Image Analysis of Unusual Structures on the Far Side of the Moon near the Crater Paracelsus C

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ABSTRACT

The authors present an analysis of Apollo 15 and Lunar Reconnaissance Orbiter images of two unusual structures near the crater Paracelsus C on the far side of the moon. At first glance these structures appear to be walls or towers on the lunar surface. By combining multiple images we show the larger structure, oriented in a northeast/southwest direction, is not simply a wall but two walls on either side of a narrow valley or "passageway". Based on its orientation and latitude it is possible the self-shadowed passageway is never fully illuminated by the sun at any time during the lunar day. Using single image shape from shading and 3D terrain visualization we show in a computer generated perspective view looking northeast that the southwest end appears to be the entrance to the passageway. A reverse angle view looking southwest shows the passageway ending at a rise of terrain at the other end, possibly leading underground. The terrain surrounding the two structures is not flat but appears "excavated" by some unknown means, natural or artificial.

Introduction

Early in his career Carl Sagan spoke boldly about the possibility of extraterrestrial visitation (Sagan 1963)

"It is not out of the question that artifacts of these visits still exist, or even that some kind of base is maintained (possibly automatically) within the solar system to provide continuity for successive expeditions. Because of weathering and the possibility of detection and interference by the inhabitants of the Earth, it would be preferable not to

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erect such a base on the Earth's surface. The Moon seems one reasonable alternative. Forthcoming high resolution photographic reconnaissance of the Moon from space vehicles – particularly of the back side – might bear these possibilities in mind."

Arizona State University (ASU) receives, processes, catalogs and studies hundreds of thousands of images from NASA's Lunar Reconnaissance Orbiter (LRO). ASU scientist Paul Davies believes that "rather than leaving SETI to a small and heroic band of radio astronomers, we should mobilize the entire scientific community to 'keep their eyes open' for telltale signs of alien technological activity." One suggestion is to look for evidence of mining or quarrying activities. Where on Earth the evidence may be buried beneath overlaying strata, Davies states: "Quarrying or construction on the moon or asteroids would persist conspicuously for much longer, and scrutiny of the Lunar Reconnaissance Orbiter data would be a useful exercise."

Independent scientific groups such as The Lunascan Project[4] and Society of Planetary SETI Research[5] investigate reported anomalies on the moon and Mars. In May 2016, Ananda Sirisena notified Lunascan project coordinator Fran Ridge that he had found an article[6] posted on the Internet in 2014 reporting unusual features on the surface of the moon resembling dark "walls" or "towers" photographed by the Apollo 15 astronauts in 1971. Ridge determined the coordinates of the features and found a more recent and much higher resolution image over the area, M118769870L, acquired by LRO in 2010. In the LRO image the features appeared to be "structures" of some kind in the southwest corner of a 24 km crater named Paracelsus C on the far side of the moon. In the meantime, the original Apollo 15 panoramic camera image frames A15-P-8868 and AS15-P-8873 were located. Fig. 1 is a stereo pair constructed from these two frames. Three additional LRO M-frames were located using PIPE (Fig. 2). In total, four LRO M-frames, two Apollo 15 P-frames, and five Apollo metric camera M-frames have been found over the area of interest (Table 1).

2D Analysis

The structures near Paracelsus C are located at latitude -21.6474° and longitude 165.2133°. Using LRO image M1153132512R and associated metadata, the largest structure was calculated to be approximately 62 meters long and 10 meters in height. As shown in the map projected imagery in Fig. 2 the structure is oriented in a northeast/southwest direction. In M118769870L and M1115441699L the sun is to the northwest, illuminating the northwest side. In M1153132512R and M1168450258L the sun is northeast, illuminating the southeast side of the structure. At this sun angle the terrain to the north casts a shadow along the northwest side.

[4] http://www.astrosurf.com/lunascan/
[5] http://spsr.utsi.edu
[6] http://www.ufosightingsdaily.com/2014/01/new-moon-discovery-of-two-tall.html

Registering and combining multiple images reveals new information about these structures that is not evident in the original images. Fig. 3a and Fig. 3b are map-projected images M118769870L and M1168450258L, respectively. North is up. In Fig. 3c the two images have been merged by replacing shadowed pixels in one image with non-shadowed pixels in the other image, and vice versa. In Fig. 3a the sun is to the left, in Fig. 3b the sun is to the right. The resultant merged image reveals the larger structure (A) is not simply a wall but two walls on either side of a narrow valley or “passageway” (Fig. 4a). Based on its orientation and latitude it is possible the self-shadowed passageway is never fully illuminated by the sun at any time during the lunar day. The smaller of the two structures (B) appears to have a ridge-like depression in the middle similar to A as shown in Fig. 4b.

3D Analysis

Viewing the imagery in a three dimensional context further aids in our ability to understand the shape of these structures and their relation to the background. Existing elevation maps of the moon do not have sufficient detail to resolve the features under study. Height maps can be computed with stereo matching algorithms from a pair of images acquired at different look angles. The Apollo 15 images AS15-P-8868 and AS15-P-8873 are good candidates for stereo as they were acquired from different directions (camera looking fore and aft) at the same sun angle. However structure A is only about 10 pixels in size in the P frames and even smaller in the lower resolution M frames thus limiting the usefulness of the Apollo data.

Shape from shading (SFS) algorithms are another means of extracting height information. SFS is particularly well suited in situations where the reflectance characteristics and albedo are uniform across the scene and the image is acquired at or near nadir. Previously, single image SFS was used to analyze the shape of the "face" on Mars in order to predict how it would appear under different lighting conditions (Carlotto 1988). Here we use SFS to visualize the shape of these structures and that of the surrounding terrain.

SFS height maps were computed from the two original images using a strip integration algorithm (Horn 1977). The height maps were then combined by averaging[7]. Once the height map has been computed synthetic views can be generated in any look direction by an oblique parallel projection (Foley and Van Dam 1983). Fig. 5a is a view at a 40° elevation angle looking northeast. From this look angle the southwest end of structure A appears to be the entrance to the passageway. Fig. 5b is a reverse angle view looking

[7] A potentially better approach would be to use a two (or more) image photometric stereo algorithm (Horn 1979).

southwest that seems to show the passageway ending at the rise of terrain at the other end, possibly leading underground.

Full pixel resolution northeast views of the two structures are shown in Fig. 6. There is insufficient information in the imagery to determine the depth of the valley in between the two walls. It is also not possible to determine if the valley ends or leads underground. Further analysis is required to determine if the interior structure of A is ever fully illuminated by the sun.

The 3D view of structure B reveals a radically different shape from that of structure A. What appears to be a long thin depression is in fact a steep cliff. The top of B is concave with a rim along the opposite side. The terrain surrounding the two structures is not flat but appears “excavated” by some unknown means, natural or artificial.

Fig. 7 is a perspective view of the area of interest. The cratered hills surrounding these structures do not look at all like a terrestrial mine with its terraced sides (Fig. 8). That this area is an extinct alien mining or mineral processing operation seems unlikely.

Discussion

Enormous quantities of lunar and planetary imagery are available to the public by way of the Internet. While enabling a “citizen science” approach to SETI, the availability of so much data also tends to generate new “discoveries” on a regular basis by those who want to discover something such as alien bases, towers, construction and other activities on the lunar surface[8]. Most turn out to be camera aberrations, JPEG compression errors, image enhancement artifacts, or simply misinterpretations of unfamiliar surface features imaged in unfamiliar ways. Some remain unexplained.

At the other extreme is a decidedly conservative mainstream scientific establishment attitude that sometimes rejects anomalies based on subject matter alone, i.e., there cannot be ET artifacts on the moon because there are no ET artifacts on the moon (or other planets). Such a view is an example of circular reasoning, based on an assumption that ET does not exist, or if it does exist could not have traveled to our solar system or even evolved within our solar system. Such prevailing assumptions will change gradually as we discover more and more planetary bodies in our Galaxy and realize that life can and does exist in extreme temperatures and pressures.

[8] The history of lunar anomalies goes back to astronomer Franz von Paula Gruithuisen’s “discovery” of a walled city on the moon in 1822. George Leonard’s 1976 book *Somebody Else is On the Moon* and Fred Steckling’s 1981 book *We Discovered Alien Bases on the Moon* analyzes a number of anomalous features photographed by Lunar Orbiter and the Apollo astronauts.

As independent scientists we attempt to bridge the gap between these two divergent camps. One the one hand we do not have to worry about grants, tenure, or allegiance to a prevailing paradigm or belief system and so can consider hypotheses outside current scientific paradigms. Still, accountable to the basic standards of ethical behavior, we are not interested in becoming the latest Internet sensation by posting a provocative but unsubstantiated report. Our goal is not to prove the existence of an ET artifact, only to show that it cannot be explained, or is, at least, “interesting”.

After careful study we believe these structures and surrounding terrain near Paracelsus C on the far side of the moon are interesting and worthy of further investigation by ongoing and future orbital missions and surface rovers.

Only when we encounter the first ET artifact will we be able to say what we are searching for. Until then the search for ET is a search for the unexpected. We may have difficulty in recognizing ET artifacts initially, as they might not conform to our society's conventional objects such as buildings, roads, mines or factories.

References

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Table 1 Apollo and LRO images over the area of interest

Frame	Resolution (meters)	Solar Elevation[9]	Emission Angle[10]	Incidence Angle[11]	Phase Angle[12]
AS15-P-8868		14	(forward)		
AS15-P-8873		14	(aft)		
AS15-M-0081	6.4	14			
AS15-M-0082	6.3	14			
AS15-M-0083	6.3	15			
AS15-M-0084	6.5	16			
AS15-M-0085	6.5	16			
M118769870L	0.55		1.7	68.9	70.5
M1115441699L	0.8		1.7	34.4	35.8
M1153132512R	0.94		1.2	58.7	57.6
M1168450258L	0.90		1.7	54.6	56.3

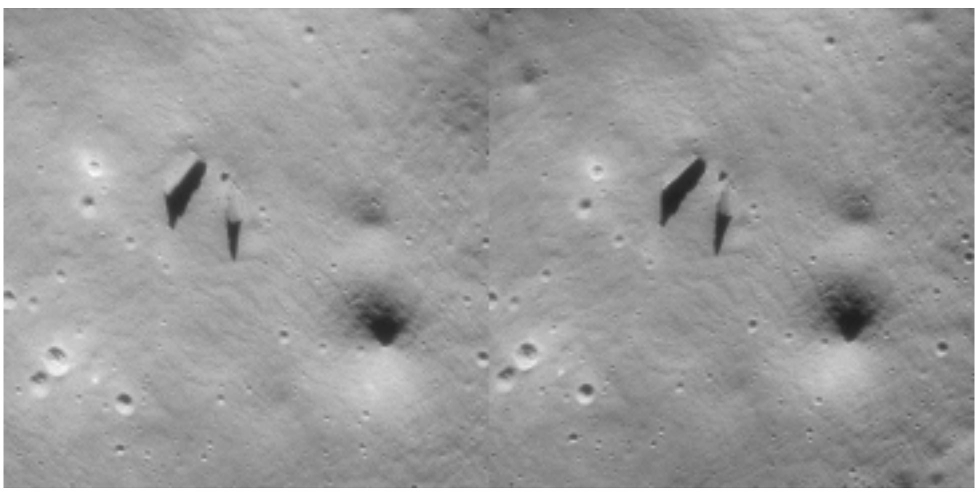


Fig. 1 Stereo pair constructed from AS15-P-8868 and AS15-P-8873

[9] Angle between ray directed toward the sun and the surface of the moon.
[10] Look angle of ray directed toward the sensor and the local surface normal (nadir).
[11] 90° – solar elevation angle.
[12] Angle between the emission and incidence angle.

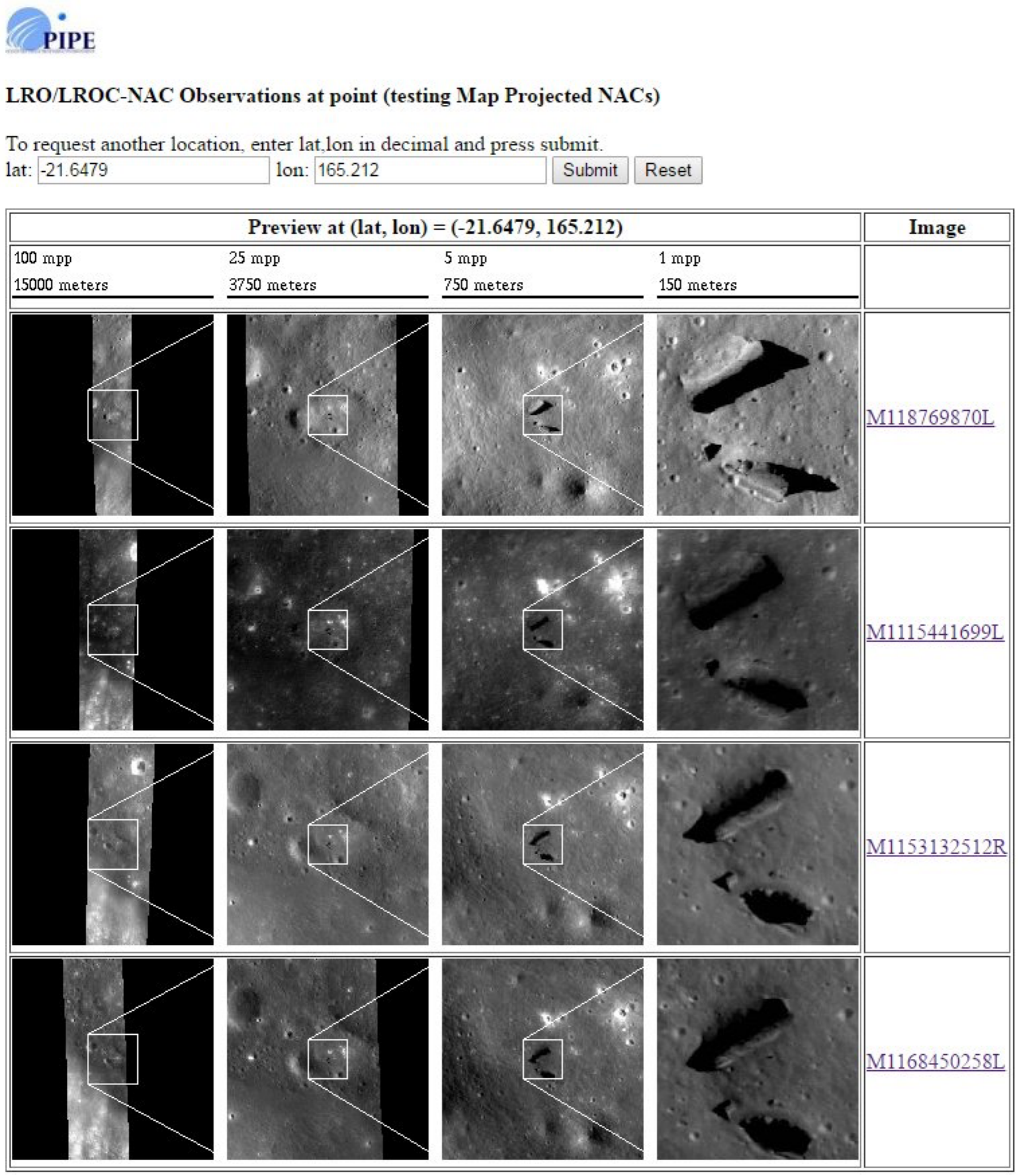
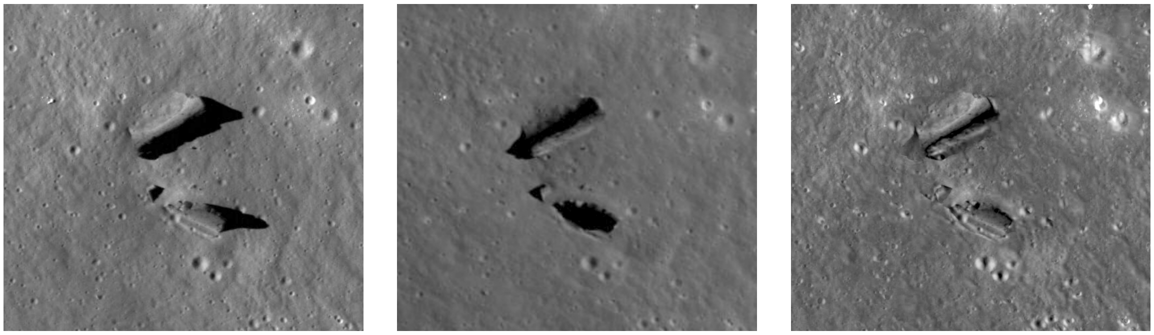
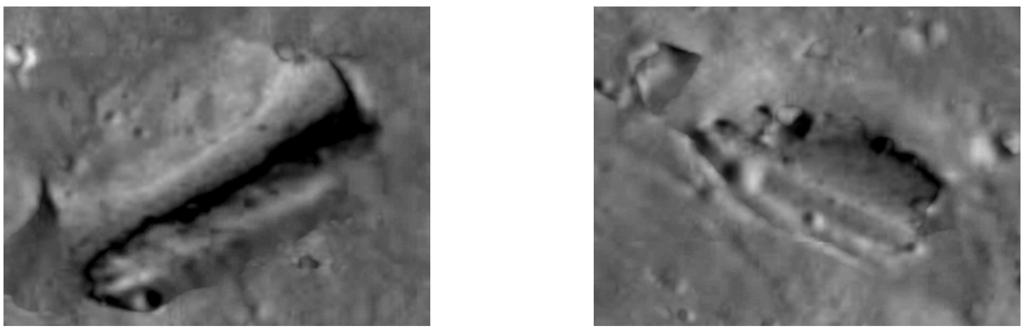


Fig. 2 LRO image search using Planetary Imagery Processing Environment (PIPE)



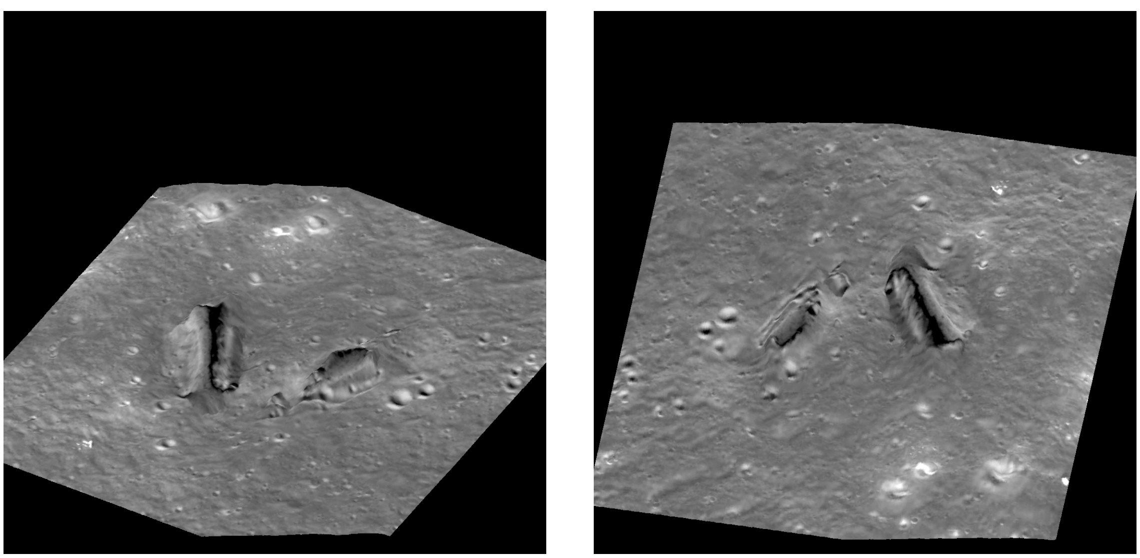
a) M118769870L b) M1168450258L c) Combined

Fig. 3 Merging registered images using shadow pixel replacement



a) Structure A b) Structure B

Fig. 4 Close up (full pixel resolution) combined images of the two structures



a) 40° elevation angle view looking northeast b) 50° elevation angle view looking southwest

Fig. 5 Two synthesized oblique views computed from the merged image and SFS-derived height map

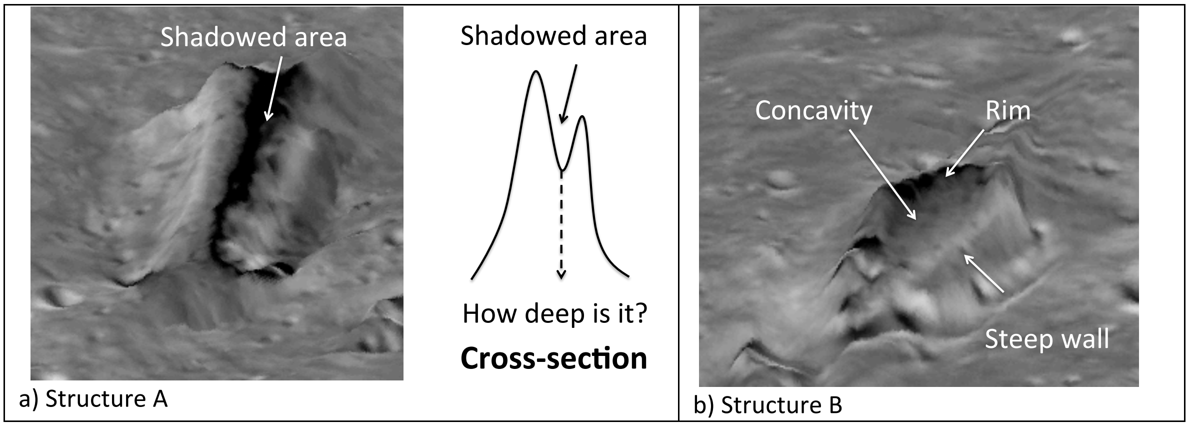


Fig. 6 Details of 3D renderings in 40° elevation angle northeast view

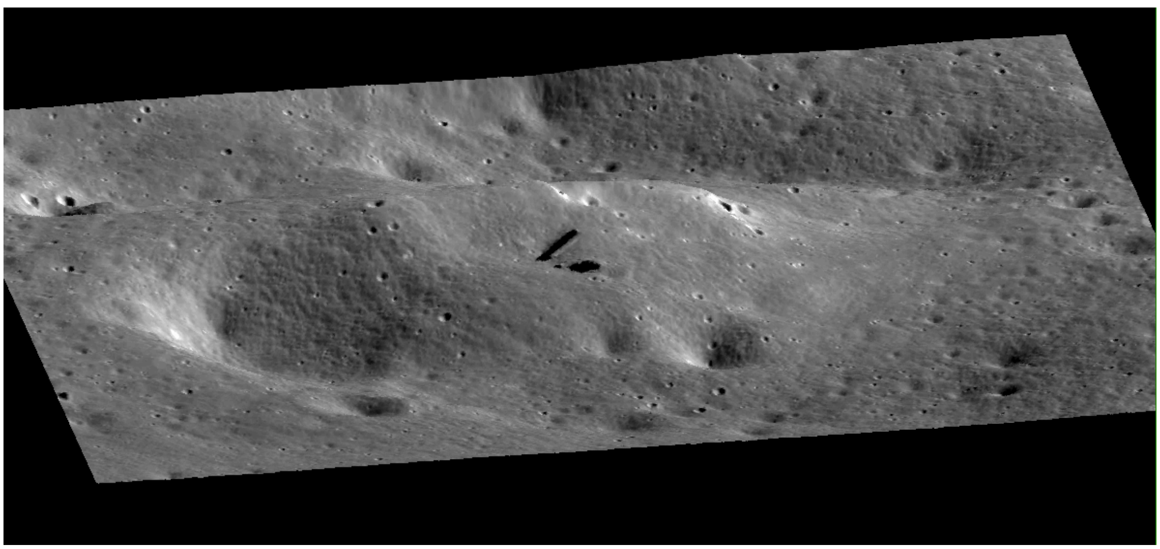


Fig. 7 Perspective view of surrounding area. Structures A and B are in the middle.

Fig. 8 Bingham Canyon Mine, Utah, USA (Image courtesy Michael Lynch)[13]

[13] http://whenonearth.net/awe-inspiring-aerial-images-worlds-mega-mines/