

MSIP Proposal

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Introduction

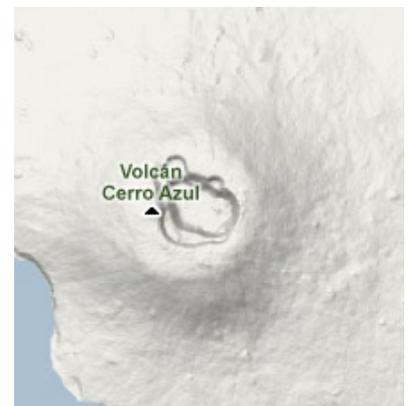
What is the size range of lava tubes on Mars compared to Earth? There are several types of volcanoes, so there are many bases for comparison. The various features associated with each type of volcano could be tied into the features of the lava tubes due to their size, elevation, etc. Studying and comparing lava tubes can assist us in drawing a relationship between Earth and Mars. Studying the features of Mars can assist us in learning more about our home planet. By applying the fact that both Mars and Earth were formed at the same time, but are on different evolutionary paths, the question of whether or not the state of Mars is the future of Earth can be posed. Lava tubes are interesting because they could provide a safe environment for future discoveries. The tube's interior is underground and is therefore protected from wind, dust, and the harsh radiation that hits the surface of Mars. This, along with the assumption that the temperature of the interior is more stable, could indicate that life might exist in the tubes. This experiment allows for future progress to be made towards unveiling the geological history of Mars, and allows for more information to be gathered about Earth.

Background

Mars and Earth both have volcanoes which indicate that there once was tectonic activity inside of Mars. From the volcanic eruptions on both Earth and Mars, lava tubes were formed. Though Martian volcanoes are currently classified as dormant, lava tubes were formed long ago as a result of lava flow from active volcanoes. These lava tubes can be described as “caves formed by flows of high viscus lava - a river of molten rock flowing from a particular eruption source - a volcano or fissure for instance” (Frederick, R.D. “Modified



Norwebster) whose tops and sides harden as lava continues to flow inside the new tunnel. After a volcano erupts, the lava flows; sometimes for many kilometers. Lava tubes typically run several meters below the surface and can leave a long empty tunnel that almost appears man-made (Cain). For example, a known tube on Mauna Loa starts from the eruption point and then



flows 50 km to the ocean. The image on the left displays the lava flow of the volcano Lullailaco along the Argetina-Chile border in South America (Stefanov, William B.; Earthobservatory.nasa.gov). The image on the right shows Volcano Cerro Azul, located on the Galapagos Islands (Google Maps). When observed, it faint lines extending out from the volcano can be seen, which likely represent lava tubes.

Although Mars is at least half the size of Earth, the volcanoes on Mars' surface surpasses any of the volcanoes that we have. The lava tubes on Earth have parallel sides causing any flowing fluid to erode the outside of curves instead of the inside. However, most of the channels on Asraeus Mons (on Mars) maintain a constant width. Mars and Earth's lava tubes also differ

in that lava flow on Earth joins together producing a wider flow; where the channels on Mars join creating either no change in flow size, or even decreasing it (“The Strange Lava Tubes Of Mars”).

The volcanoes on Mars have been divided into three main types of volcanoes. The three types found on the surface of Mars are *montes* (mountains), *tholi* (domes), and *paterae* (complex, collapsed shields). (Caplinger, Mike; “Martian Volcanoes”) The *montes* variety are very large, and could be basaltic. Examples of *montes* on Mars are Ascraeus Mons, Pavonis Mons, and Arsia Mons. *Tholi* are generally smaller in size than the mountains, but are also steeper. *Tholi* that exist on Mars include Tharsis Tholis, Ceraunius Tholis, and Uranus Tholis. Several theories exist regarding the differences between the two types of volcanoes, including ideas that the volcanoes are comprised of different materials, or specific details regarding the nature of eruptions, stating the idea that the eruptions of *tholi* were smaller, therefore resulting in a smaller area of the actual volcano. (Caplinger, Mike; “Martian Volcanoes”) The last type, *paterae*, can be varied in form, but are generally observed to have shallow slopes, complex edges, and contain channels. Many types of *paterae* are present on Mars, including the Apollinaris Patera, Biblis Patera, Tyrrhena Patera, Ulysses Patera, and Uranus Patera. (Caplinger, Mike; “Martian Volcanoes”) The various features associated with each type of volcano could be tied into the features of the lava tubes emitting from each volcano due to their elevation, size, etc. The image to the right shows collapsed lava tubes on the south side of Ascraeus Mons (Themis.asu.edu).



With regard to lava tubes on Earth, their formation appears to be quite similar those of Mars; fast-moving lava during eruptions forms streams of lava that harden around the sides and tops to create “caves” in which lava continues to flow. The levels of viscose present in lava tubes impacts their size, as lava with high viscosity tends to form long, narrow lava streams whereas low-viscosity lava generally forms short, wide streams. However, in contrast to Martian lava tubes, which appear to be smooth for the most part according to THEMIS images, Earth lava tubes often are seen to have collapsed sections scattered along the length of the lava tubes, which frequently turn into simple caves. This is theorized to be a cause of Earth’s atmospheric conditions such as winds, storms, gravity, etc. acting upon the lava tubes (Tokinka, Lyn; “Description: Lava Tubes and Lava Caves”, whereas Mars’ thin atmosphere may be the reason why most Martian lava tubes appear mostly smooth without many cracks or collapses. A great example of a place on Earth to find lava tubes is Hawaii, because of its geography, tectonics, and abundance of volcanoes. The image to the right shows lava tubes on Mars (Thunderbolts.info).



Lava tubes on Mars are a topic of great interest for scientists, due to a variety of reasons including the fact that their inside environments may protect from the harsh external environment of Mars. Also because of the fact that the enclosed environment of lava tubes may be able to sustain moderate temperatures from the heat of the lava that once flowed, there is a belief that this stable temperature might provide opportunity for water formation and possibly primitive forms of life. (Daga, Andrew; “Lunar and Martian Lava Tube Exploration”) Human

interest in Martian lava tubes also strengthens due to the possibility that the favorable internal environments of lava tubes may provide reasonable locations for future explorers to set up observation bases inside the lava tubes. By exploring such lava tubes on Mars, there is strong reason to believe that discovering relationships between factors of lava tubes can provide insight to the formation or general nature of lava tubes.

Experimental Design

To be able to complete the Mars project and figure out the answer to our scientific question; the use of the THEMIS camera on board NASA's Mars Odyssey spacecraft will be needed to take pictures of the different types of lava tubes found on Mars. The relationships between Mars' lava tubes and Earth's lava tubes will be examined. The measurements of the lava tube's elevation, width, length, and location will be recorded on both Mars and Earth in order for our question to be answered. By answering the question, one may be able to know any new connections between Mars and Earth.

This proposed observation will comprise of several main steps in the procedure. First, the surface of Mars must be observed to locate volcano-rich areas so as to receive the best results. The two main volcanic regions on Mars are Tharsis and Elysium. Tharsis is the largest volcanic region on Mars, and it is 4,000 kilometers in length and is 10 kilometers in height. Elysium is the second largest volcanic region, and it is 17,000 kilometers by 24,000 in size. Areas of lava tube flow must be selected and taken by a THEMIS camera, which stands for Thermal Emission Imaging System. Below is a table for the location of major volcanoes on Mars, and will be used as a starting place for finding images of Martian lava tubes.

Locations of Martian Volcano:

<u>Volcano</u>	<u>Longitude</u>	<u>Latitude</u>	<u>Type</u>
Albas Mons	250° 24' 0" E	40° 30' 0" N	shield volcano
Albor Tholus	150° 24' 0" E	18° 48' 0" N	
Apollinaris Mons	174° 24' 0" E	-9° 18' 0" N	shield volcano
Arsia Mons	240° 30' 0" E	-9° 30' 0" N	shield volcano
Ascræus Mons	255° 30' 0" E	11° 48' 0" N	shield volcano
Biblis Tholus	235° 24' 0" E	2° 42' 0" N	
Ceraunius Tholus	263° 4' 0" E	24° 2' 0" N	basaltic shields
Elysium Mons	146° 54' 0" E	24° 48' 0" N	pyroclastic shield volcano
Hecates Tholus	150° 12' 0" E	32° 6' 0" N	shield volcano
Olympus Mons	226° 0' 0" E	18° 24' 0" N	shield volcano
Pavonis Mons	246° 36' 0" E	0° 48' 0" N	shield volcano
Peneus Patera	53° 30' 0" E	-58° 6' 0" N	shield volcano
Pityusa Patera	37° 6' 0" E	-67° 0' 0" N	
Syrtis Major Planum	69° 30' 0" E	8° 24' 0" N	low relief shield volcano
Tharsis Tholus	269° 0' 0" E	13° 30' 0" N	shield volcano
Ulysses Patera	239° 33' 0" E	2° 53' 24" N	shield volcano
Uranius Patera	53° 5' 0" E	-58° 1' 0" N	shield volcano
Uranius Tholus	239° 36' 0" E	2° 54' 0" N	shield volcano

The THEMIS camera will be used to provide visible images, and since the range of each image stamp is very small, at least 100 images need to be taken or as many images as possible given our time constraints. After the Mars images have been taken, lava tubes must also be observed and photographed in order to compare Martian lava tubes and Earth lava tubes. Once that step has been completed, the information in the images must be used to calculate lava tube features such as width, length, elevation, and distance from volcano and depth in both Martian and Earth lava tubes. However in order to look up the elevation of the lava tubes and volcanoes on Mars, then one must use the MOLA map. The MOLA map is the measurements of Mars' topography. This was made by sending laser pulses to Mars' surface, and it measured the distance of the object that it hits, thus finding the elevation of the object on Mars. Then the data must be compared so as to find relationships in factors between the lava tubes on Mars and on Earth.

Analysis Plan

To compare the lava tubes from volcano to volcano on Mars and Earth, the following variables will be recorded.

Image ID #	Latitude	Longitude	Length of lava tube	Average Width of lava tube	Depth	Elevation of parent volcano

First, the group will create a scatter plot to illustrate the height of the observed volcanoes versus the length of lava tubes found approximate to the site on Mars and Earth. Both variables will be measured in kilometers. Hopefully, this data will show a synonymous correlation between the two planets' geological features.

Then, the team will conjure a scatter plot showing the relationship between the length and width of lava tubes. This graph will also be measured in kilometers. Most likely, there will be no connection between these recordings on Mars and Earth, because the dimensions of lava tubes is dependent on outside variables rather than each other.

Next, the THEMIS experimental team will develop a bar graph to display the association between each location of volcanoes on Mars and Earth versus the abundance of lava tubes at

these sites. Dubiously, there will be a direct correlation between the two subjects, because lava tubes typically form close to volcanoes.

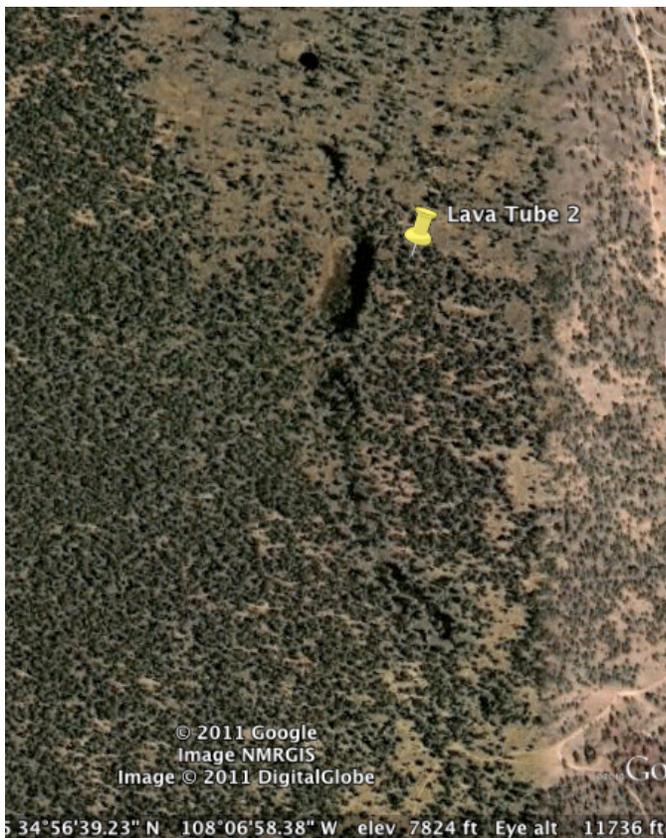
Finally, the group will quantify the depth of the located lava tubes against the elevation of the volcanoes from which they originated. Expectantly, elevation and depth will have no relationship whatsoever, because lava tubes always form at the surface of the planet. Thus, their depth never changes.

Below is a table of THEMIS images possibly containing lava tubes for study.

Image ID	Longitude	Latitude	Volcanic Region
V11426003	59.29791	15.382655	Syrtis Major
V39664023	256.72266	14.281971	Tharsis
V11753011	150.31926	26.08202	Elysium
V38828010	254.03593	6.685989	Tharsis
V15395003	223.53128	-8.373171	Tharsis
V11129006	150.49478	23.542994	Elysium
V36844022	73.29343	1.153691	Syrtis
V16044001	257.27026	-2.702542	Tharsis
V39689008	254.72618	8.57383	Tharsis
V17504001	329.52115	-6.734005	Tharsis
V39215004	165.44995	1.760915	Elysium
V15994001	254.65953	-10.401602	Tharsis
V17504001	329.52115	-6.734005	Tharsis
V35821013	244.70999	23.8144	Tharsis
V39552004	249.62674	26.622377	Tharsis
V34323010	335.536	0.822038	Tharsis
V12402005	147.71812	20.367405	Elysium
V37257001	88.151505	-0.986751	Syrtis
V38755037	110.22702	1.076097	Elysium
V15070001	207.09674	-8.630449	Tharsis
V17504001	329.52115	-6.734005	Tharsis
V15345002	220.9731	-8.752981	Tharsis
V09403012	258.50262	13.951036	Tharsis
v38405011	131.46967	25.47674	Elysium
V16554012	253.7475	8.544783	Tharsis
V38404012	249.254	26.5643	Tharsis
V29333007	251.858	28.6216	Tharsis
V35384008	248.81921	25.556011	Tharsis
V14008006	259.97784	23.691309	Tharsis
V25976017	259.9	25.473751	Tharsis

V28297006 260.1 25.434473 Tharsis

Possible Lava Tubes on Earth



The above lavatubes on earth are located in New Mexico. We will use Google Earth to seek out other lava tubes for comparing with Martian lava tubes.

Conclusions

What is the size range of lava tubes on Mars compared to Earth? We can use the THEMIS visible camera to learn how lava tubes on Mars are similar and different with the lava tubes on Earth. Although Earth is unique, common features between Earth and Mars unite them both. This can show that Earth is unique in some areas, but not all. This proposal is vital for understanding the surface of Mars and to possibly be able to build a base in a lava tube. By having the option to build inside the lava tubes, it allows for astronauts to be sheltered from radiation and the Martian elements. Through the data we have collected, we should be able to make a decent conclusion about the lava tubes on Earth compared the lava tubes on Mars.

References

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"The Strange Lava Tubes of Mars." *Thunderbolts.info | A Voice for the Electric Universe*. Ed. Wallace Thornhill and David Talbott. Web. 25 Sept. 2011. <<http://www.thunderbolts.info/tpod/2005/arch05/051111ascraeus.htm>>.

Christensen, P.R., B.M. Jakosky, H.H. Kieffer, M.C. Malin, H.Y. McSween, Jr., K. Nealson, G.L. Mehall, S.H. Silverman, S. Ferry, M. Caplinger, and M. Ravine, The Thermal Emission Imaging System (THEMIS) for the Mars 2001 Odyssey Mission, *Space Science Reviews*, 110, 85-130, 2004.

'New Mexico, USA' 34°56'49.27"N and 108°06'09.05"W. Google Earth. November 15, 2003. October 4, 2005.

'New Mexico, USA' 34°56'39.23"N and 108°06'58.38"W. Google Earth. July 1, 2005. October 4, 2005.