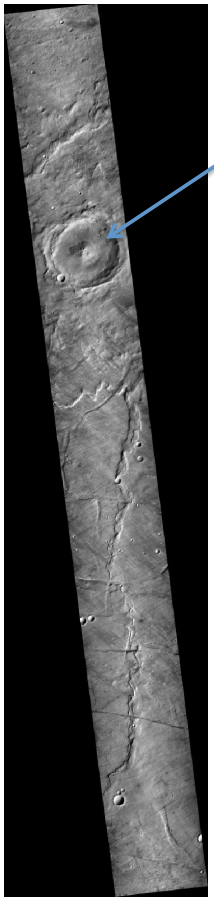


This is the chart of the depth of our crater.
It is 850 m in depth.

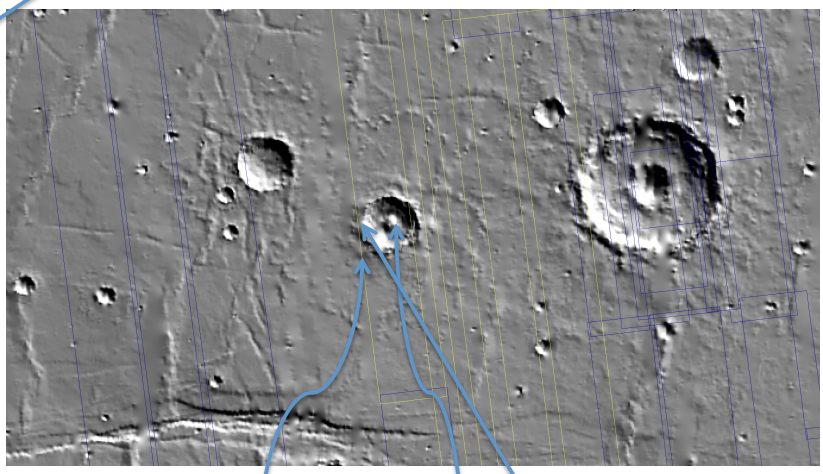
TES Carbonate



3. Crater V24503003



The crater has a central peak. The ejecta blanket cannot be seen. Rim condition is mostly destroyed.
Part of the crater's rim is missing, maybe from erosion of water or impact rock landing on rim.

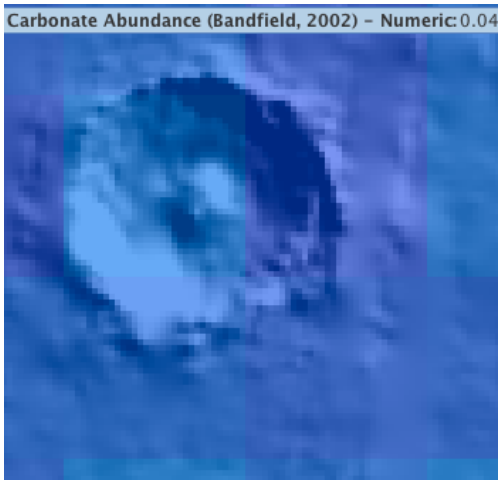


This is a picture of our crater. It is a modified crater.

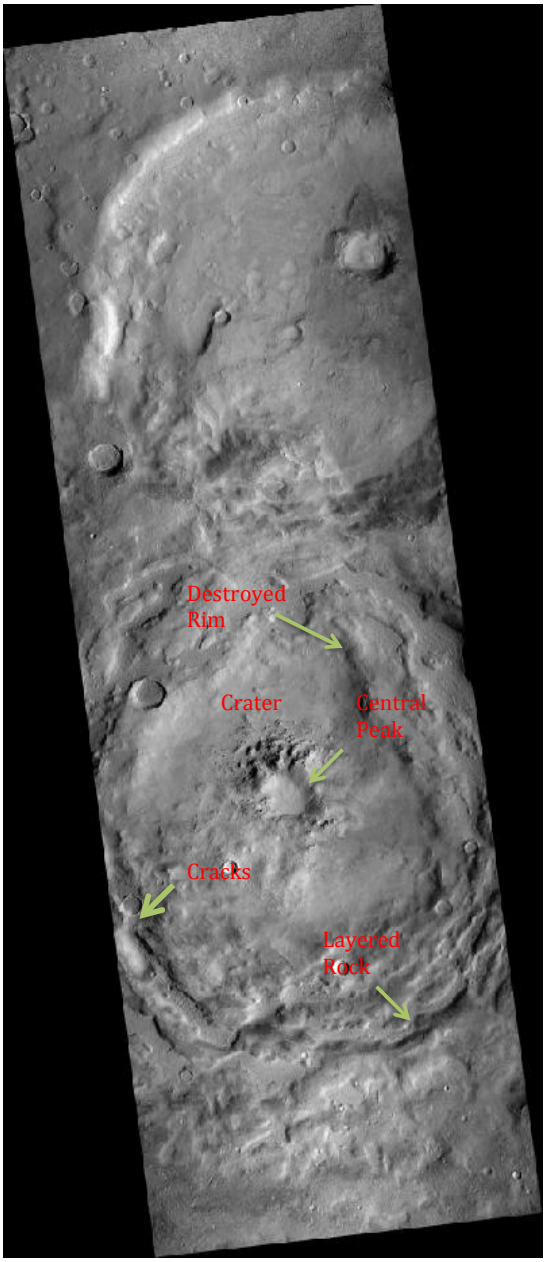
Central Peak

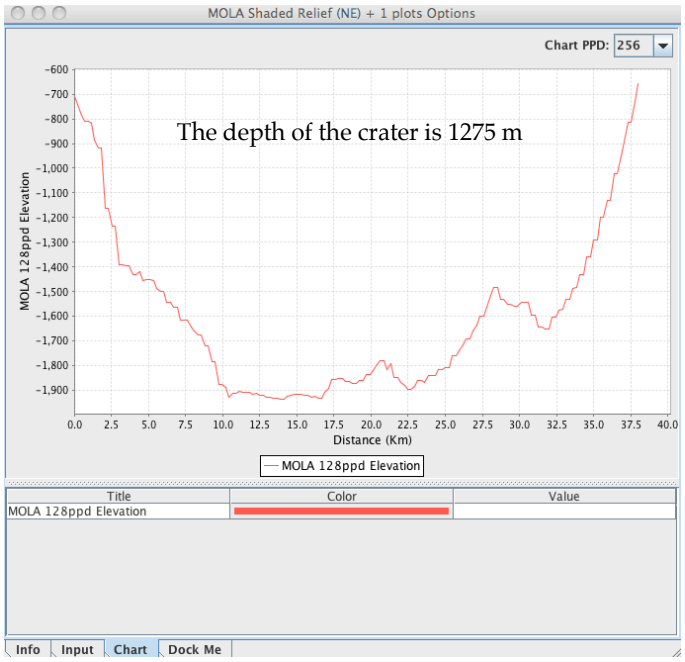
Slight evidence of gullies

Clay Carbonate Picture



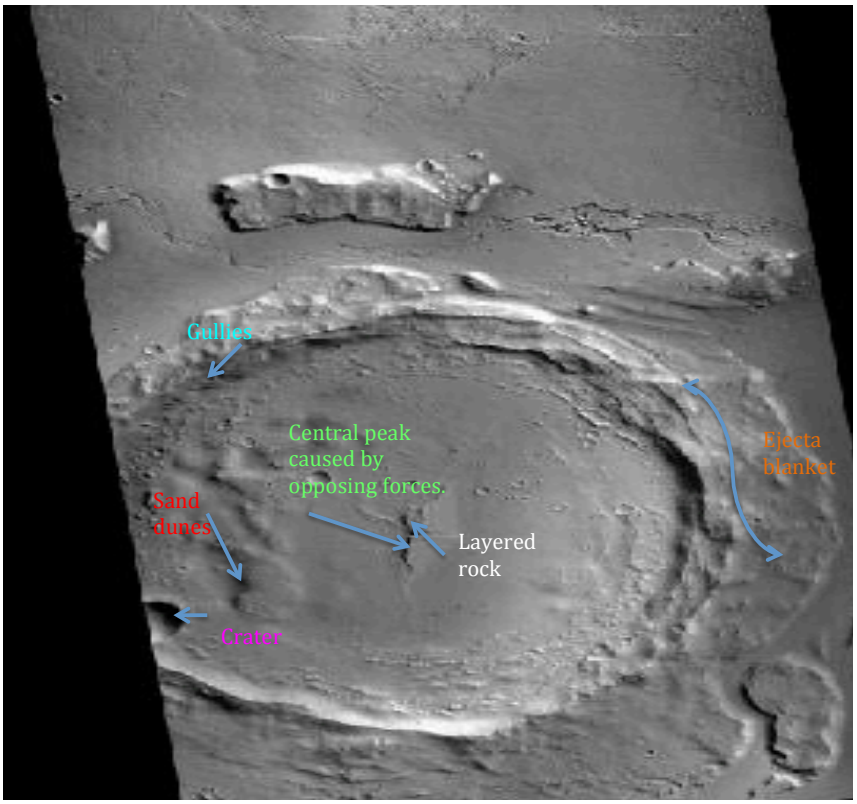
4. Crater V20343006

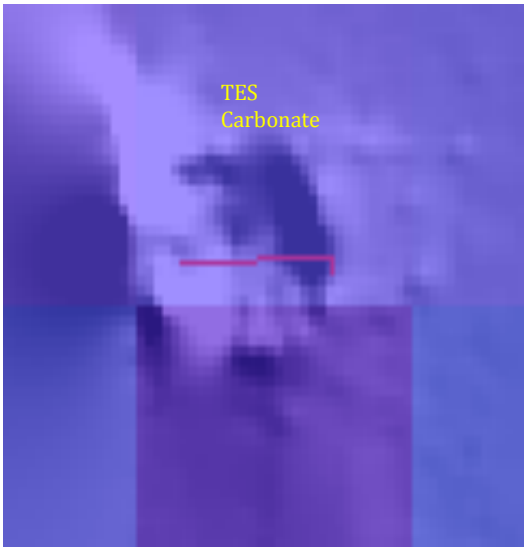




TES Carbonate

5. Crater V19074010 (Sulak)




TES
Carbonate

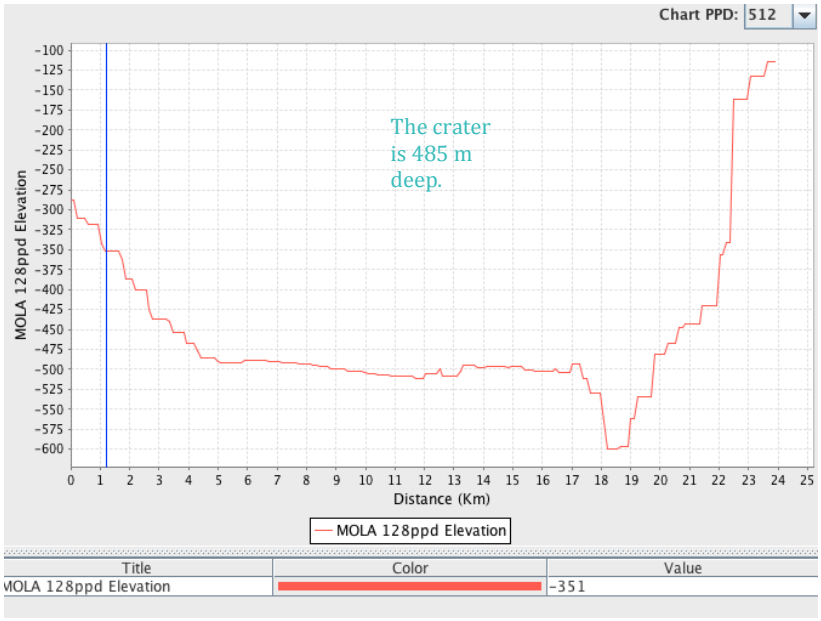
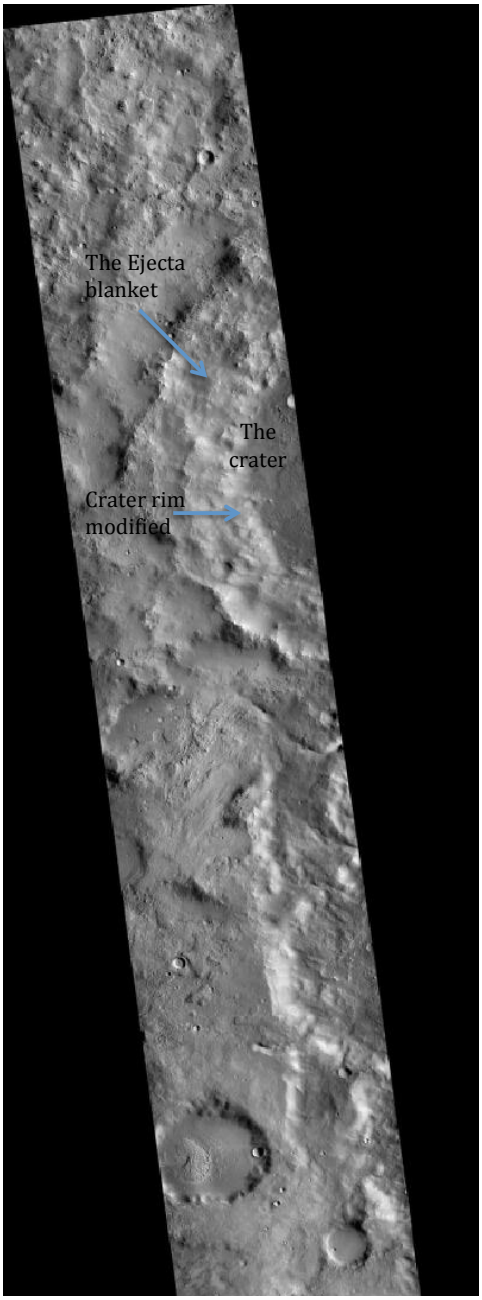
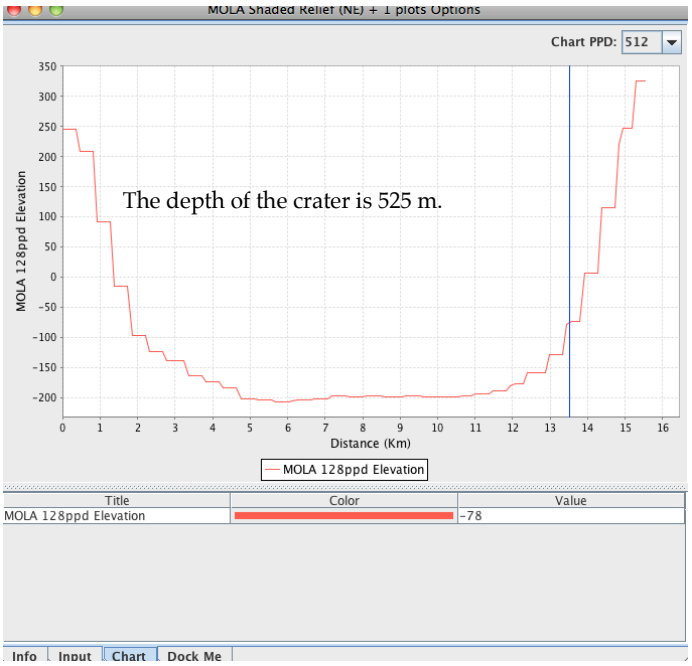


Chart PPD: 512
The crater is 485 m deep.
MOLA 128ppd Elevation
Distance (Km)
MOLA 128ppd Elevation
Title
Color
Value
MOLA 128ppd Elevation
-351

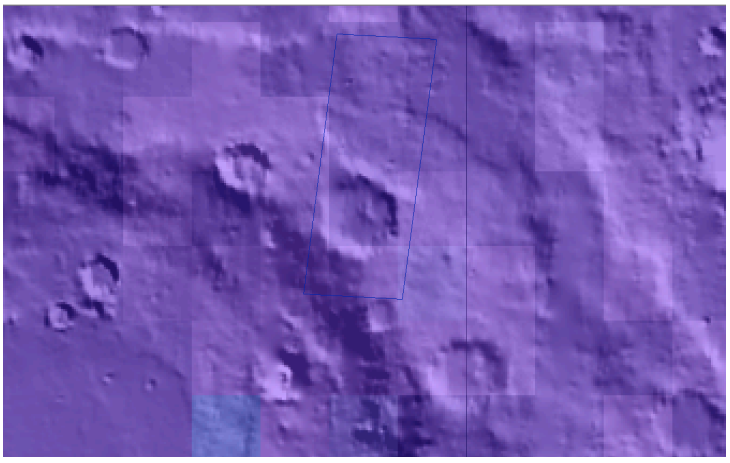
6. Crater V28479007



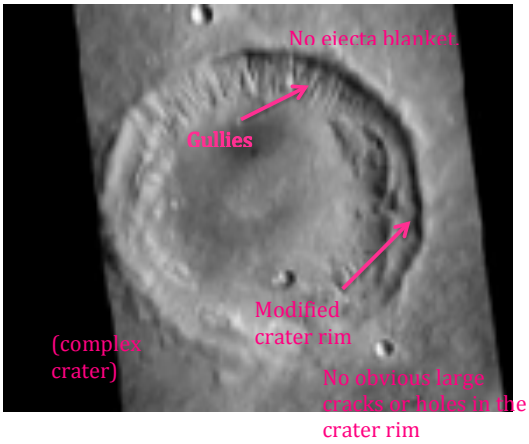
This crater has no gullies in the crater rim. This crater also has no obvious cracks in the rim. This crater does not have evidence of layered, sedimentary rocks.

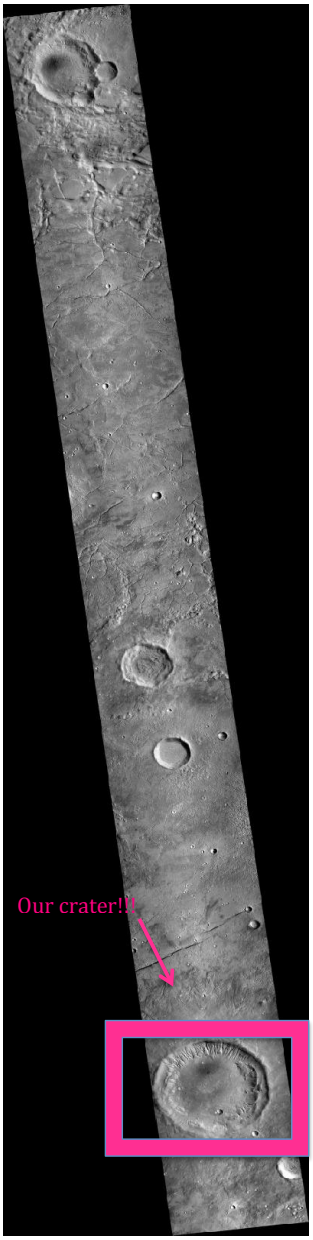


TES Carbonate

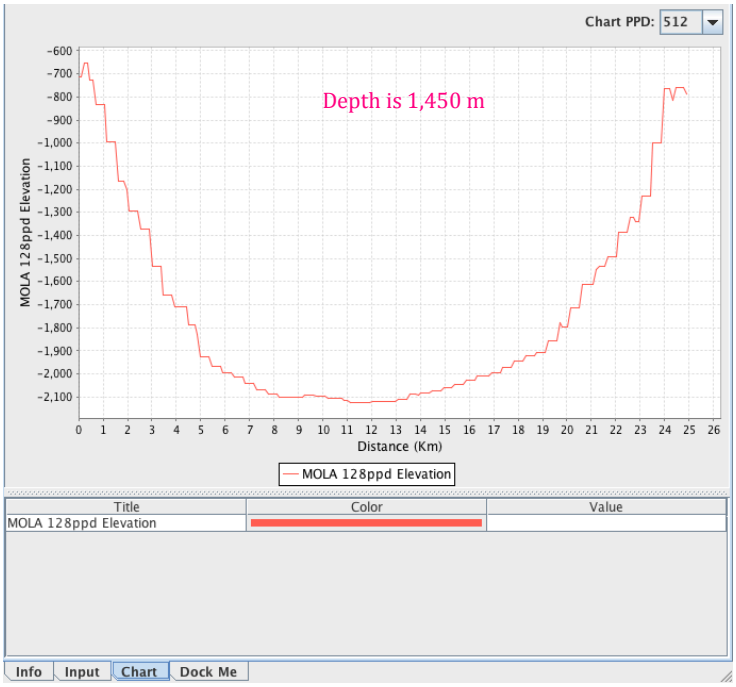


7. Crater V20122008

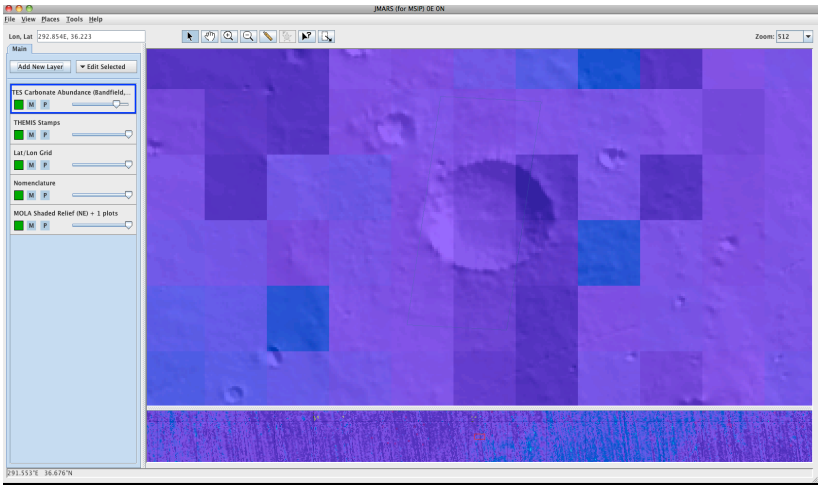




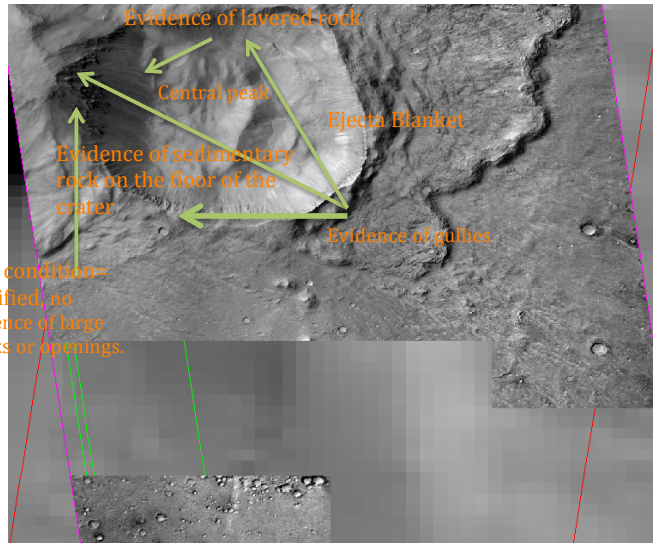
Depth chart of the crater



Clay carbonate of the crater

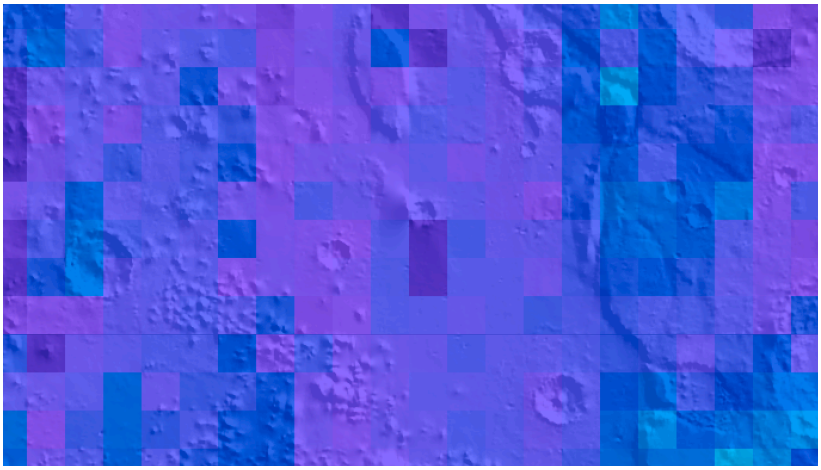


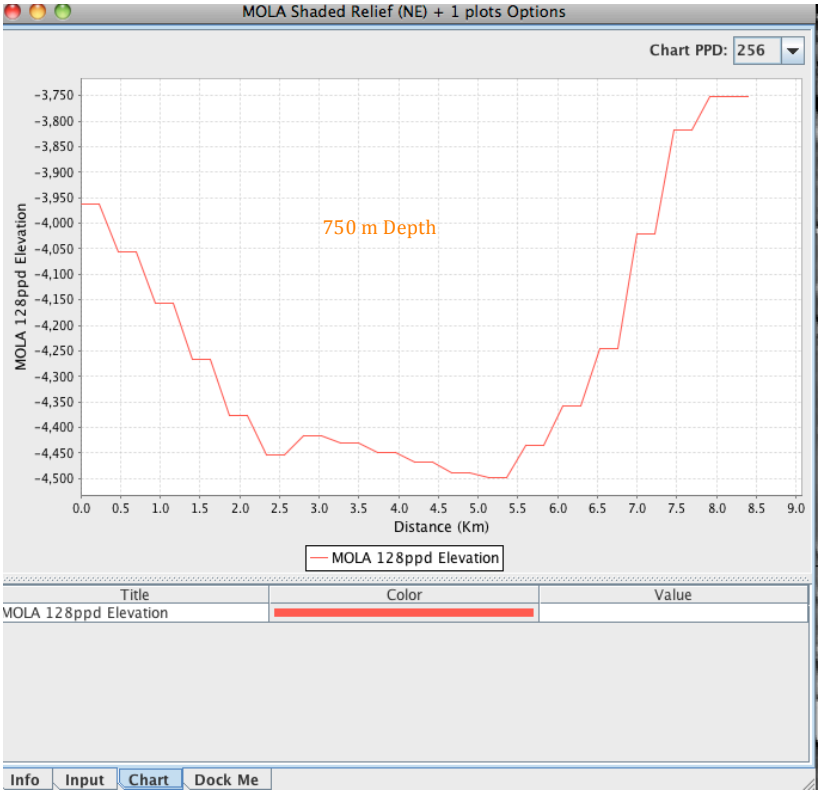
8. Crater V46152053



This crater has evidence of layered rock on the floor of the crater, and an ejecta blanket.

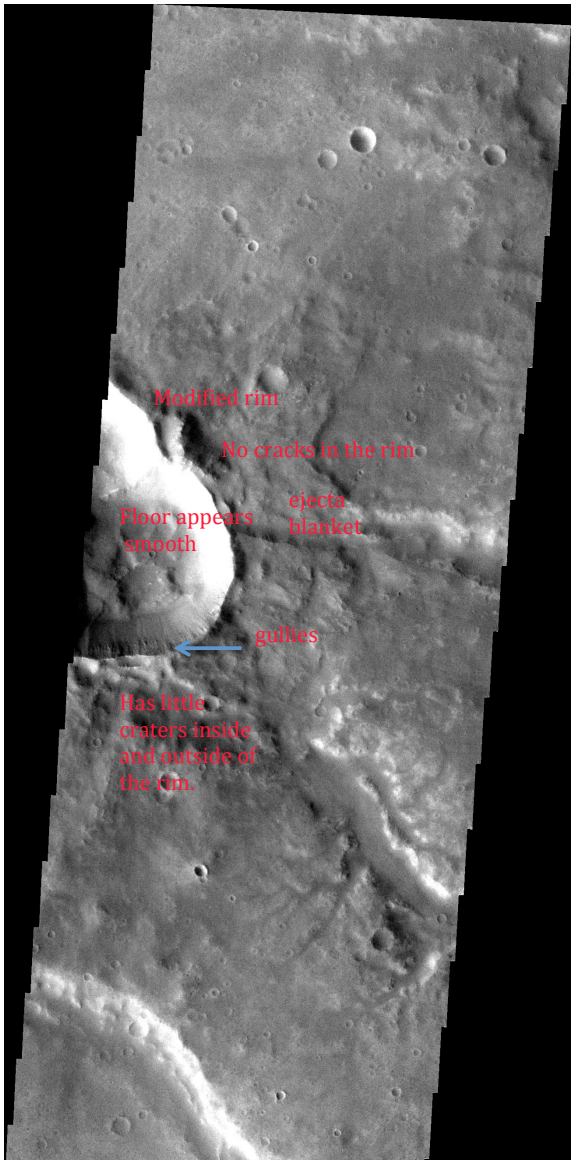
TES Carbonate

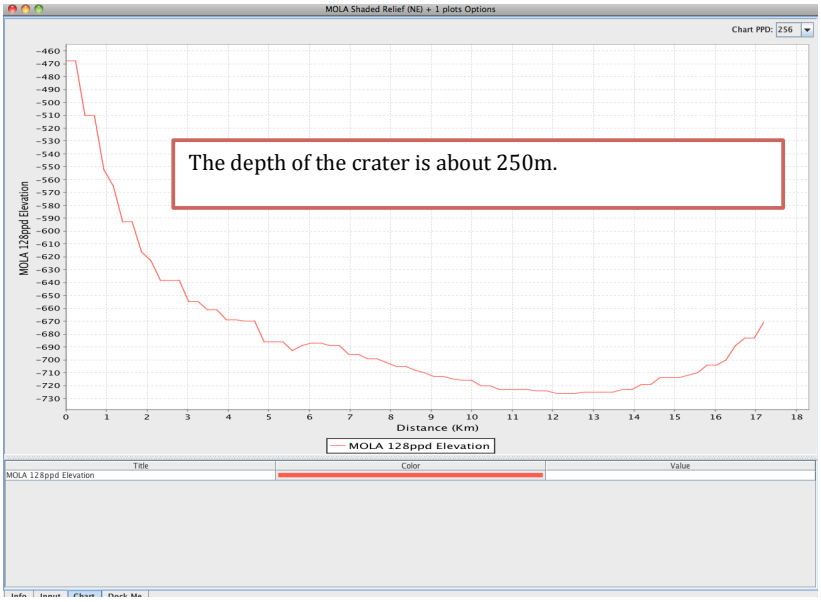



MOLA Shaded Relief (NE) + 1 plots Options
Chart PPD: 256
MOLA 128ppd Elevation
-3,750
-3,800
-3,850
-3,900
-3,950
-4,000
-4,050
-4,100
-4,150
-4,200
-4,250
-4,300
-4,350
-4,400
-4,450
-4,500
750 m Depth
0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0 8.5 9.0
Distance (Km)
MOLA 128ppd Elevation
Title
Color
Value
MOLA 128ppd Elevation
Info
Input
Chart
Dock Me

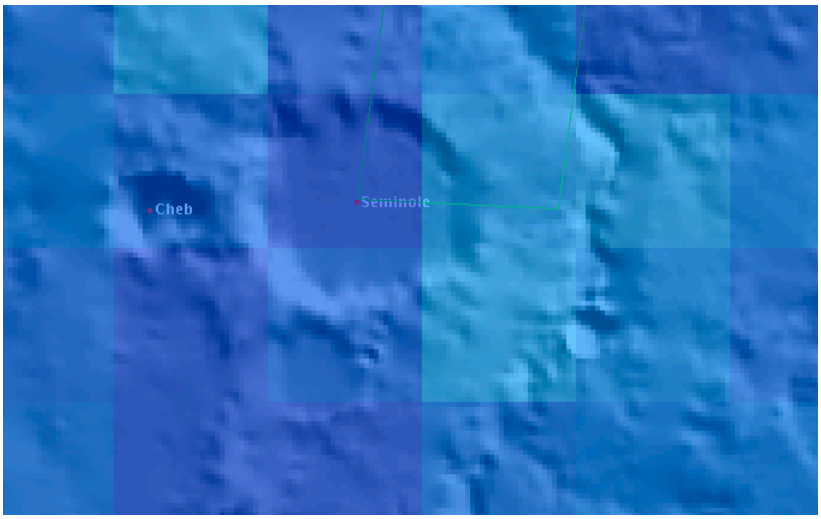
9. Crater V24414003 (Seminole)

Seminole

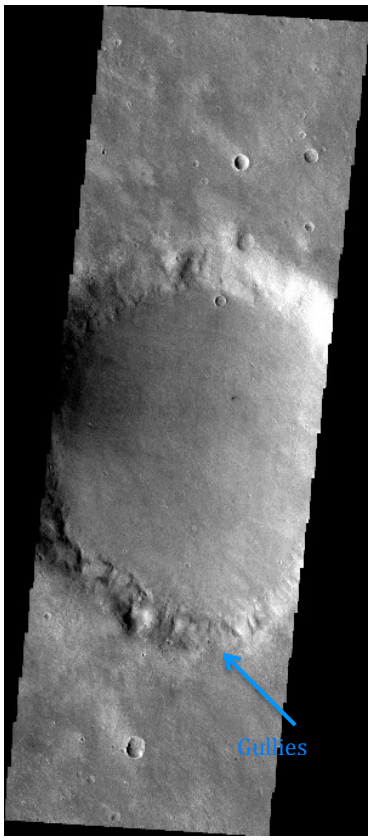




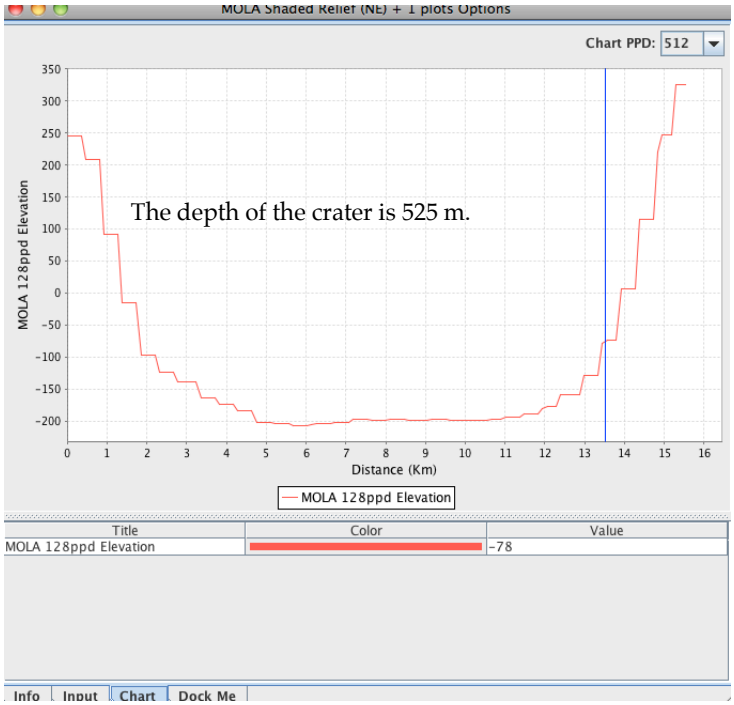
TES
CARBONATE



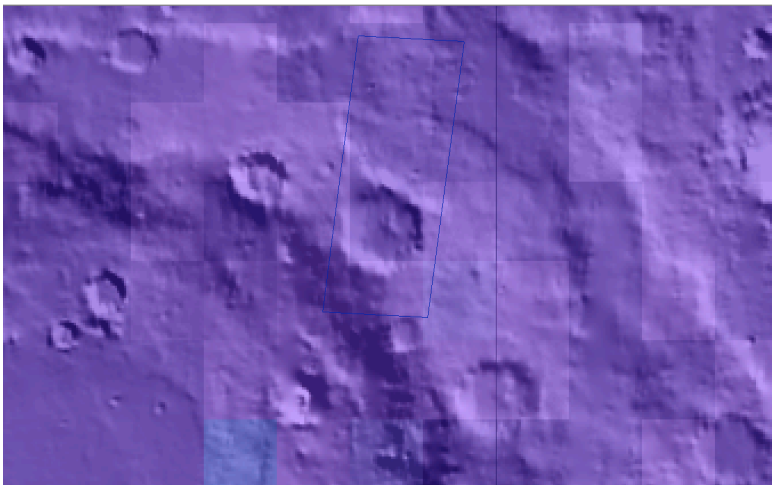
10. Crater V49961002 (Our THEMIS Crater)



There are no obvious cracks in the rim. There is no evidence of sedimentary rock or layered rock on the crater floor. It is smooth.



TES Carbonate



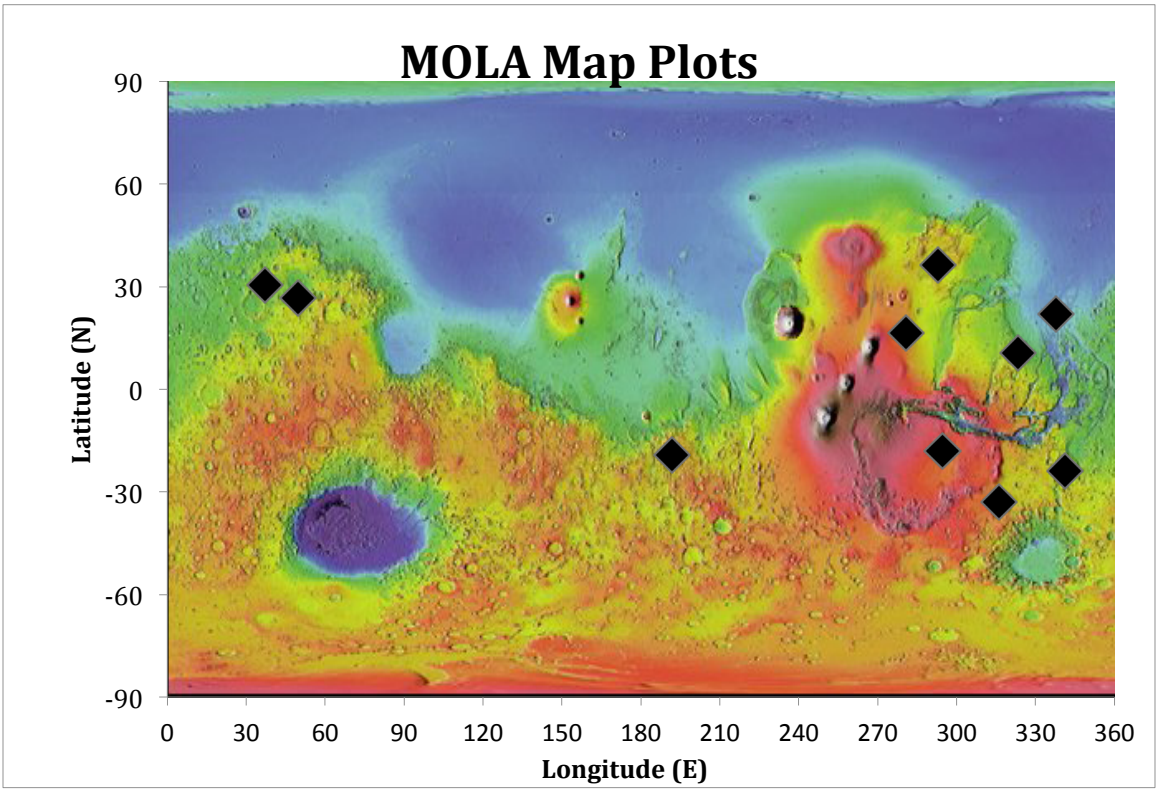
Data Table

All of the information we collected about each crater may be found in our data table below.

THEMIS ID #	Latitude	Longitude	Depth (m)	Evidence of Gullies	Rim Condition	Evidence of Layered Rock on Floor that may be Sedimentary	Mineral Composition (Clay-Carbonate Evidence)
McLaughlin Crater (Our Control)	21.9	337.63	1,600	Yes	No obvious large cracks or openings	Yes	0.06704
V31968004	-19.1979	191.719	850	No	Many cracks	None	0.00458
V24503003	-17.9939	294.54	1,150	Yes	Part of rim appears missing	None	0.05189
V20343006	30.5949	36.939	1,275	No	Many cracks	Yes	0.02635
V19074010 Sulak	16.5115	280.771	485	Yes	No obvious large cracks or openings	Yes	0.02065
V28479007	26.5166	49.6477	525	No	No obvious large cracks or openings	None	0.00957
V20122008	36.2778	292.83	1,450	Yes	No obvious large cracks or openings	None	0.01263
V46152053	10.6203	323.397	750	Yes	No obvious large cracks or openings	Yes	0.02221
V24414003 Seminole	-23.737019	341.11682	250	Yes	No obvious large cracks or openings	None	0.05971
V49961002 (Our THEMIS Crater)	-32.951317	316.1144	625	Yes	No obvious large cracks or openings	None	0.05817

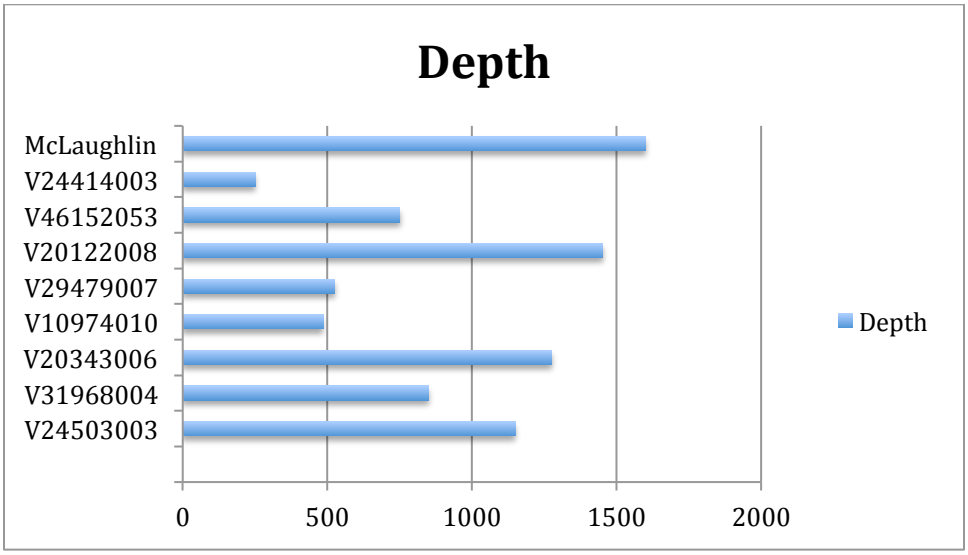
MOLA Map of Our Craters

Below is a map of our craters plotted out on the Martian surface. We chose craters that were in various places on the planet. Our craters are plotted on the MOLA map below, so we can map our position.

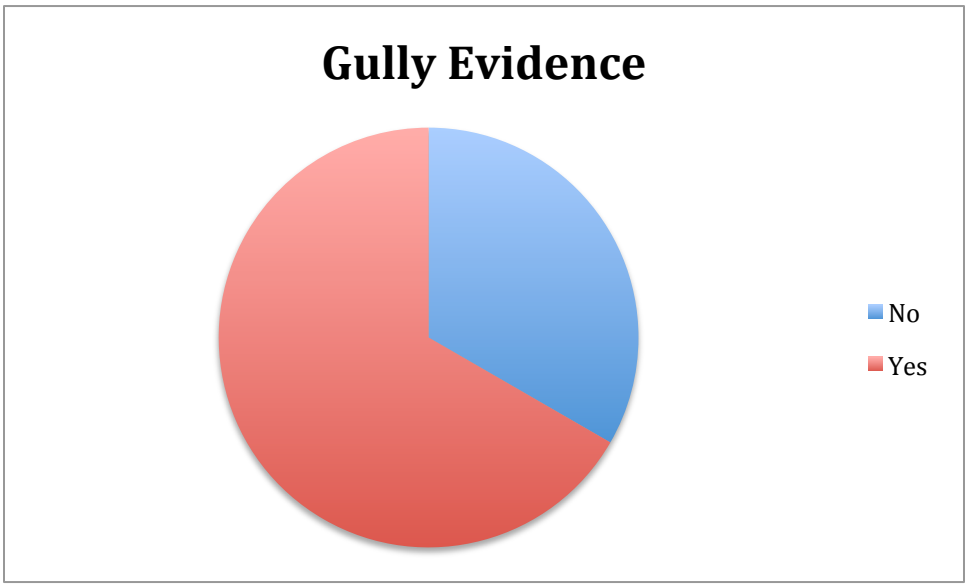


Graphs of the Data

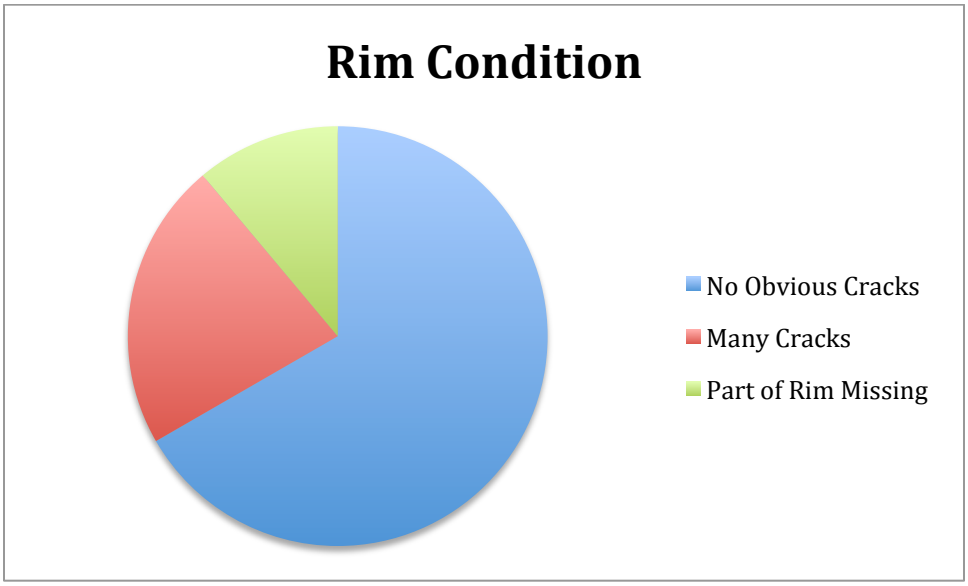
The following graphs were created to summarize the data table.



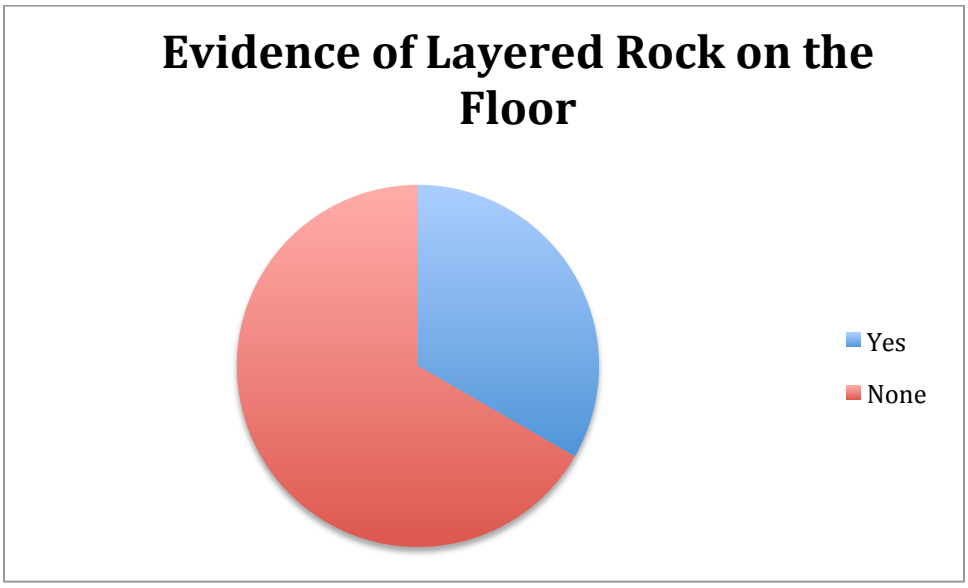
The depth graph shows that V20122008 and V20343006 are the only craters that are relatively close to McLaughlin's depth.



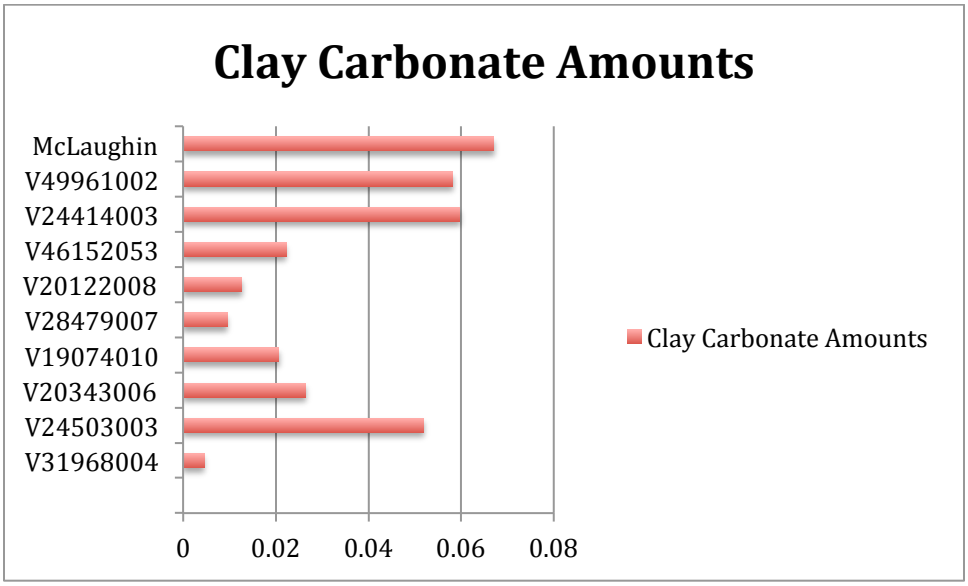
Our gully evidence graph shows that most of the craters that we looked at had evidence of gullies. V24503003, V19074010(Sulak), V20122008, V46152053, V24414003 (Seminole), and V49961002 ("Our Crater") have gully evidence.



The condition of the craters' rims is an important clue to find evidence of water. McLaughlin's rim has no obvious cracks and openings, and there are a few craters that also don't have and large cracks and openings. These craters include V19074010 (Sulak), V28479007, V2012008, \V46152053, V24414003 (Seminole), and V49961002 ("Our Crater"). These craters have many cracks in the rim: V31968004, V20343006. This crater is the only crater that has part of the rim missing: V24503003.



These craters may have evidence of layered or sedimentary rock on floor. The craters that are most similar to McLaughlin are: V20343006, V19074010 (Sulak), and V46152053. Most craters do not show this evidence.



Finally the mineral composition for craters similar to McLaughlin are: V24503003, V24414003 (Seminole), and V49961002 ("Our Crater").

Meaning of our Data

In looking at our data, we think that there are craters that have some similar characteristics to McLaughlin Crater, but none of them match exactly.

There are three craters that have three out of five characteristics are the same as McLaughlin's. V46152053, V20122008 and V109004010 (Sulak) are the three craters. However, V46152053 is about half of the depth, so out of the three, it is the least like McLaughlin. If we look closer at these craters, we might find more signs of water. We conclude that Sulak and V20122008 hold the most probable evidence of water since they are most similar to McLaughlin.

Potential Errors

As with any science experiment, there are errors that may occur in the data. We believe this summarizes some of those potential errors:

- In some of the images, there could have been misinterpretation of the features in and around the crater. For instance, gullies may have been mistaken for layers.
- The images may not have been detailed enough for us to see all the features present.
- The measurements we took for the crater depth may be inaccurate and not as precise as possible due to limitations in JMARS.
- The measurements we took for the clay carbonate measurements are not precise because they are an average of carbonate in the area and not in one specific place.
- Going into the project, most of us believe that there is water on Mars.

VI. Conclusions

Science Question

Are there other craters similar to the McLaughlin Crater on Mars?

There are, but none of the craters we looked at match all of McLaughlin Crater's characteristics that give probable evidence that water exist. There are three craters that have three out of five characteristics that are the same as McLaughlin's, proving they are most similar. V46152053, V20122008 and V109004010 (Sulak) are the three craters. However, V46152053 is about half of the depth, so out of the three, it is the least like McLaughlin. If we look closer at these craters, we might find more signs of water. We conclude that Sulak and V20122008 hold the most probable evidence of water since they are most similar to McLaughlin.

Hypothesis

If we can find another crater with similar characteristics to the McLaughlin Crater, then there is evidence that water once existed in that area of Mars.

This is a reasonable hypothesis because most of the craters displayed at least one similar characteristic to the McLaughlin Crater. Some of the craters show more similarities than others, making them more like McLaughlin than not. Evidence for water includes layered rock, clay carbonate, depth, gullies, and rim condition. Using these has helped us identify craters that are most like McLaughlin and least like McLaughlin. Future, in-depth research on both McLaughlin and other craters, such as the 9 we researched, may in fact hold or held water based on the characteristics we researched.

Future Work

NASA could use our proposal to further research our scientific question. For instance, a rover could be sent to any or all these craters for further exploration to see if there is more evidence for water. They could also take more detailed photos of these craters to get more information about each one.

Acknowledgements

We would like to thank the following people for helping us make this project possible:

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- Jessica Swann for giving us good constructive criticism and tips. She was a true guide in helping us do all we needed to do to be successful.
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- Dr. Angela Zinkl for being our amazing science teacher.

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