Room like shapes with free standing walls

Undergraduate science student, University of Queensland, Brisbane, Australia, 4000,
Gregory.orme@uqconnect.edu.au

Abstract

Amazonis Planitia on Mars has many pits of unusual shapes, concentrated in an area west of Olympus Mons. They have approximately the same area, with a similar depth and with the same kinds of walls around their edges. These walls appear to have gaps in them such as where a door or entrance would appear. This area is near the Square Mesa formations; the walls surrounding these pits may have used similar construction methods as these mesa formations. The proposed hypothesis is that these were the lower part of former buildings, some hills nearby may still have the roofs on them. They would most likely have been mud roofs or materials that could have crumbled into soil filling part of these depressions. This would account for unusual hill shapes nearby, some appear to have partially collapsing exteriors.

Keywords

Square Mesa, pits, Amazonis Planitia, Acidalia Planitia, lacustrine, paleosea, polar wander, hollow hills.

Introduction

Mars is known to have undergone polar wander in the past. In Orme and Ness (2011) a proposed cause of this polar wander was the Argyre meteor impact. There are two hypotheses proposed that are associated with this impact, one is that it was deliberately caused as part of a terraforming project. The proposed explanation of possible artifacts on Mars is that someone visited Mars around 3.7 Ga, probably with the aim of terraforming it and seeding it with life. They would have done this using oblique meteor impacts directing shock waves at the poles. This would melt the ice at the poles creating seas, also increasing the air pressure by sublimating frozen gases at the poles. Additionally, volcanic outgassing created by these impacts would have thickened the atmosphere. The second proposed hypothesis is this impact, or several impacts, happened by chance. There is little difference between the two hypotheses other than life on Mars would have been seeded in the first case, and evolved by itself in the second case.

In both scenarios, whether sentient life was seeded or it evolved on Mars, as the planet cooled this life would have died out hundreds of millions or even billions of years ago. All that remains so far are enigmatic formations discovered in images from NASA's orbital cameras. This artificiality hypothesis was first put forward with the discovery of the Cydonia Face by the Viking orbiter, then with the Mars Orbital Camera other possible artifacts such as Nefertiti and the Crowned Face were discovered. More of this is explained in Orme and Ness (2011). With an increasing number of these discoveries a more complete model is forming as several interlocking hypotheses. Four of these sites of possible artifacts form a great circle like an ancient equator, this corresponds to a pole close to one proposed by Schultz and Lutz-Garitan (1982) west of Hellas Crater. An important part of this model is where these hypothetical creatures lived, whether there is any evidence of buildings.

Natural explanations, the null hypothesis

Jones et al. (2012) discuss how a pingo is a perennial frost mound, it has a core of ice formed by an injection of water. It is covered with soil, on Earth or Mars it could also be covered with plants. They form by the injection of water into near-surface permafrost which then freezes. Because ice expands by about 9% in volume this forms an ice core which pushes up the overlying sediments. More water may rise under the pingos and freeze, this can cause them to grow. This can then result in a hill with a similar shape to the formations discussed here. There are hydrostatic (closed-system) and hydraulic (open-system) modes of formation. The hydrostatic pingos tend to form in drained lake basins, this may have been water runoff from Olympus Mons as shown by outflow channels directed at these formations. Hydraulic pingos form in discontinuous permafrost, the water source can be a sub-permafrost aquifer. These pingo types commonly occur in areas with topographic relief, such as lower hillslopes, alluvial fans, and fluvial valleys.

It is intended here to differentiate these formations from pingos, as they are the closest form of natural geological formation to them. However, they would also be ideal to be altered for habitation, they would either have an empty core after the ice melted or this could be drained away by exposing part of it to the atmosphere. Also a collapsed pingo could be used far more easily than building a habitable enclosure from scratch. It would also explain why these possible buildings are similar to natural formations, the differences between them would mainly be found by looking at parts of their surface. This also gives a way to falsify the artificiality hypothesis, if there are parts of these formations different enough from pingos then that would indicate some parts of them are artificial. With the other possible artifact sites it makes sense for dwellings to exist, the prediction here is that they will appear more artificial when these areas are reimaged by HiRise. So far they are mainly imaged by CTX which is the low resolution part of the HiRise orbiter. Each formation then can be falsified if they appear more natural when reimaged. There are hundreds of these formations so their all appearing artificial by random chance should be very unlikely.

Figure 1 shows some pingos in Canada, they show a settling on the surface which is similar to some of the Martian formations discussed here. This occurs when the ice core is melting and the sediments above begin to settle downwards. The ice lens inside can ablate or melt, this creates a hollow area that the upper surface can subside into or collapse completely.

Figure 1. Pingos near Tuktoyaktuk, Northwest Territories, Canada.

Figure 2 shows a melting and collapsing pingo, the polygons on its surface are similar to on some of these Martian formations.

Figure 2. A melting pingo in Pingo National Landmark

Figure 3 shows an overhead view of the most distant pingo in Figure 1.

Figure 3. A pingo at Tuktoyaktuk

Figure 4 shows palsas, these are low, often oval, frost heaves occurring in polar and subpolar climates containing permanently frozen ice lenses. Palsas, like pingos, consist of an ice core with overlying soil, they may develop from ground water without additional hydrostatic pressure and so are flatter. Some of the formations discussed here are flatter like this. However they generally have a highly irregular shape which differentiates them from palsas and pingos.

Figure 4. Palsas.

Figure 5 shows how unfrozen saturated sands can lead to pingo creation, the water rises and freezes. This expands about 9% in volume giving the pingo a dome shape. Because this ice tends to form a rounded shape it is much less likely to have angular corners like many of these Martian formations. Figures 3 and 4 are both round, it indicates this shape is a property of an ice lens.

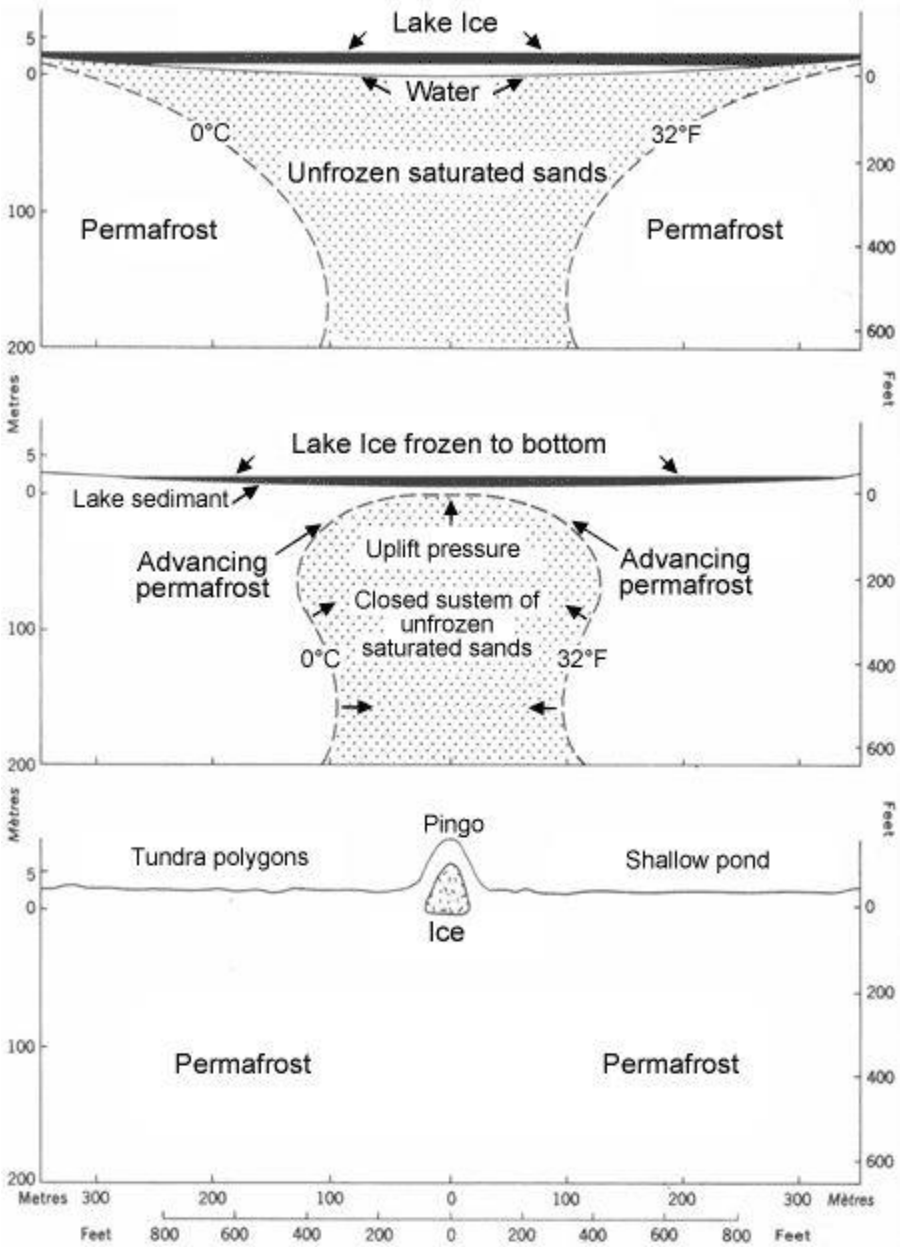

Figure 5. Pingo formation. From natural resources canada.

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Figure 6 is another example of this, the pingo can collapse forming a pingo scar. The ice lens ablates or melts, the sediments on its surface crumble into the cavity forming a depression with wall like shapes around it. These walls however tend to be rounded in pingos and palsas while the Martian formations are not. This represents a problem for the natural or null hypothesis because the collapse of a pingo should still have the rounded shape as its scar.

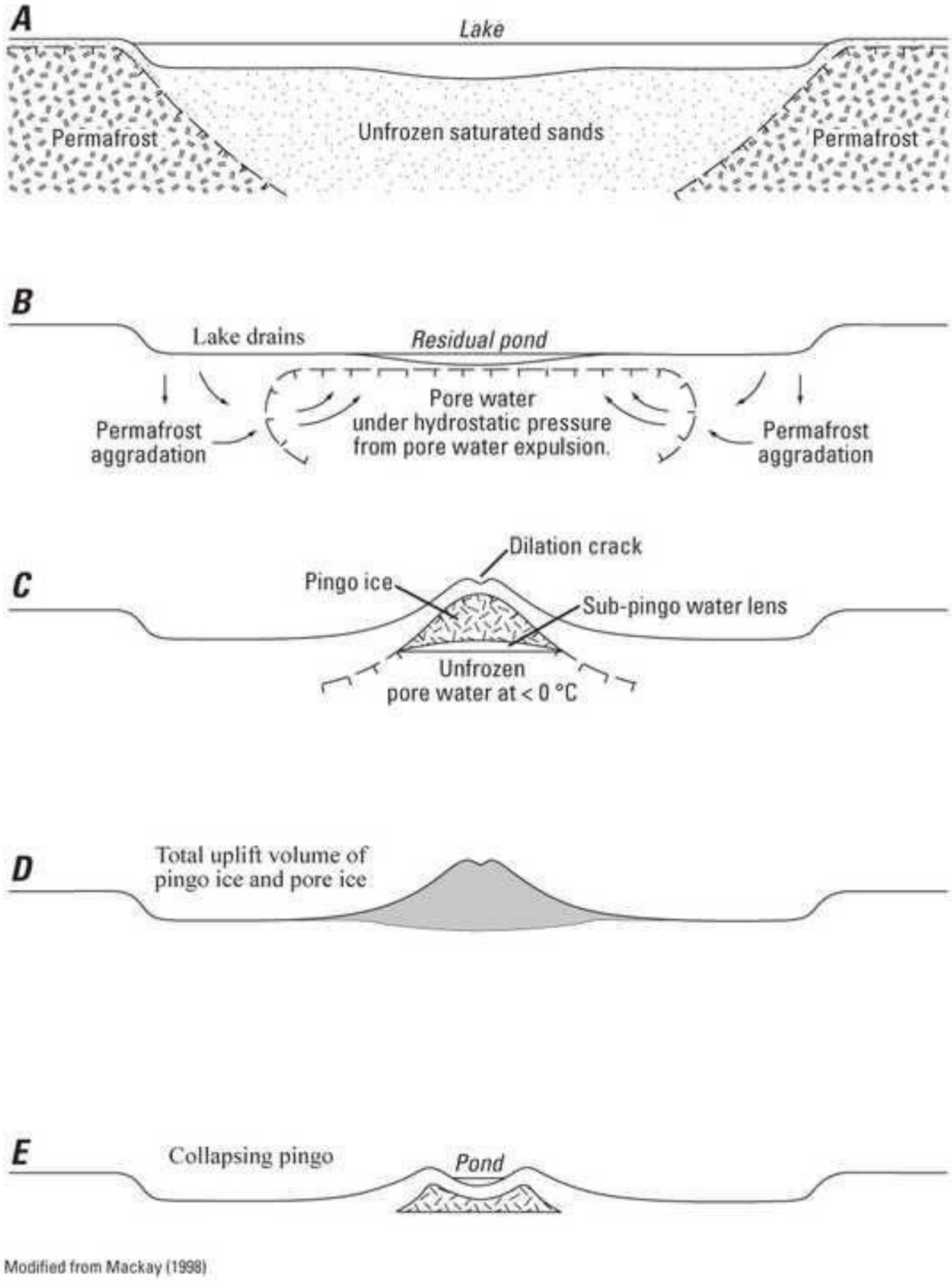

Figure 6. An illustration of collapsing pingos, from the USGS.

Figure 7 shows a collapsing Earth pingo, sometimes the ice core can become sealed inside and it does not collapse into a scar. The null hypothesis implies some of these Martian formations could retain this ice lens even now. Polygons are also a common features of pingos on Earth, however the Martian formations show no polygons but in some cases irregular rock fragments on their surfaces.

Figure 7. Collapsing pingo.

Vasil'chuk et al. (2016) have an example in their Figure 2 of a collapsed center of a pingo similar to some of the Martian formations examined here. They discuss how there are approximately 1600 pingos in Western Siberia, so they can also form in large numbers like these formations. Pingos can be tens of meters high, on Mars they may be higher because of the lower gravity. It is possible then for there to be large numbers of pingos in a small area, like this part of Amazonis Planitia examined here.

Mouginis-Mark and Wilson (2016) discuss the Galaxias Quadrangle on Mars, 33.0–35.5 N, 216.0–218.0 W, this is a similar distance from the Elysium Highlands to the Martian formations examined here. It is part of the artificiality hypothesis that some areas were habitable because of being near volcanoes, these would have kept some of the paleoseas liquid. A ring of possible settlements around Elysium Mons have been proposed as well as the subject of this paper. There are so many a population in the millions is conceivable, however it is more difficult to falsify the natural explanations for them. This paper then concentrates on looking at the differences between them and known natural formations, to try to falsify this null hypothesis. Because they are highly eroded they tend to become more natural looking over time, particularly if they are modified pingos and palsas originally.

Hrad Vallis according to the authors could have been covered by an ice sheet, this could have been related to a possible former pole in this area. In Orme and Ness (2011) it was proposed a shallow impact created the Argyre Crater and Tharsis Montes. Because there was a pole there this caused the polar ice to melt creating Northern seas. Opposite this was another pole, antipodal volcanism or a second shallow impact may have caused the rise of the 3 Elysium Highlands volcanoes: Elysium Mons, Hecates Tholus, and Albor Tholus. This ice sheet referred to by Mouginis-Mark and Wilson (2016) may be this former pole. The authors ask where this ice sheet came from, considering this as unknown.

Near Galaxia Mons the authors discuss enigmatic domes (their words) that are 20–25 m high and <1 km in diameter, they are similar to the possibly artificial formations discussed in this paper. The authors do not propose any artificial hypothesis, nor do any of the other references in this paper suggest artificial processes. The authors propose these enigmatic domes are pingos and collapsed pingos. These would have collapsed forming pingo scars, they are a similar shape to the pits with surrounding walls discussed in this paper. However the possibly artificial formations in Amazonis Planitia are much more irregularly shaped than these circular domes shown in Figure 7.

These pingos according to them would have collapsed when the ice sheet receded. This might then be either when the polar ice melted with the Argyre impact, or when Mars cooled and the ice sublimated to the poles. Figure 7 shows these domes at 35° 060 N, 142° 310 W, distant from the 3 Elysium Highlands volcanoes but perhaps receiving heated sea or Artesian water from them. This area then may also have been habitable, there are unusual formations in this area similar to the possibly artificial ones discussed in this paper. It may then be another population center according to the artificiality hypothesis. These domes show signs of collapse which can be explained from the loss of the ice core in the pingos. More problematic are the ridges which appear to bisect the pits, these may have been built to support the roofs as these were rebuilt. An ice core should not form a central ridge like this. The ice lens in a pingo forms from freezing water, just as a freezing lake should not form walls in it the ice here should remain a single piece. The authors do not identify the process that formed these domes with any certainty.

Figure 7. Enigmatic domes in Galaxia Mons

Harris and Ross (2007) discuss how a pingo on Earth can have a diameter of up to 250 meters, this would be expected to be larger on Mars with lower gravity. They also show a collapsed closed system pingo in their Figure 2, this can be compared to the possibly artificial walled pits examined in this paper. This example of theirs is much more rounded and circular compared to them.

Their Figure 3 shows how pingos can form and collapse into these pingo scars like these walled pits. As their diagram shows, the ice core should tend to form a single piece not be broken up into separate walled segments. The pingos form generally from circular or elliptical taliks of unfrozen water, the formations on Mars are often of very different shapes to Earth taliks. The authors also discuss how pingo degradation is accompanied by the development of radial dilation cracks, this occurs through the bending and extension of the frozen overburden as the pingos grow. These cracks do not appear to occur on these Martian formations, one hypothesis is that the pingo surfaces have been repaired by mud or cement filling in any cracks. This is a logical solution if the environment was habitable, a large hill with a hollow core would be much easier to patch than building from scratch.

A summit crater can form exposing the ice core and causing it to melt sometimes forming a lake, this can explain some of the deformations on the top of these possibly artificial formations. Thermal erosion of the surrounding frozen ridge causes the lake to expand with intermittent breaching of the central pond, resulting in drainage outflow. There does not appear to be signs of these outflow channels or of lakes forming next to these possibly artificial formations. However north of them there are some similar formations with this ponding, it may be that this area was warmer. These are not examined in this paper. This could be explained by the ice sublimating if the air pressure had fallen below the triple point of water. This is where ice vaporizes into a gas without a liquid phase. However this area has been proposed to have a long lived paleosea of up to a billion years. Ponding and outflow channels should then have occurred with at least some of these formations if they are natural. Complete thaw of the ice core can leave a pond, similar to the pits described here, surrounded by a ridge of sediment that accumulated around the base of the former pingo from mass movements. The collapse of the pingo could then form these walls around the central pit similar to the formations examined here. Because these pingos are rounded it would be expected the ridge of sediment would also have this rounded shape. However the Martian formations have wall shapes of even height and width following highly angular and unusual shapes. The material from the collapsed pingo then is not seen, the walls are apparently vertical, it may have been artificially moved or fell into the pingo scar.

Soare et al. (2013) discuss how closed-system pingos on Mars would indicate ponded water at these sites, a freeze thaw cycle, and also the temperature and pressure would have to be above the triple point of water. Their Figure 2h is a good example of a pingo scar with slump material, similar to some of the Martian formations described in this paper. However, these are much less random looking in appearance than the Earth examples.

Page and Murray (2016) discuss hundreds of pitted debris cones in Elysium Planitia, these are similar to some of the walled pits hypothesized to be artificial. They are presumed to be explosive, forming from an interaction of molten lava with near surface ground ice. This would be a different hypothesis to pingo scars. They also discuss how these would be difficult to distinguish from pingos remotely. Figure 8 shows examples of these, some of the walled shapes appear to go around several cones. This could indicate according to the authors that some pingos reformed in the debris of older ones. The artificiality hypothesis here would be that these had a roof on them that disappeared over time. 4L is an example of how this roof may have cracked and disintegrated leaving the walled enclosures. If pingos were close together then they may have been combined artificially into a larger hollow dwelling, in some cases there appears to be corridors connecting the hills shown later.

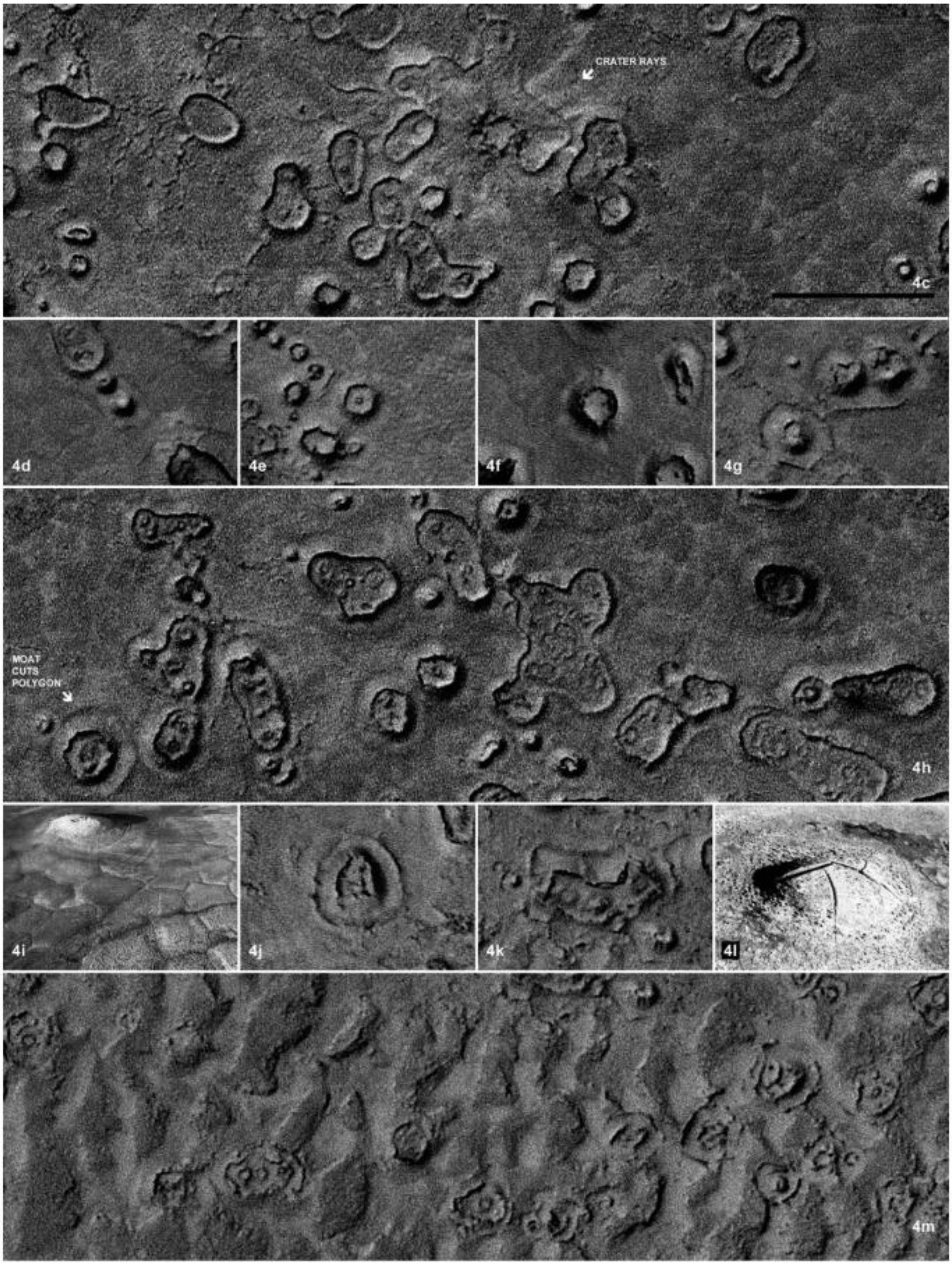

Figure 8. Pitted debris cones similar to the walled pits

Page and Murray (2016) also suggest that the lava-ice mechanism is just one explanation, that they may also be pingo scars. They say that before pingos rupture they do not have summit depressions, 4I in Figure 8 is an Arctic pingo on Earth. These formations do not have summit craters which makes the volcanic origin less likely. Pingos tend to have cracks that propagate downwards from their summits, as will be seen later these cracks are not found in the possibly artificial structures described here. Some of the shapes can be controlled by polygons as in 4E, giving a 6 sided shape. However, this is not seen around the possibly artificial formations discussed here nor are any polygons visible on the flat ground around them. Some of the pitted cones in Figure 8 are surrounded by depressions as are seen around Earth pingos, this occurs from the episodic growing and melting of the ice cores. When the ice core is uncovered this leads to the pingo decaying, then the ice is lost by ablation.

Burr et al. (2005) discuss similar formations in Athabasca Vallis, near 10◦ N, 204◦ W. They also interpret these formations to come from near-surface ground ice. These are suggested to be pingos, collapsing pingos, pingo scars, and thermal contraction polygons. The ground ice that could have formed the mounds and rimmed features may have come from the deposition of saturated sediment during flooding; an alternative is magmatically cycled groundwater. Some pingo ice may still remain inside these features, the authors suggest they may contain evidence of a former biosphere. Figure 9 shows these formations, similar to Figure 8. B shows a cavity like a degrading pingo, however as will be seen this is different to the possibly artificial formations discussed in this paper. C is problematic in that the wall seems to cross over itself like a piece of string, it is difficult to see how an ice core could create this structure. The surface of a degrading pingo tends to form a depression that may pulsate, eventually this later forms cavities similar to Figure 9. Figure 7 shows a collapsing pingo on Earth, similar to some features in Figure 9. Figure 6 shows the interior ice core of a pingo, being formed from water this should not been forming interior wall shapes. This area may also have artificial formations, it could then be another large-scale settlement. This area is not examined for artificial structures in this paper, but will be in a proposed future paper.

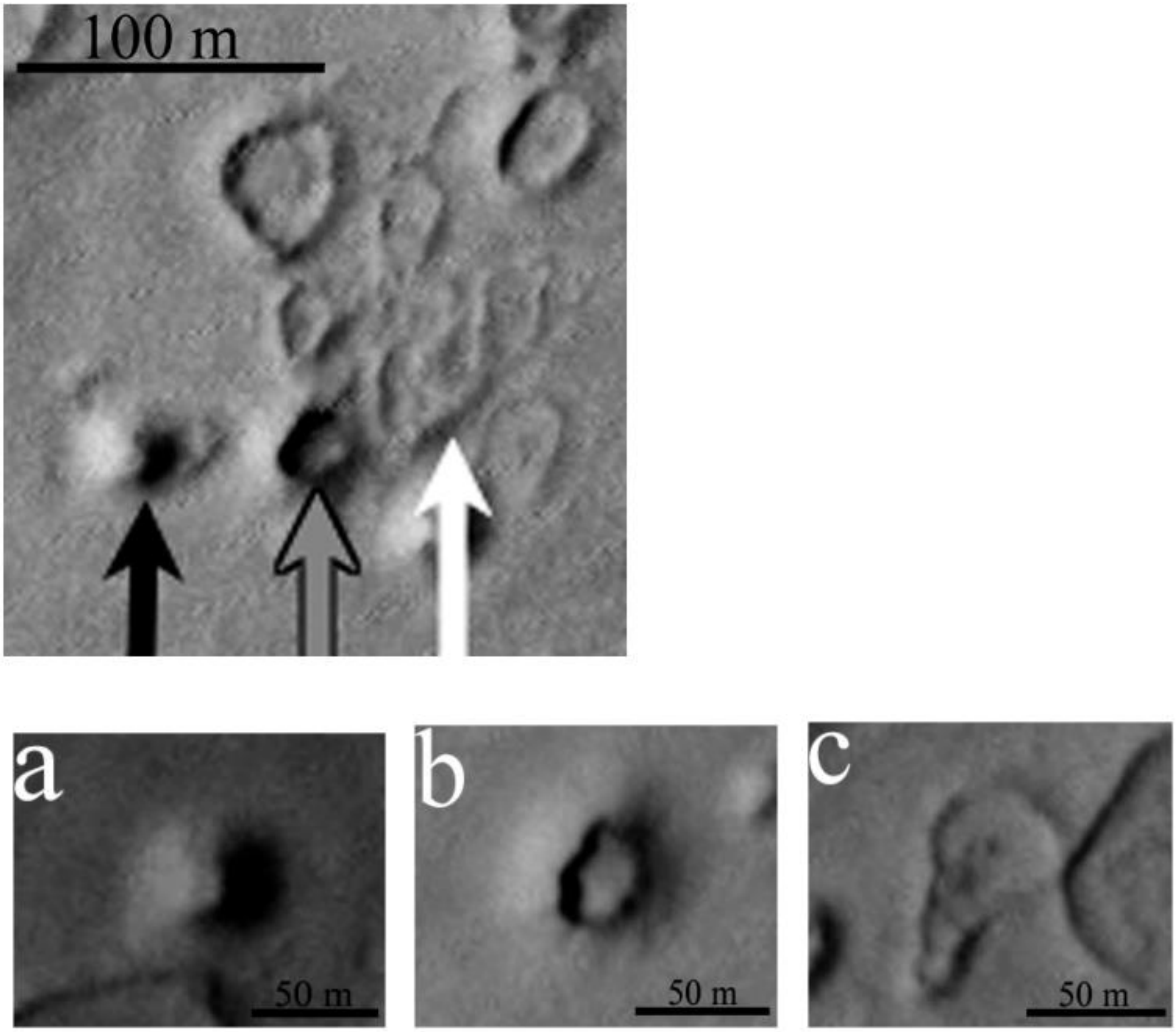

Figure 9. Walled shapes

Possibly artificial formations

The next section discusses formations extending from 34-43° North and from 141-142° West. The previous section will be referred to so as to differentiate them from pingos, and to falsify the natural or null hypothesis. This area appears to have received water from Olympus Mons according to the outflow channels there, perhaps this was another source of heat for an inhabited area. They would appear to have been on the edge of the proposed paleosea. Figure 10 shows pins on Google Mars that were selected as unusual formations. This was done without looking at the elevation map, they turned out to be on the edge of this proposed paleosea. The red area to the right is Olympus Mons. These question marks and other names shown here represent predictions that they will appear more artificial when reimaged by HiRise. Because there are so many predictions the odds of this occurring by chance would be very remote.

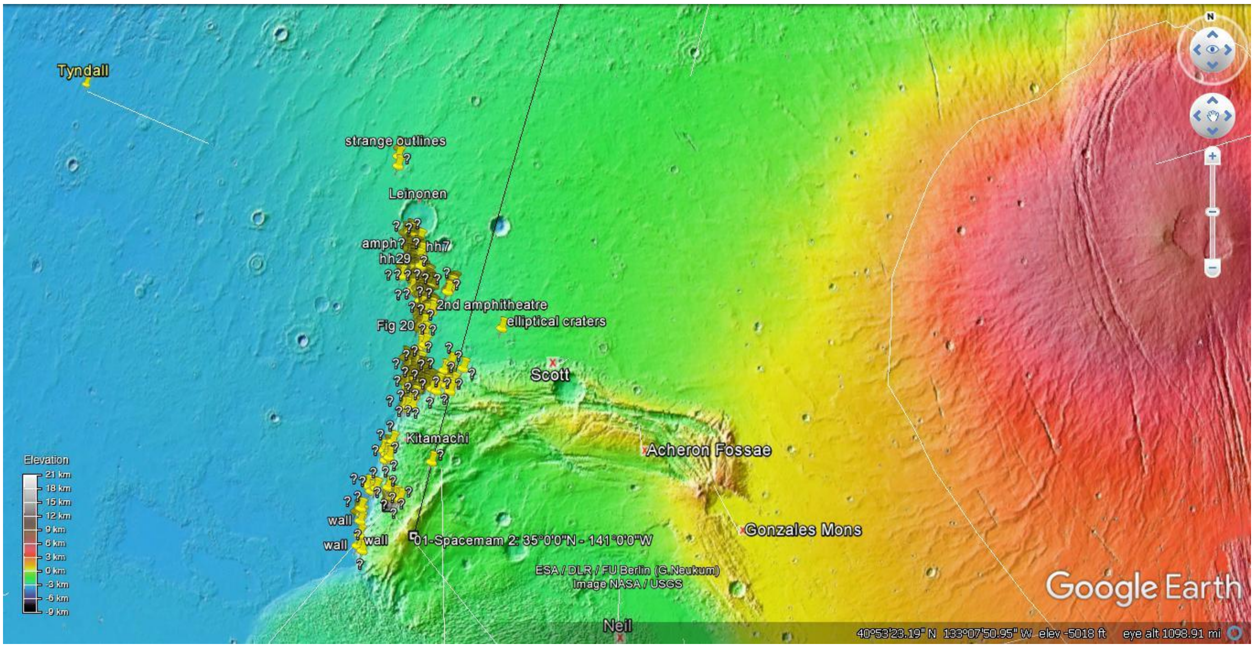

Figure 10. The extent of the possibly artificial formations

Three rooms

In Figure 11 a house like shape is shown, it has 3 room shapes with each having an entrance at ground level. It has a larger main like entrance on the upper right. This could be used like a dwelling today by putting a dome over the walls. Some of the hills nearby may have retained a mud or cement dome over these kinds of depressions. It can also be a kind of pingo scar, the modified pingo may have collapsed leaving some of the artificial supports as these walls. These appear different to those shown in Figures 8 and 9, instead of an ice lens forming one rounded shape here it would have to form 3 with almost straight walls between them. Whether this is possible for an ice lens then is an important factor in falsifying the null hypothesis.

This could also have been adapted from a pingo scar, the walls would have been reformed on the edges and then the interior walls created. A roof might have been made of vegetation or mud, then have collapsed and disappeared. The processes in Figures 5 and 6 could then have caused the pingo roof to collapse leaving the formation in Figure 11. However, the shape is not rounded at all unlike pingos in general so this shape tends to falsify the null hypothesis.

Many similar walled shapes are in Figure 8, however all appear to be rounded without these straighter sides, and none seem to have these interior wall like ridges. These are also not related to typical polygonal shapes, also polygons are cracks while these are ridges. This then tends to falsify the pingo geological explanation. In Figure 7 the top right formation appears to be a collapsed dome with a similar interior wall like ridge. These may then also have been braced to prevent collapse. Figures 2 and 3 show Earth pingos, these are developing cracks and polygons prior to collapse. This formation does not connect to other polygons like in Figure 3. If this was then formed with polygons then the others would have to disappear by some mechanism.

Figure 11. Three room like partitions.

Figure 12 shows the house like formation in Figure 11, the hills to its right have unusual summits on highly unusual shapes for pingos. They may then be hollow as buildings that did not collapse. The central part of the hill appears to be a different lighter material, the darker areas around it may have been built up. Alternatively, the summits may have been patched if these were collapsing pingos, the depressions in the summit show no signs of cracks or polygons associated with their deformation. If this is hollow then it is likely to remain intact, if artificial then it may hold clues of this proposed extinct civilization. They have no real resemblance to Figures 2,3, 4, and 7.

In the hill to the right some parts seem to have subsided showing a T shaped ridge at A. This is like the interior walls in the depression, it implies they are related formations. This dome then may be in the process of collapsing or has been patched with interior walls. If it is collapsing, then the sediment may eventually degrade and fill up the remaining scar like the 3 roomed depression. For example, if the roof was made of mud, as is used for construction in some parts of Earth, then when it collapsed it could completely disintegrate into soil. When the paleoseas sublimated, and moved to the poles, these roofs might have experienced severe storms that broke them up into mud leaving the walled depressions. The flat floor in these depressions could be from the roof where it dissolved into mud then solidified. These hills are similar to the Earth pingos in Figures 3, 4, and 7 but in each case as if the degraded surface was patched. There is an impression of a darker skin that surrounded the summits coming to an unusual point shape at B, this exposes a different lighter material underneath it further towards the summit. C and D also show the unusual shape of the whole formation, the two hills almost form a S shape. The Earth pingo examples have nothing like this difference in albedo, how two dissimilar layers could form like this is unknown and may falsify the null hypothesis. The depressions are quite deep in the roof on the bottom right at E, however this has not left a hole. If the depression is a natural pingo scar then it is unlikely this hill would have subsided without leaving a cavity.

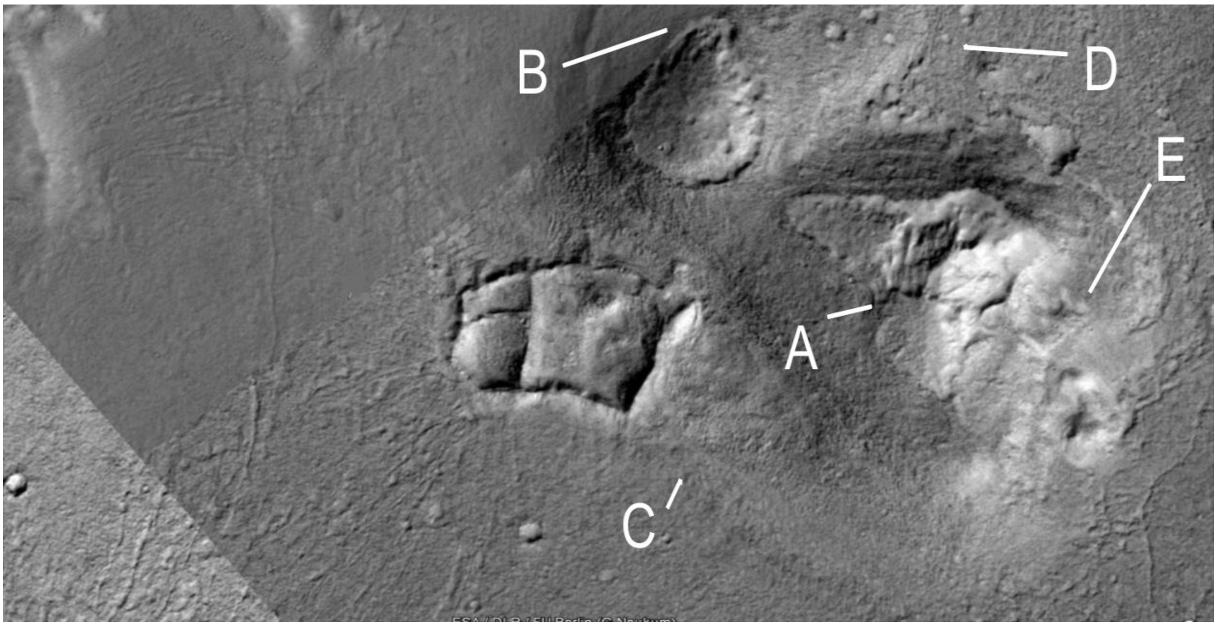

Figure 12. An overview of the area

Two rooms

Figure 13 shows a similar house like shape at A with more wavy sides, these arcs can make walls stronger. There is a central wall to hold up the possible former roof. This appears to be different to a pingo scar because of its unusual shape, the walls are of approximately constant height and width not like debris. The shape is rounded in some parts but is straight on the base, this is not circular like a typical pingo. The central wall is also problematic for how an ice lens would form the shape of the pingo scar.

The other hills at B and D also show ridges along them similar to the ridge in the depression, this could be where subsidence is causing the central walls to become visible. The hill to the upper right has a squarish shape at B on it like walls showing through. It is the most similar to a circular pingo shape such as in Figures 2 and 3. Just above this depression at C could be another one filled completely with soil, this is also not a natural pingo scar shape. The hill to the left appears to have a curved wall at D showing through on its upper surface. Figures 8 and 9 also showed walled depressions that may be natural, but they are very rounded like an ice lens might be expected to make. The hills B and D have depressions on their surfaces like in the Earth pingo in Figure 2, but the settling is not accompanied by visible cracks like it has been patched.

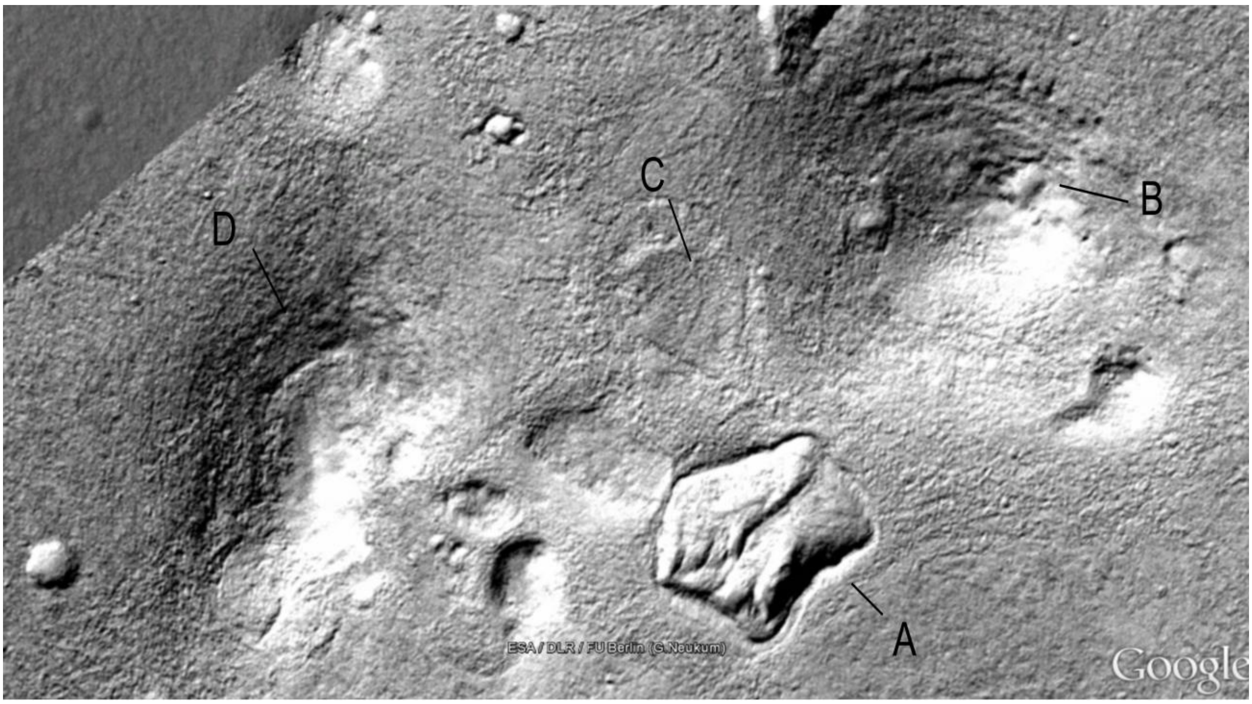

Figure 13. A Hollow with wavy sides and collapsing hills.

Heart shaped depression

Figure 14 shows a heart shaped formation with the same kind of walls, also with an entrance at the bottom. The hill on the right also shows signs of subsidence like a pingo, but with no cracks and no central area where an ice lens would be degrading. The ground inside this depression appears to be very similar to that outside it, perhaps this was a completely constructed wall rather than a walled depression. This is again very different to the shapes in Figures 8 and 9, the usually rounded ice core is unlikely to form this sharp vertex of the heart shape.

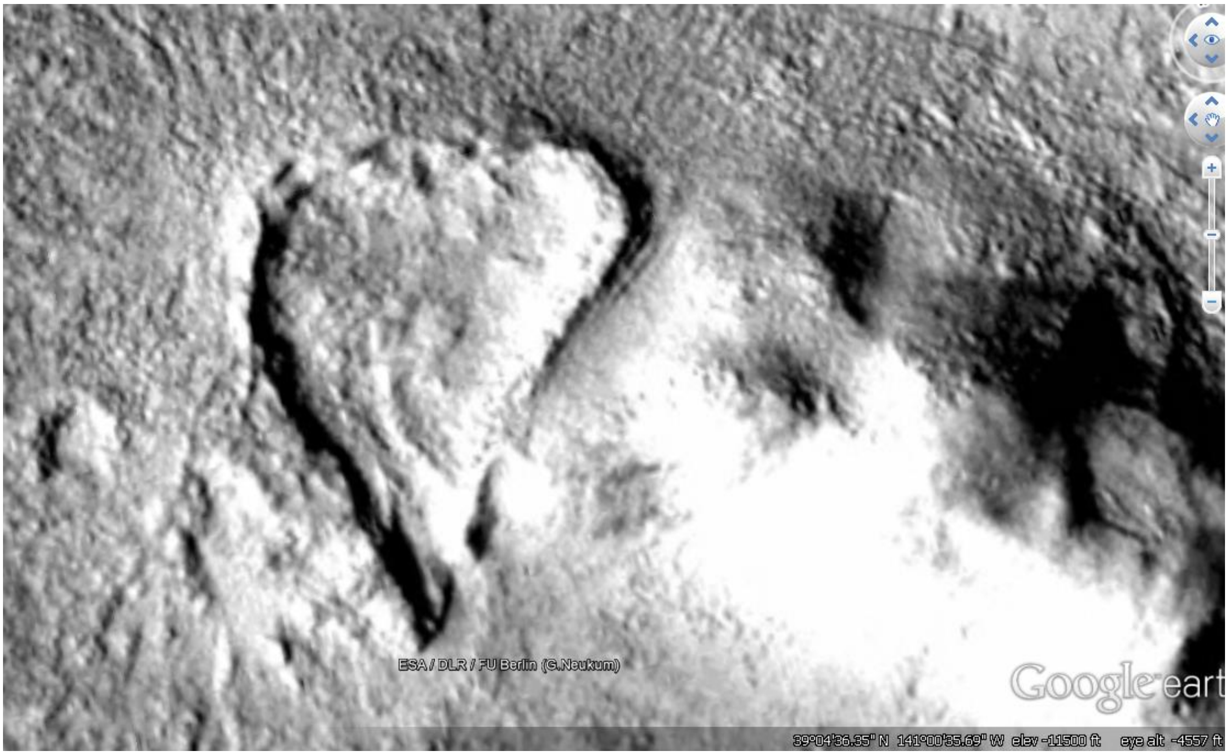

Figure 14. A heart shaped hollow.

A single room

Figure 15 shows another kind of shape with the same walls at A, each wall has about the same height and thickness. The heart shaped depression is at B, the same kind of process such as a growing ice core, would have to create these two different shapes. The hill at C is the one in Figure 14, the other hill has a similar shape but here the depressions appear to have collapsed at De, E, and F. This is then not a pingo as ice cores are rounded and circular not shaped like corridors. It looks then like separate hills were bridged with some kind of covering, such as mud or cement. This is perhaps degrading in Figure 14 but collapsed in Figure 15. Some natural process would otherwise have to create these hollow shapes between hills, which appears to be unknown in geology.

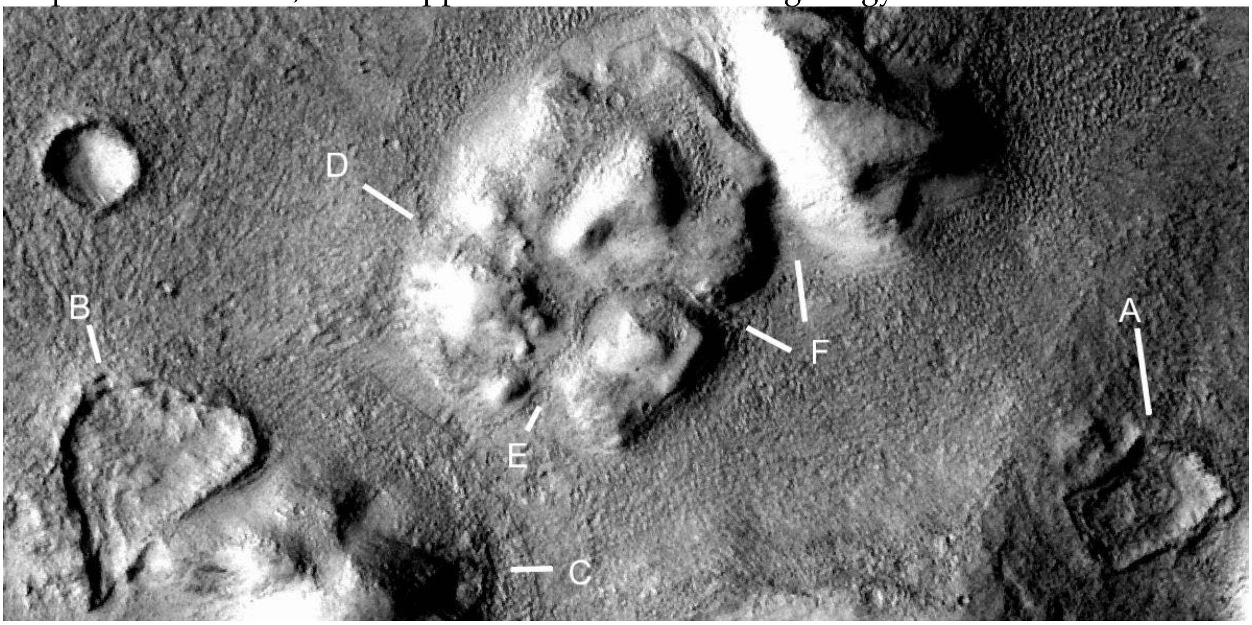

Figure 15. Curved walls and an entrance.

Figure 16 is an example of some Kaarst lakes or pingo scars in the Mackenzie Delta Canada. As shown these can have angular shapes like in Figure 15. Figures 3 and 4 are also surrounded by lakes, these can form from water leaking out of a pingo as it degrades. A lake generally would not have these walls, and a pingo tends to be round not with these angled corners. Some of these depressions could then be lakes, but something then would have to form these regular walls around them. If artificial they may have been designed to hold water, but then the entrances are problematic unless they are from erosion.

Figure 16. Lakes in the Mackenzie Delta, Canada from Google Maps.

Varied shaped depressions

Figure 17 shows many more like this, different shapes with the same kinds of raised walls. Each is not rounded in shape like a pingo scar. They might be Kaarst lakes or turloughs, but they would be typically formed by springs underneath them filling them with water. If so then how the walls formed around them remains problematic, tending to falsify this natural explanation. There may be an entrance to the structure through this gap, perhaps there was a gate there and this was to keep some animals inside. This would be a logical reason to build a wall around a pit like this on Earth, lower parts of the enclosure may have accumulated water. Walls like this have been built around farms and animal enclosures on Earth.

The hill in the bottom left has a wall like ridge on its surface, perhaps showing signs of collapsing. A shows another pit with an entrance, also with regular walls around it. B shows an irregular pit shape with walls, the mound may have been a support for the mud dome. C also has walls and an entrance as do D and E. Figure 6 shows how these should form if they were pingo scars, but again they have straighter sides than the formation in Figures 8 and 9. The hill between B and D has a depression around it similar to that formed by water leaking out of a pingo. There are no visible polygons that would fit into these angular pit shapes. B has a mound inside it similar to proposed pingos Figure 8, but this is on the edge of the shape.

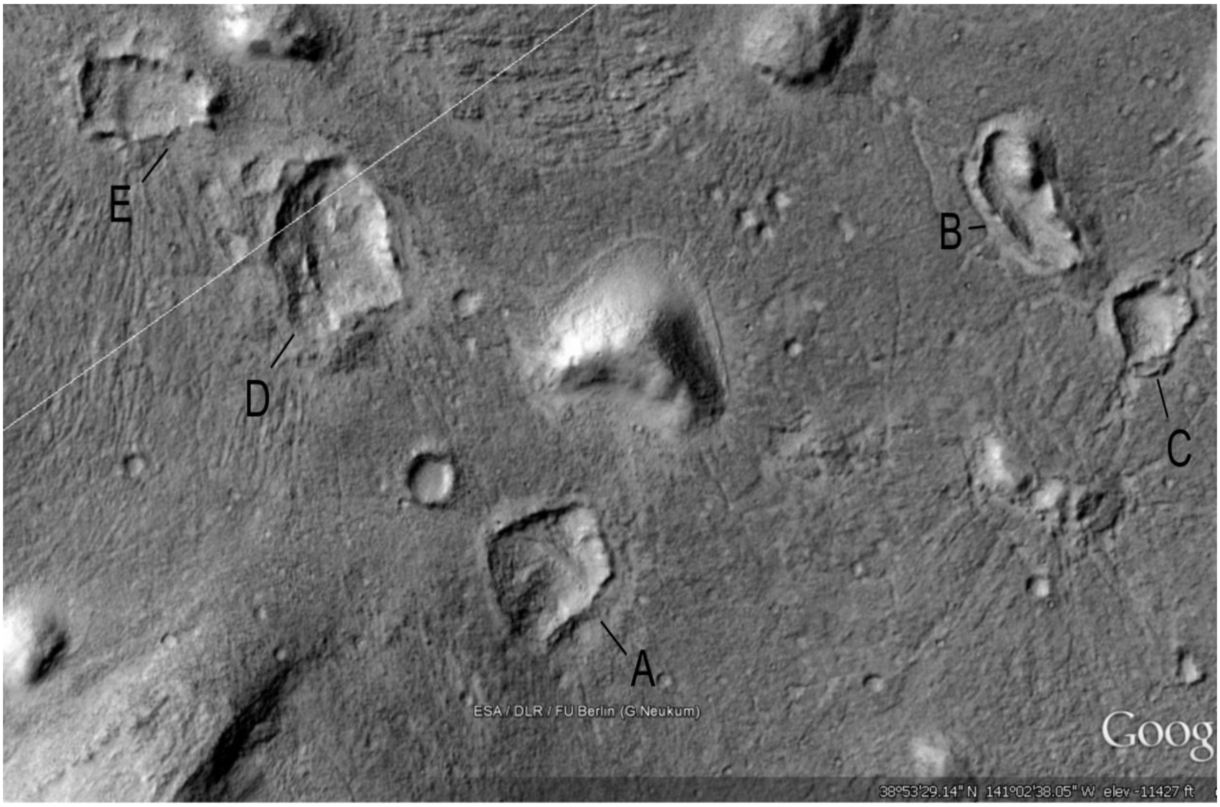

Figure 17. Multiple hollows.

A central mound for support

Figure 18 also has angular shaped walls with an entrance, this us unlike a typical rounded pingo shape. These angled walls could have connected to a pingo domes such as in Figure 2, however the internal shape is not likely to have been an ice lens. The central mound could have been a natural formation that acted as a support for the roof, it could also have been a growing pingo. To the right of this central mound there appears to be an attached part of the former roof. If this was a growing pingo inside an old pingo scar then it should not have this part of the old pingo roof connected to it.

The depression may be filled to some degree from this roof material, however as with all these depressions there are no signs of large fragments, polygons, such as in Figure 2, or broken supports for a roof. It's likely then the roof, if there was one, was made of mud or organic materials that could disintegrate. It's unlikely a roof would have collapsed when there was high wind otherwise there would be a pile of this soil, or dunes, on one side of these depressions. Figure 13 does appear to contain some duns, these may be from the roof material. If the ocean was sublimating as Mars cooled then this might still have produced a lot of wind and rain with the atmosphere becoming humid, the rain or the humidity itself might then soften the mud roofs. The rain water might have quickly sublimated again, but it should have taken a long time for the triple point of water to have been passed. Extreme weather then was likely at this time. This formation is similar to some in Figure 8, however it is not a regular polygon shape.

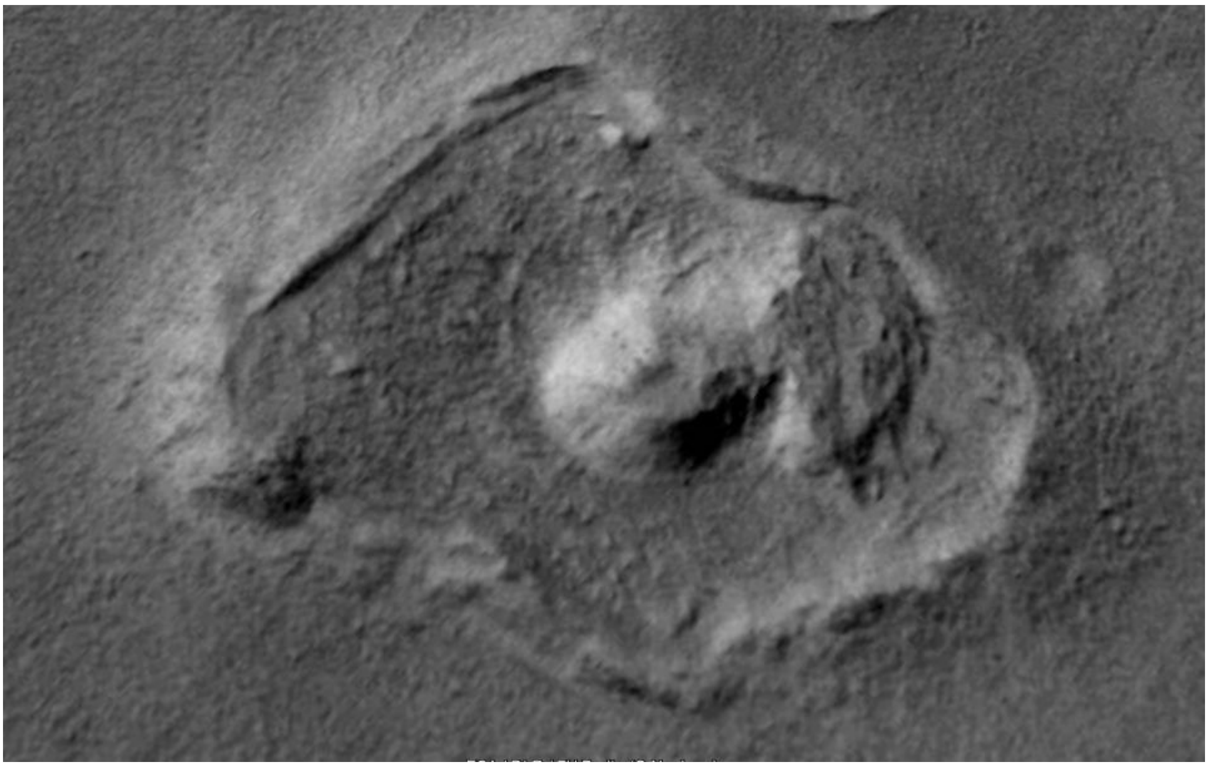

Figure 18. A hollow with a central support.

Single wall supports

Figure 19 shows 3 more, each with straight walls in them as if to hold up a roof. In this area, virtually every depression has this unusual kind of shape with walls and central supports unlike in pingo scars. If Figure 8 were pingos then they are very different from these. The hills all appear to have the same unusual shapes often with wall like ridges showing on their surfaces. This implies either some unknown geological explanation or artificial modifications to natural formations. Further away from this area there are no depressions like this, and hills revert to normal shapes. Figures 11 and 13 have pits with similar interior ridges, there is a strong connection between the outline of these pits and the hills nearby. It implies then that the pits formed from some of these hills or vice versa, but these are not typical pingo shapes such as with Figure 3.

Figure 19. central walls in each depression

A rectangular depression

Figure 20 shows a walled depression that is almost rectangular, it may have been a perfect rectangle but was distorted by uneven weathering of the sides. Outside this wall the ground seems to be increasing in elevation as a slope like in Figure 18, this continued upwards would give a rounded hill shape. It is similar to one of the lakes in Figure 16, however the walls around it imply it is a pingo scar. This is not a polygon shape like some in Figure 8. It may be a pingo was artificially hollowed out inside to a squarish shape, and then it later collapsed to an unusual pingo scar shape.

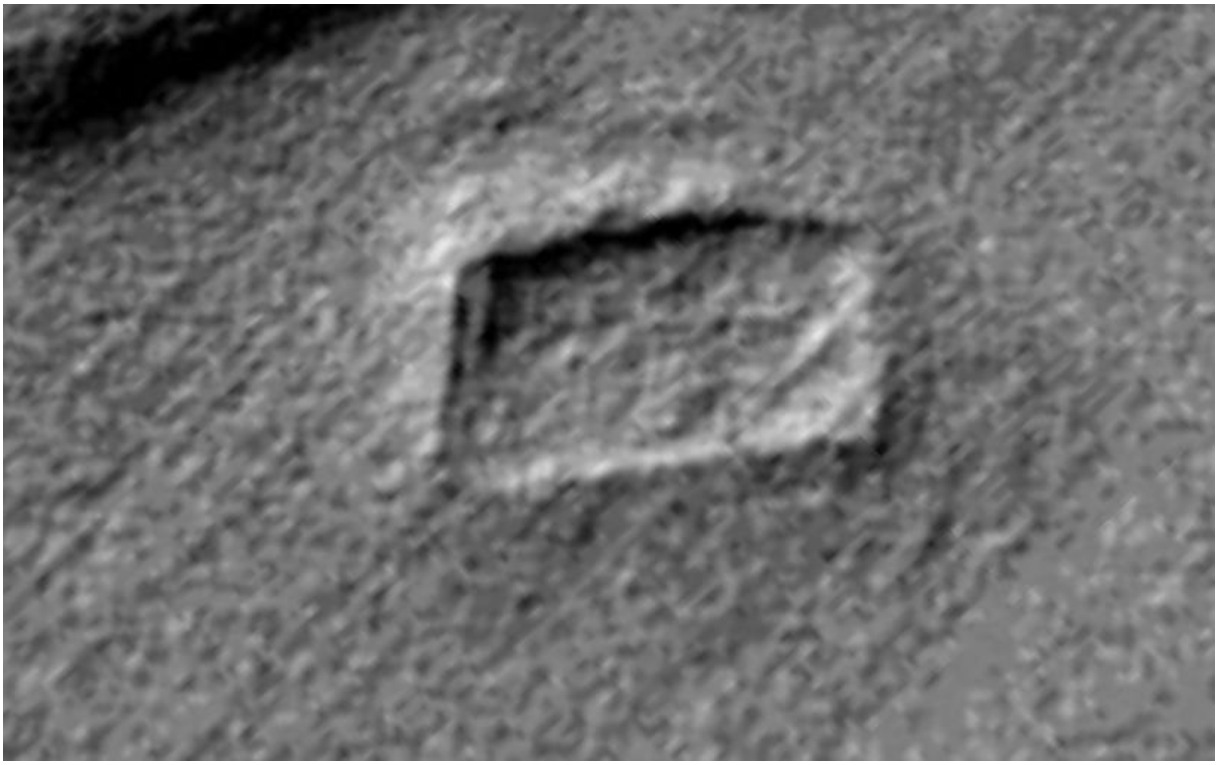

Figure 20. A rectangular hollow with walls.

Layered terrain

Some of the following formations appear to have layers in them. They can be lower on the edges, rising up in concentric circles to a peak. They can have a central plug similar to the degraded pingo in Figure 2 but instead of polygons they have these layered concentric rounded arcs. If artificial this can be based on arches, the rounded shape could be hollow and supported by circles of bricks like a Corbel Dome shown later in this paper.

Image ESP_012729_1830 in Figure 21 shows some hills with layering at A and B, also a layered slope at C. However the layered hills in this paper have some characteristics inconsistent with layers being deposited as sediments. Some appear on a flat surface as in Figure 22, more like the layers inside a tree trunk. Others are lower on the outside as in Figure 21 but not in a consistent way due to gravity laying down sediments.

Figure 21. Layered terrain

A first amphitheater shape and the rectangular hollow

This rectangle in Figure 20 is shown below in Figure 22 at the bottom at A, to the north west of this is another shape with circles on its top at F. This is like a nearby possible artifact referred to as the amphitheater shown in Figure 24, the circular arcs are reminiscent of seats but if artificial they would likely be to strengthen the dome. It is then a friendly name not likely to describe its purpose if artificial, more likely the arcs would be strengthening a hollow area under them. These could then have been collapsing pingos that had their roofs strengthened using arches and domes.

All the hills here have unusual shapes; each could be hollow as described. These circular arcs on the surface could be used for strengthening like with an arch, this could be the typical method of construction which might only show through where an outer skin on the roof is thinning. B shows a plug like shape, as if to seal a depression on the surface like with Figure 3. The plug shape is similar to the center of Figure 2. C is like a pingo with a depressed central section, however this can also be like the skin like outer material peeling away. There are hundreds of examples of this outer skin degrading, usually on the southern side. Sometimes these arcs are exposed, in other cases there is a mottled or fragmented appearance like rock fragments. No signs of polygons like in Figure 2 have been observed so far here.

D then would be like this complete shape, either a natural pingo or one that has been modified. E has some unusual shapes on its lower side, this near vertical edge is harder to explain as a pingo because the ice lens tends to form with shallow sides. G shows another pingo like shape such as in Figure 3 but possibly with the depression sealed with arc like shapes. H shows a rounded depression with a central ridge like the other walled depressions shown here. It is also like the walled pit in Figure 20 but as part of a hill. This supports the hypothesis that these depressions were former hills, but they are not shaped like typical pingo scars.

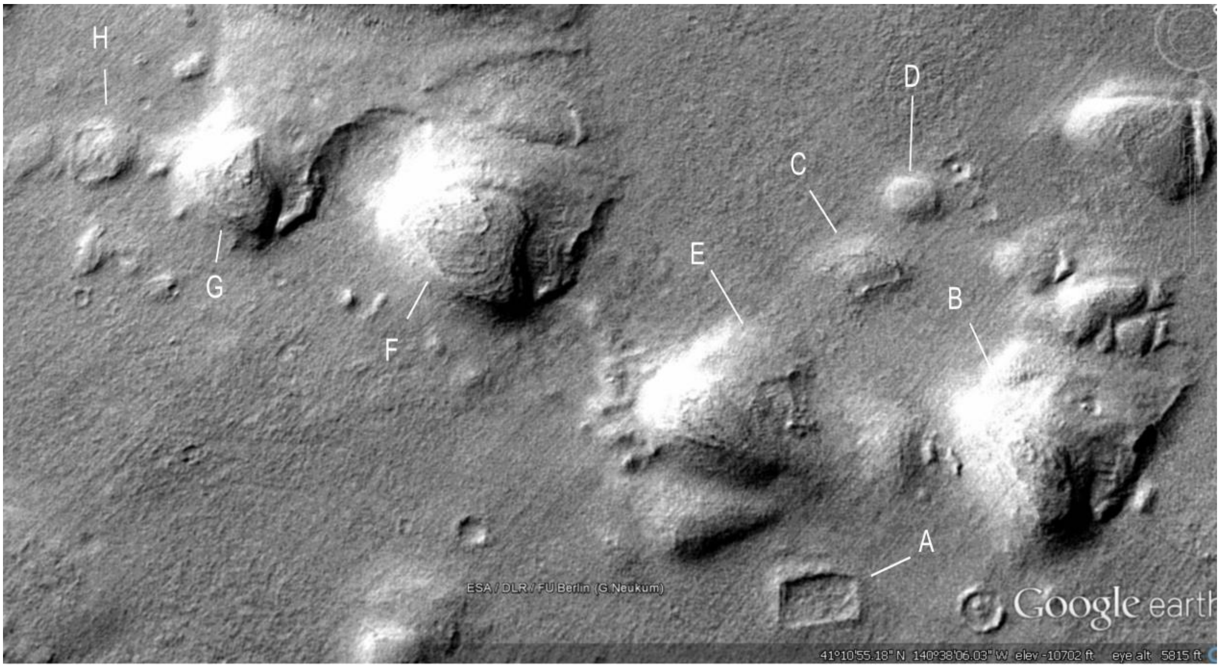

Figure 22. Arcs on the surface of the hill.

A second amphitheater shape

Figure 23 shows another amphitheater shape with circular arcs on its surface, also the top of the left hill looks like how an artificial roof might be attached to the walls. It has a circular dark area on it like the central plug in Figure 2 but without polygons. The roof shape is very different to typical pingoes, it may have an arced shape to give it strength. The leading edge is very straight, the whole structure looks very artificial. A natural explanation for this formation would be difficult to justify.

Figures 2 and 7 are similar to the amphitheater shape on the lower right, it may be these polygons were sealed with cement or mud to act like bricks. Arcs of this shape are not known to be a kind of crack in pingo surfaces. To the upper right of the amphitheater shape may be a collapsed part of the former pingo, if so then this roof would have collapsed without cracking or disintegration. This cannot happen with a pingo because the ice would have to settle and melt, this would tear apart the upper surface. Here though there are no cracks, there are no cracks on any part of these formations with any kind of subsidence. The lower edge of the amphitheater shape is nearly vertical, however an ice lens as with the idea of a lens shape, has a gentle slope on its sides.

Figure 23. Another amphitheater shape.

The original amphitheater

The author discovered all the formations including the amphitheater shapes in this paper, the first one found is shown in Figure 24. So far there are 4 of these with the same arcs on their surface. However, there may be hundreds in this and other areas, too many to show here. It is common enough then for this to not be from random chance or from an illusion in some images.

This formation is also close to Elysium Mons and would have been in the same paleosea. A shows the main amphitheater shape with the circular arcs on its surface. B shows another hill with the arcs on its roof, it has an unusual dumbbell shape with another hill and an artificial looking connection between them. This is unlikely to occur with a pingo, having a bridge of frost upheaving like this. C and D may represent hills that collapsed, perhaps from a flood melting the mud they were made of. Again there are no cracks from this subsidence, even though a hill as large as A may have deflated onto the ground. Such a process is apparently unknown geologically and may falsify the null hypothesis.

E may be an intact hollow hill, it has a depression in its lower side perhaps indicating it is deflating as well without cracks. The roofs would need to be thick to withstand meteor impacts, there are several in Figure 24 which have not caused the roof to collapse. They might be more resilient to meteor impacts because of a springiness designed into them, it might dissipate some of the shock of the impact causing less damage. It's likely the proposed builders would have taken this into account in their design, if they lived in a time when impacts like this were more common. It appears unlikely a pingo could withstand an impact like this, the heat should have melted the ice lens inside and caused a subsidence or created outflow channels and ponding.

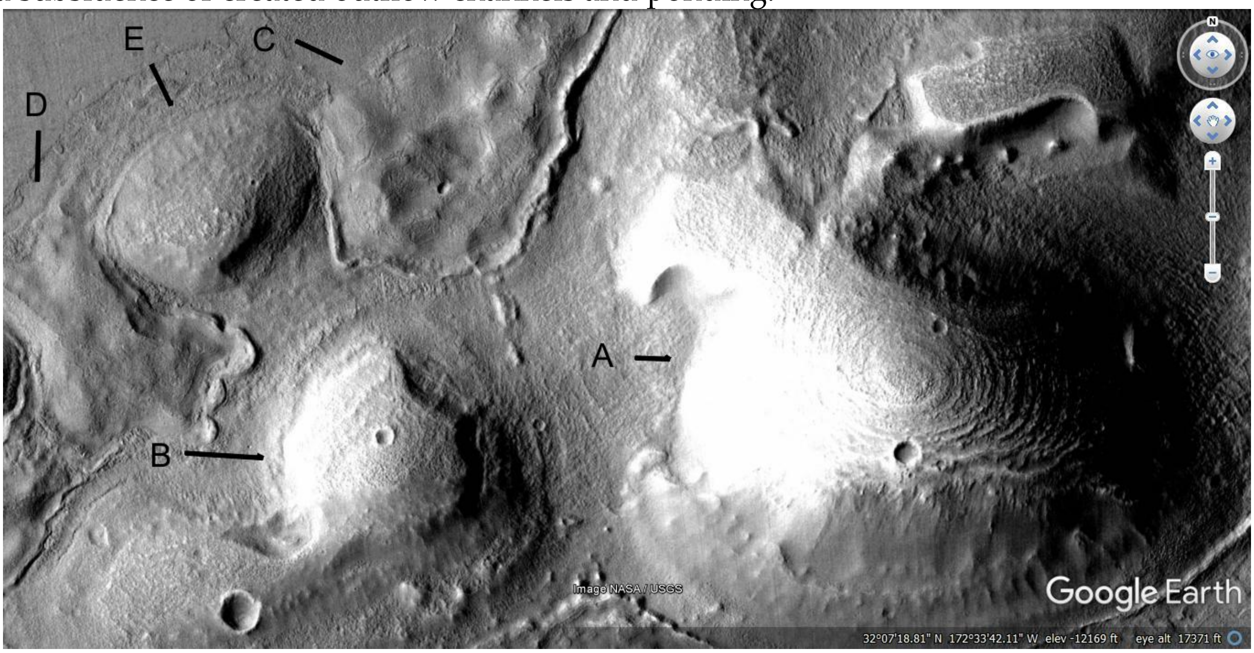

Figure 24. The first amphitheater.

A trapezoidal depression

Figure 25 shows a trapezoidal wall shape with an entrance, the hill to its right has a trapezoidal shaped section of its roof. This also has near vertical walls like another walled depression, unlike the more shallow sides of an ice lens like in Figure 13. If this roof collapsed, then it might have turned to soil and we would see a walled depression like next to it. The roof shape has a gentle arc shape, perhaps to give its strength similar to the left hill in Figure 23.

These formations should be created by similar geological processes; however, one part is a walled depression and other is an unusually shaped hill with wall like sides. Above this hill is another section with a lower elevation but part of the overall shape, this part may have subsided. In some of the subsided parts of these roofs the mud may have sagged rather than broken, this would give a depressed area on the roof. To the right of this proposed intact roof this may be a collapse area, it could be broken pieces of the roof and ridges that held it up. This trapezoidal shape is not like those in Figure 8, there are some similar shapes in Figure 2 but this is a single depression not part of a set of polygons.

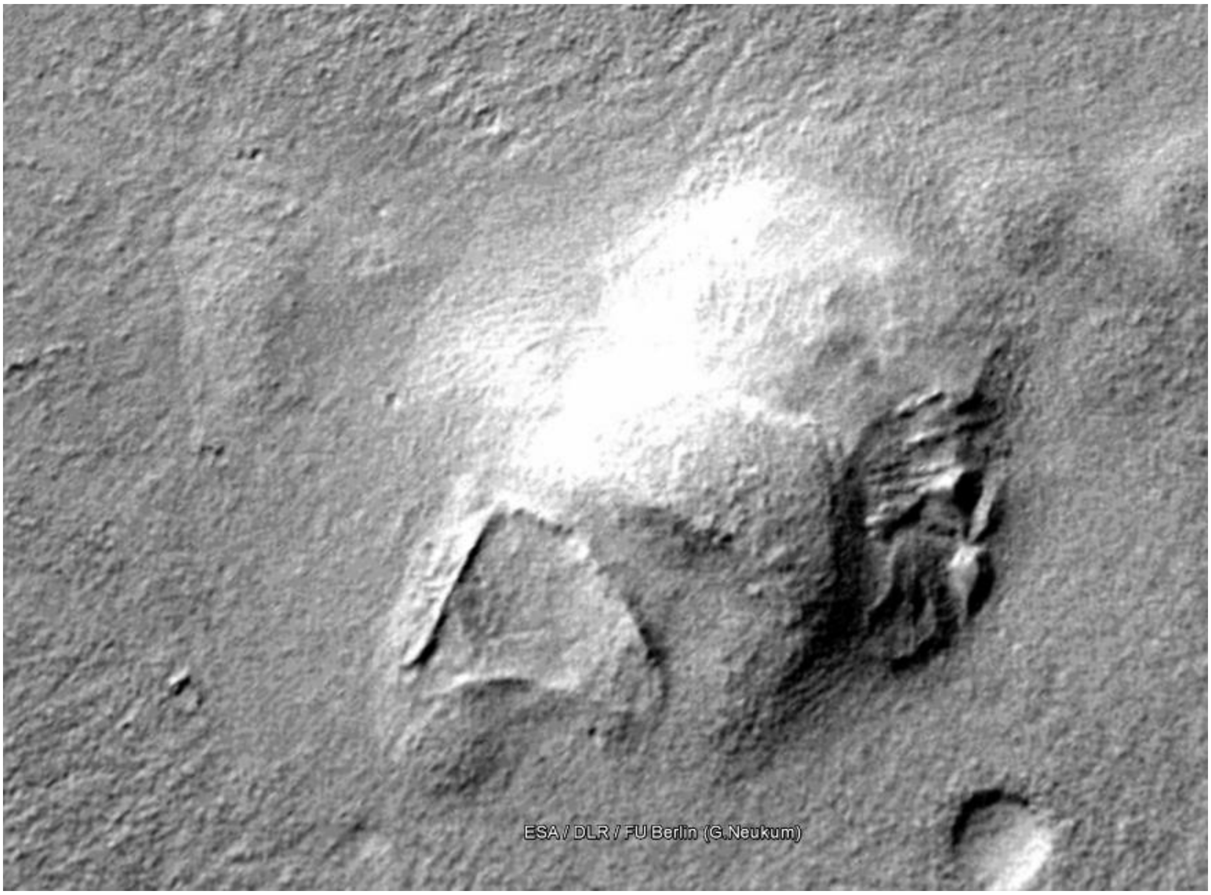

Figure 25. An unusual shape with walls and an entrance.

Broken roof edges

In Figure 26 the roofs appear to be intact on the southern sides. A natural geological process would have to form a smooth curved texture on one side of these formations with jagged edges exposing a mottled degraded surface on the rest of them. A points to one of these edges, below this the albedo is much smoother than above. B shows another example but where the interior seems to have collapsed more. Figure 3 shows a pingo, however they are not known to have a smooth surface with this mottled appearance under it. The jagged edge of this roof shape appears to be jutting out well above the rest of the surface of the hill. C shows another wall, it may be these smooth remains were mud or clay while the rest collapsed as rock fragments or bricks previously cemented together. D also appears to have part of the roof remaining on the upper side. Figures 2 and 7 also have separate rock fragments or polygons on their surface, the problem here is part of the surface is very smooth like cement and erosion appears to have taken off this outer layer to expose the rocks underneath.

Figure 26. Broken roofs annotated.

The mottled surface on these formations is hard to analyze at this low CTX resolution, below in Figure 27 is HiRise image ESP_023471_1835 of a similar hill with a collapsed summit. This is near the King's Valley, which was described in Orme and Ness (2011). The roof appears to have fragmented as it broke off a smoother upper surface, the dark lines show where these fragments appear to connect to the smoother part of the roof. If this is hollow then what is holding it up is unclear, these blocks may be cemented together. The mottled areas in Figure 35 may also be like this. They might then be fragments of this smoother surface that broke apart, or the smoother surface was covering these fragments. The pieces of rock are of a fairly uniform size, pingoes tend to break apart with larger cracks as in Figure 2 rather than shatter into fragments like this. If this had been a form of concrete then it may have had rebar reinforcing of some kind holding the pieces together. When the roof shattered then this may have held it together in a deformed shape.

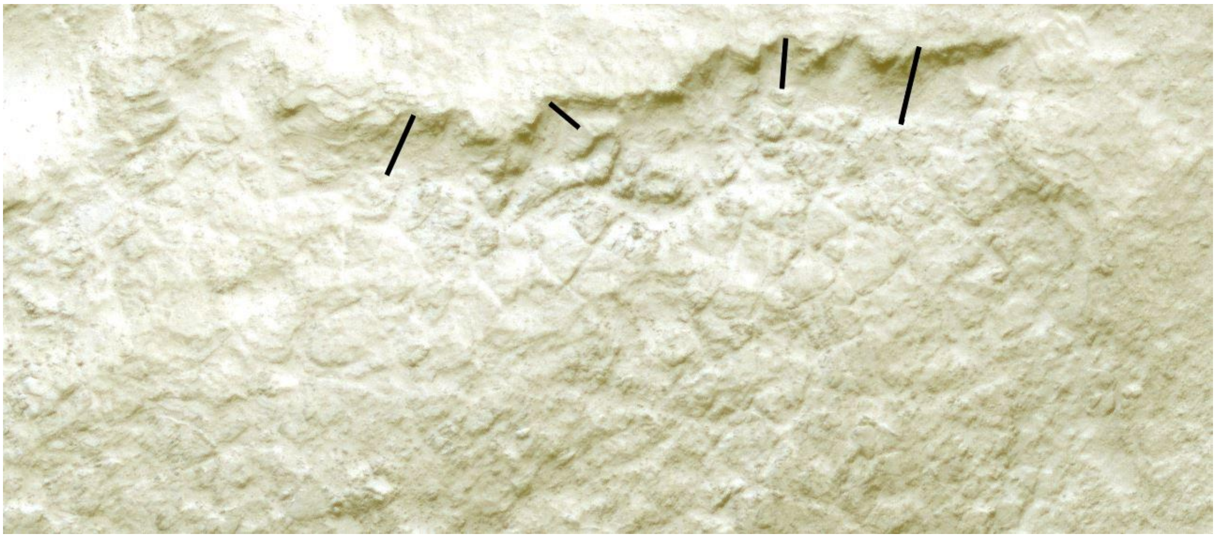

Figure 27. Near the King's Valley.

Collapsing roofs

Figure 28 shows hills that are in some cases intact, then others in various states of collapsing. A has a smooth roof surface that looks like other hills without any degradation. Then part of it seems to have had this outer layer stripped off exposing the insides. B shows a squarish section that appears to have collapsed. C shows a rectangular pit next to a hill that has collapsed in part. D may be a hill that has completely collapsed, it has a similar outline to other hills. The hill between A and D has arcs on its surface like the amphitheaters. The other hills may also have these arcs, but higher resolution is needed. The mottled appearance at D as it collapsed indicates the roof part might be breaking into brick like shapes.

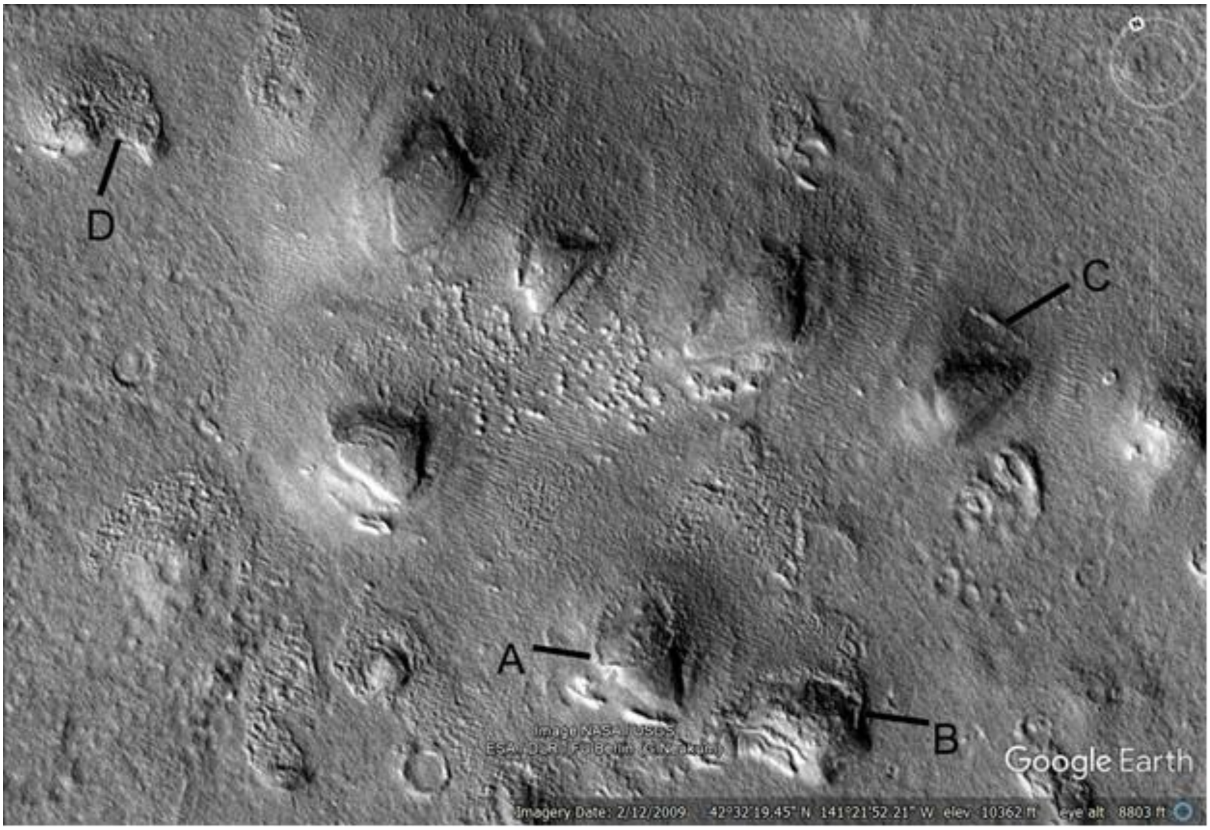

Figure 28. Collapsing roofs.

PSP_003529_2195 shows a similar change from a smooth skin to this mottled appearance, in Figure 29. There appear to be similar rock fragments joined together as in Figure 27.

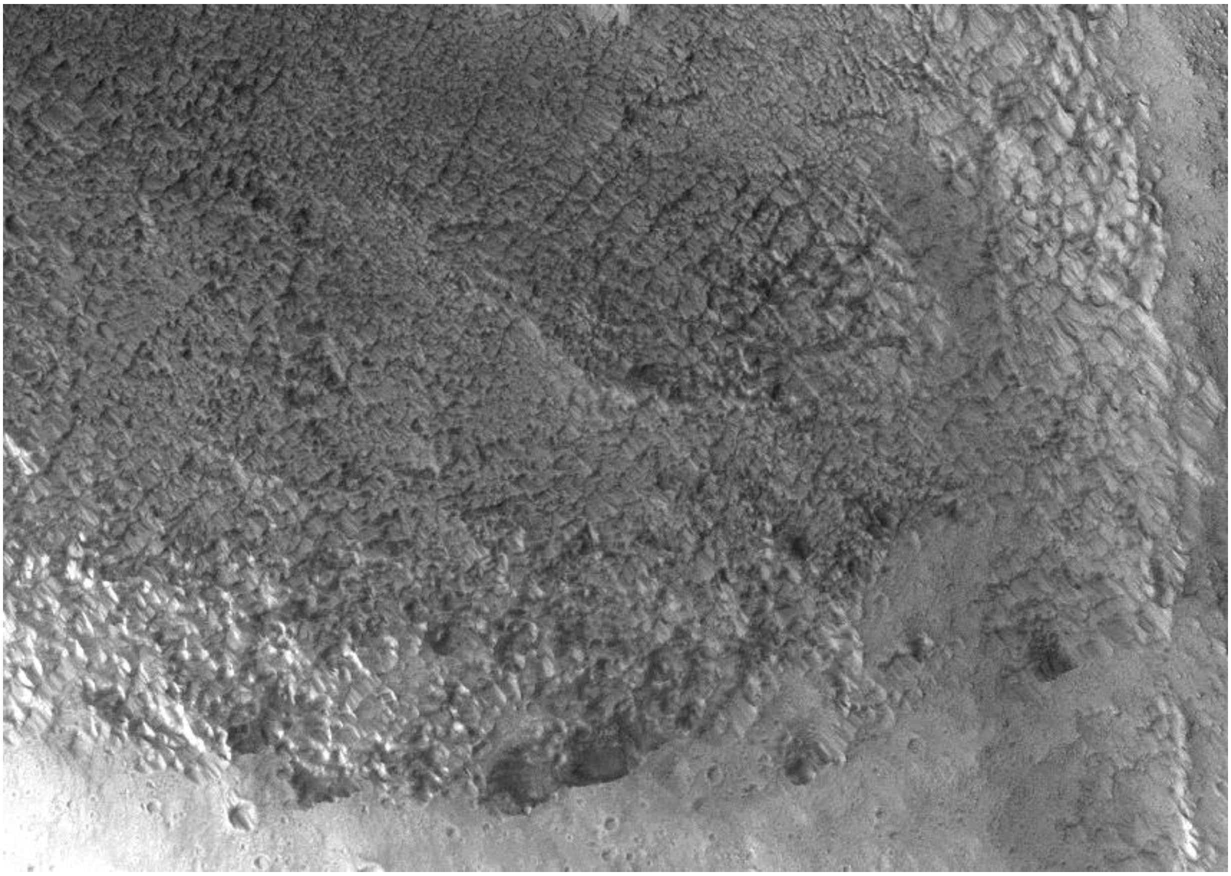

Figure 29. Connected rock fragments.

A fifth amphitheater

Figure 30 shows a fifth amphitheater shape; the layers appear to be lower on the edges indicating they may have been designed to build the roof in a series of rings. As one ring is completed then the next smaller ring might be added overhanging the central cavity and so on. They are not like the polygons in Figure 2, it may be that rings of polygons were cemented together in irregular arcs. However, there are no visible segments in each ring though the spacing between the rings is easily visible. These rock fragments or polygons may have been cemented together with a smooth surface. A pingo like in Figure 3 forms by the upward heaving of an ice lens, these have a smooth shape and do not form step like layers such as this. The enigmatic domes in Figure 7 do not have these arcs on their surfaces. Figure 21 shows a similar terraced slope at C, however the hill appears to be a mix of layers and non-layered sections. It is difficult for these formations to have formed from layered sediments and then be surrounded by terrain with no layers.

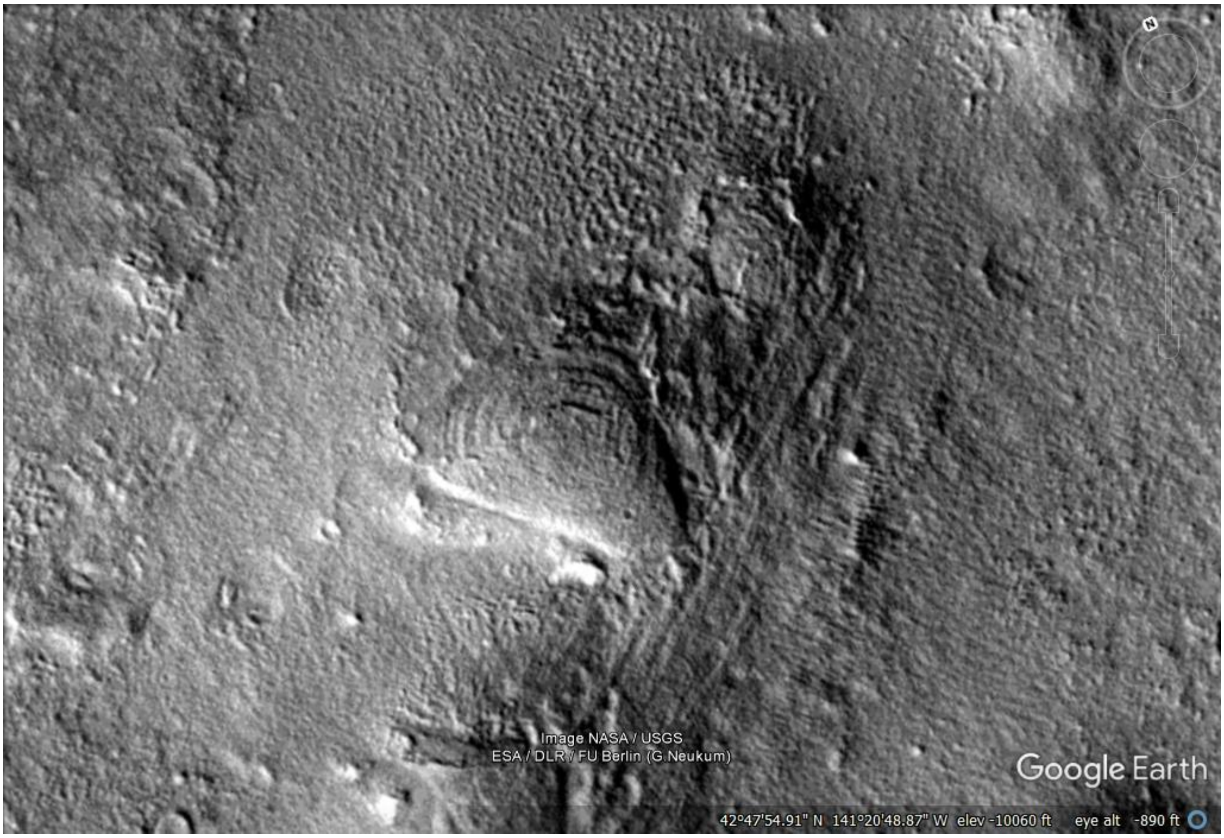

Figure 30. A fifth amphitheater

Figure 31 shows another image of this formation from P19_008513_2178, it seems to have wide steps leading up to it. There could also have been two Corbel domes to the sides of the main one. These steps could also be a variation of the Corbel design, using straight lines of layers to create a hollow area under it. They are not dunes because they appear to be on a slope from the ground up to the amphitheater, dunes could not climb a slope like this. The image is approximately 5 meters a pixel in resolution, steps would then be 10 meters apart as an estimate which would seem to rule out walking up them. However, there might be smaller steps not visible between them. These layers if part of the building design would need supports because the strength of an arch is not used. Alternatively, they could be steps used for design purposes as we use for many public buildings. These formations could be modeled with shape from shading to give a 3D representation of them. Then it could be worked out by engineers whether they could be artificial or not, whether mud or concrete could create domes of these shapes. This can be one way to falsify the artificiality hypothesis. Another test can be how similar the arcs are in the amphitheater shapes, whether this is random variation or they seem to be a standard width. The inhabitants could have been 3 times taller than us with the same kind of loading on their bones, this is because the Martian gravity is about 1/3 of our own. However we cannot know if these hypothetical creatures could have used these steps or not.

Figure 31. Amphitheater and steps

A sixth and seventh amphitheater

Figure 32 also appears to have 2 amphitheater roofs, at A and B, making it 7 so far. The third hill at the bottom of the image also has some arcs on its surface. None of these are a typical pingo shape, the process of pingo formation does not produce these arcs, and it does not produce this outer skin over the arcs. Since pingos are the only geological explanation that has been put forward in this area, then the only known explanation is falsified.

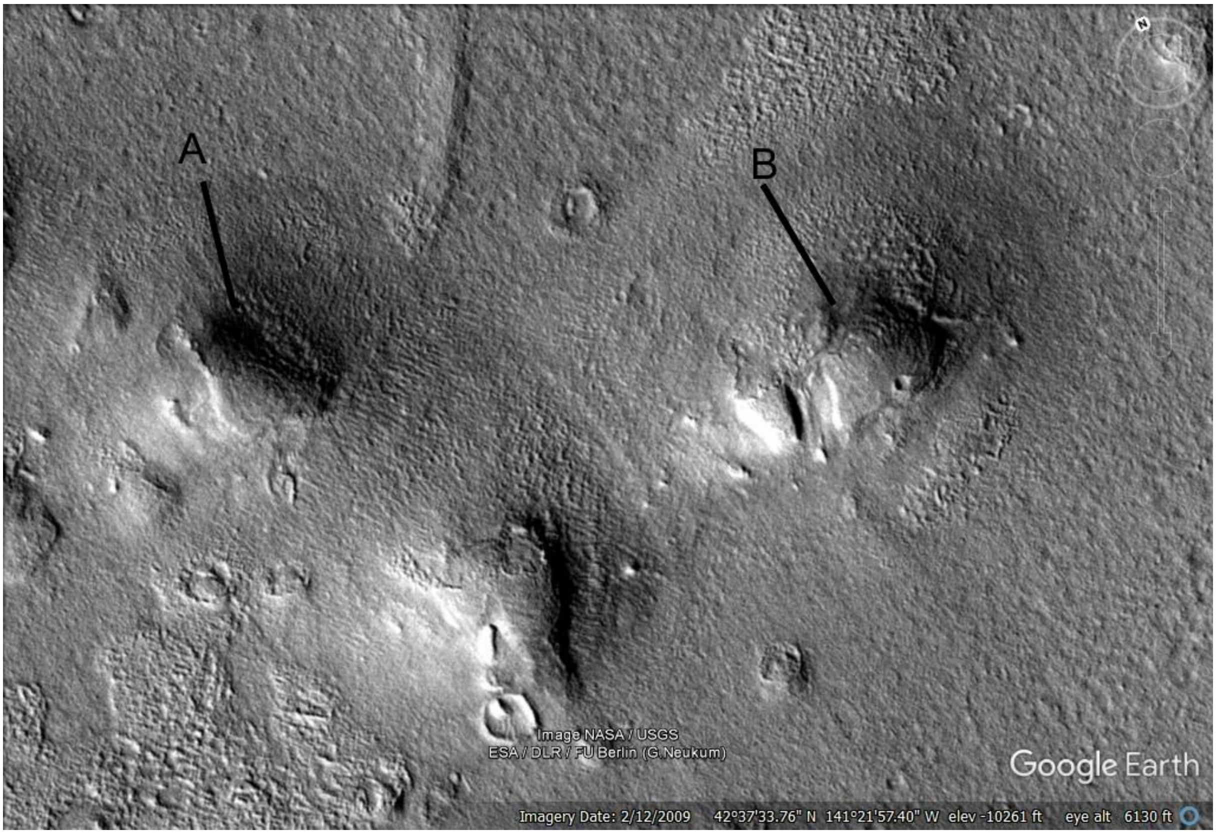

Figure 32. A sixth and seventh amphitheater.

An eighth and ninth amphitheater

Figure 33 has 2 more amphitheaters at A and B, making it 9 in total. The formation under B also seems to have these arcs. Each of these appears to have arcs not polygons like in Figure 2, the large number of these makes it more unlikely they are a chance variation of polygons. The pingo in Figure 2 does have a central rounded rock like in some of these formations, also the first circle of polygons do form a similar shape to these arcs, but there are no cracks between the rocks here.

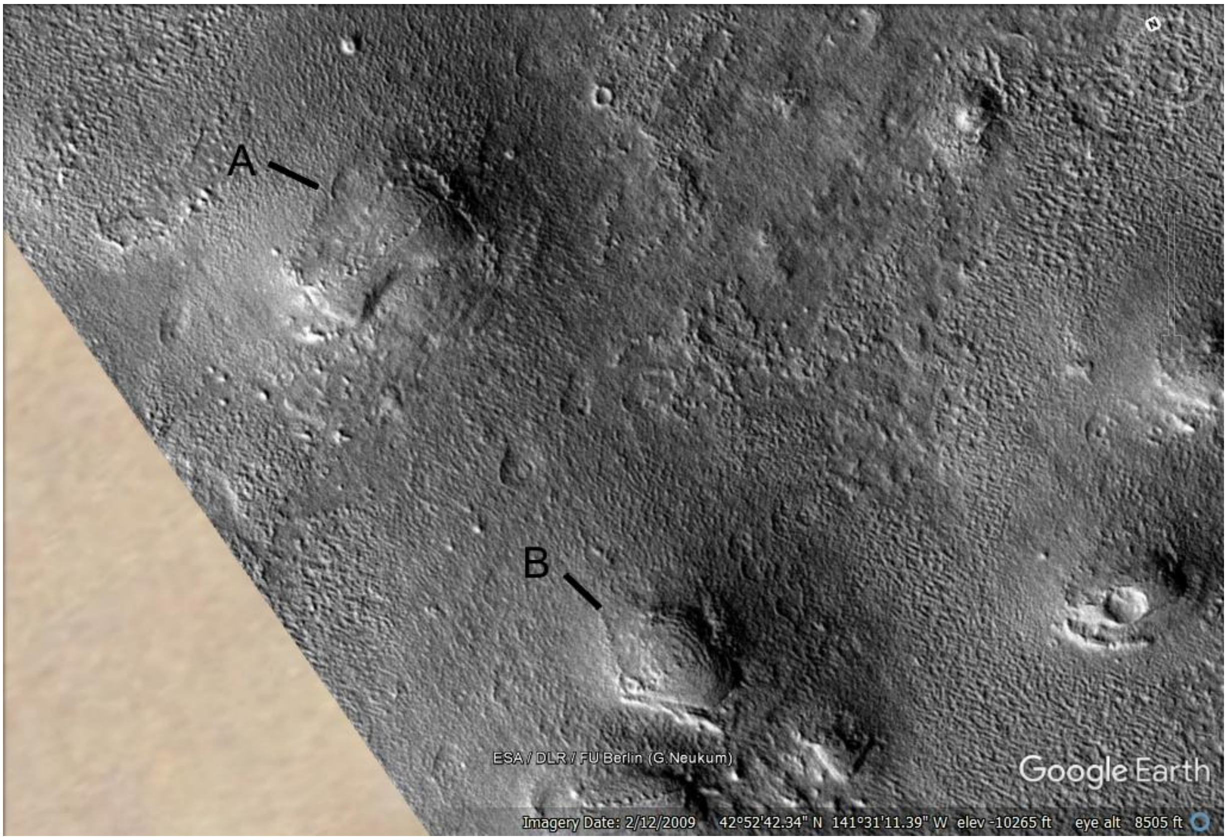

Figure 33. eighth and ninth Arcs under the roof.

A peeled back roof

Figure 34 looks like the roof has peeled up from the left and over onto the main roof. If this was a mud roof, then it might have been softened by the rain enough to be peeled back by the wind. This would also explain how they seem to have collapsed in some areas, the mud may have softened but perhaps had some reinforcement that bent. This is hard to explain with the pingo model as shown in Figures 5 and 6, the ice lens would have to push up this layer of rock but then leave it pliable enough to flip over like it was a cloth. There doesn't seem to be any kind of sediment in Earth geology that could flip over like this without breaking, the natural hypothesis would appear again to be falsified. Also, the rest of the formation did not collapse even after this piece flipping over, the stress required to do this doesn't seem to have even cracked the rest of the formation.

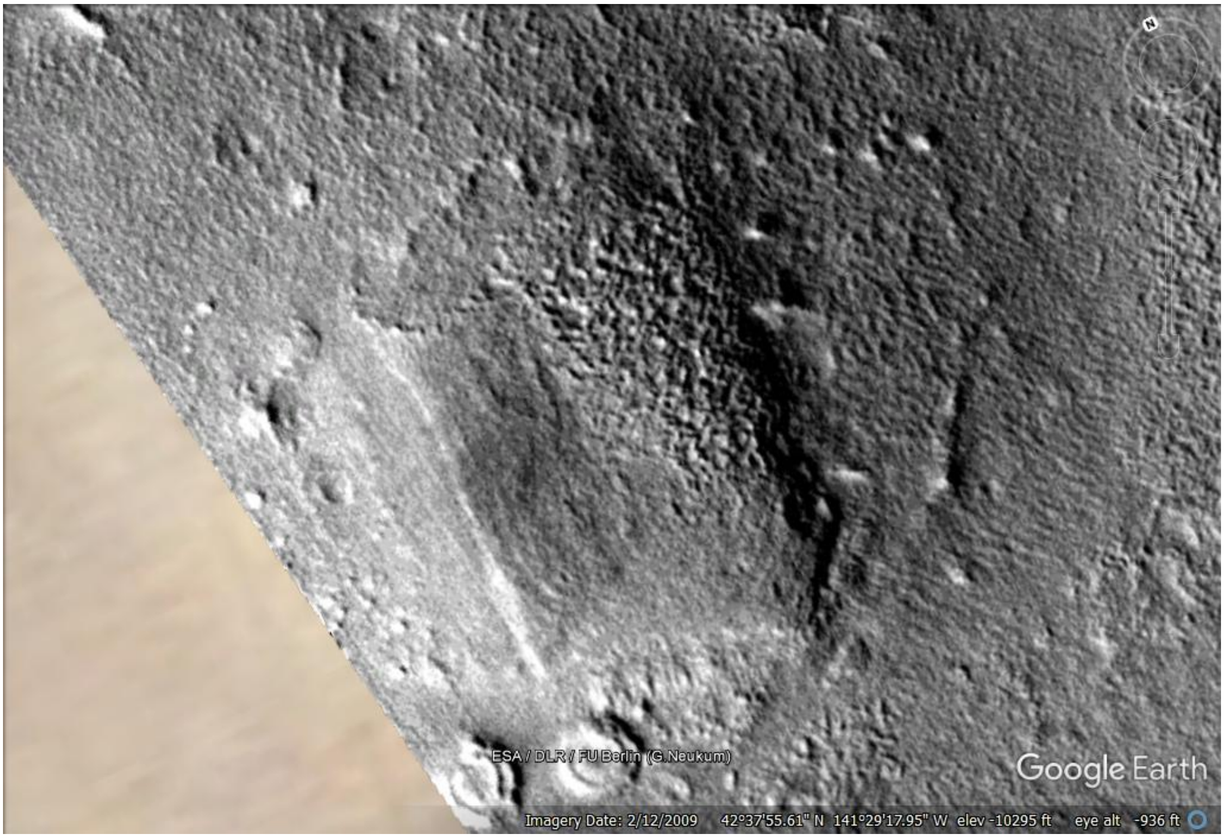

Figure 34. A possible peeled back roof.

In Figure 35 these shapes are shown. A shows where there is an entrance shape, like on many others of these pits. B shows the mottled appearance like some collapsed roofs have, there seems to have been a hollow area to its right as well. The walls are highly degraded here, this may give some insight into what they were made of. The remains appear to be like posts, which may have had material connecting them.

C and show how similar these two sections are, the dark outline could be folded back over and closely cover the light grey area. The side angles are about the same with the upper part of A and B, and the lower parts like a symmetrical hinge. E shows another amphitheater shape making it the tenth. This section would then appear to be like the collapsing pingo in figure 12, but again with concentric rings not separate rocks like in Figure 38. This then looks like a rounded pingo in some ways but it is part of this overall non-round hill. The ice lens would have had to heave up in this section to form the rounded shape but the rest of the hill also formed by this ice lens is the same height but didn't form these arcs.

To peel a roof like this on Earth would require very strong wind, perhaps on Mars it was associated with the extinction of life there. Figures 11, 13, 14, and 17 have hollows like exposed on the left of this formation but with no roof. Perhaps their roofs were torn off in the same way or in the same event, rather than being peeled over like this. As this paleosea sublimated there could have been extreme weather that caused the peeling effect on many of these hills, probably coming from the north as the more damaged side. The flipping over of the roof however would have been caused by high winds from the west. It can then give a glimpse into the conditions these formations went through. It would be difficult to assess these conditions geologically otherwise.

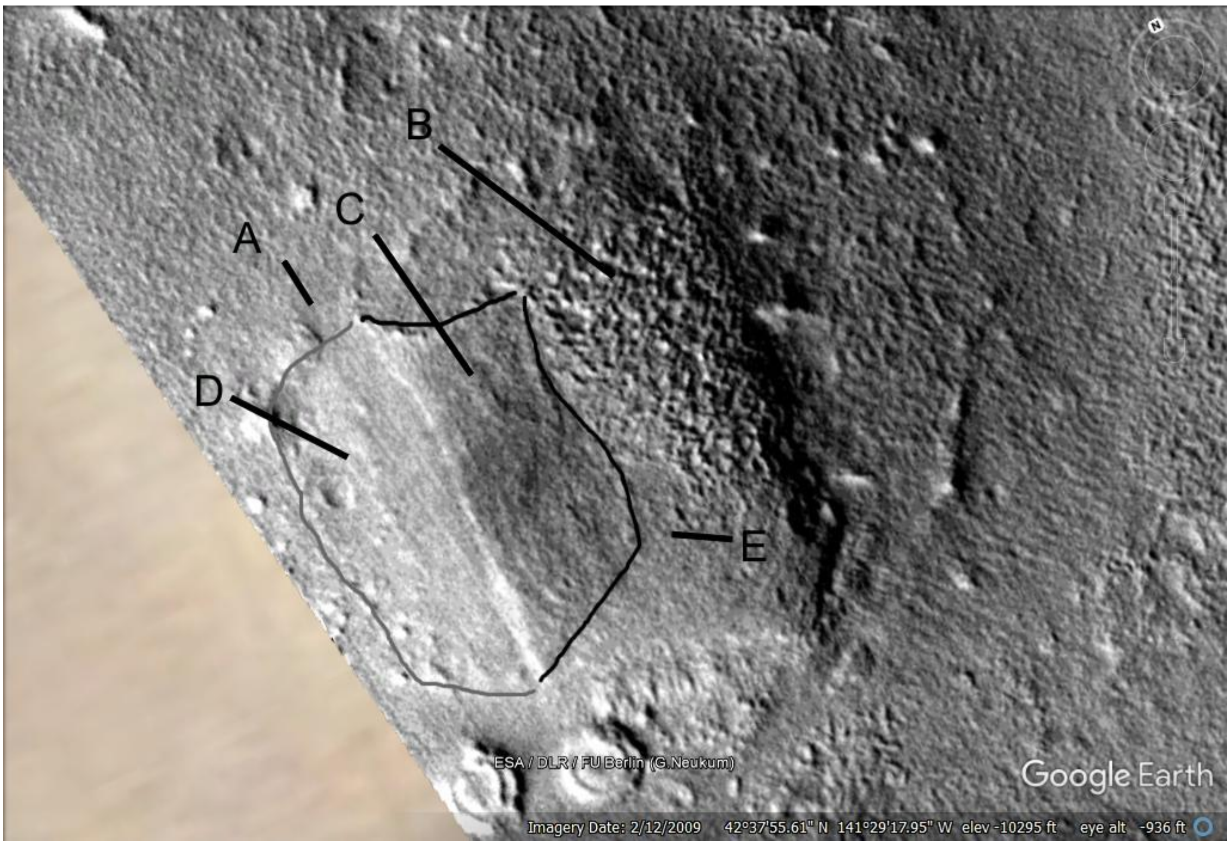

Figure 35. The peeled roof annotated.

In Figure 36 the distances between the vertices of this shape are shown. AB is the same line length as DE, if this section peeled over then it would have fitted here precisely. AF and FE are a different shade to distinguish them from AB and DE, this is the same line flipped over. Not only does it fit very well but the angles AFC and EFC are close to each other. BC and CD are the same line flipped again, they show how closely this could have fitted. Again, the angles BCF and DCF are very similar to each other. The distance from C to F is about 600 meters,

This makes the interior of these formation quite large. However, the Martian gravity is only 38% of our own so building materials can be thinner according to the square of this difference. In round terms if the Martian gravity is 1/3 of our own then materials in a dome like this could be 9 times thinner, or be much weaker compared to our own buildings.

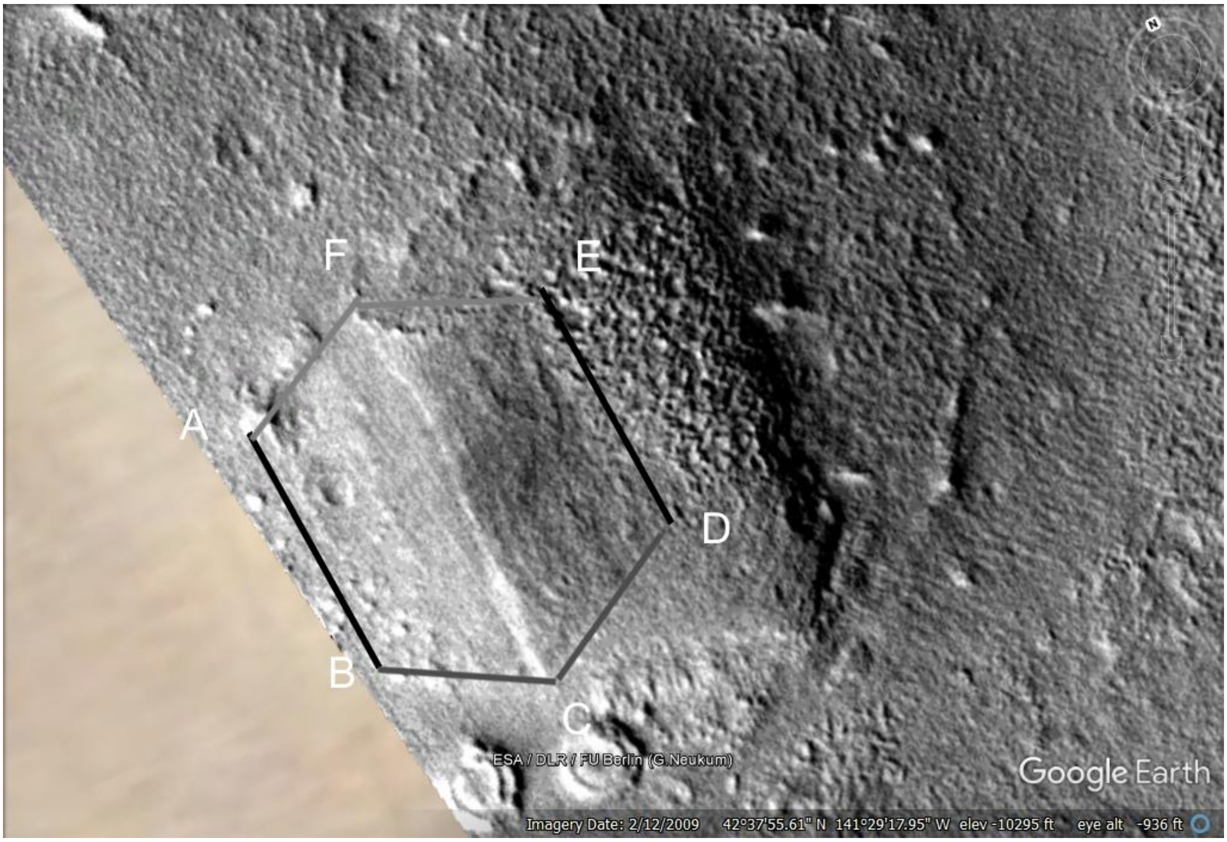

Figure 36. Equal sides and angles

Figure 37 shows this formation from D22_035927_2228, the impression of the peeled back section is also clear. The entrance shown as A in Figure 35 is also clearer. The amphitheater like concentric circles again appear to be showing through this flap.

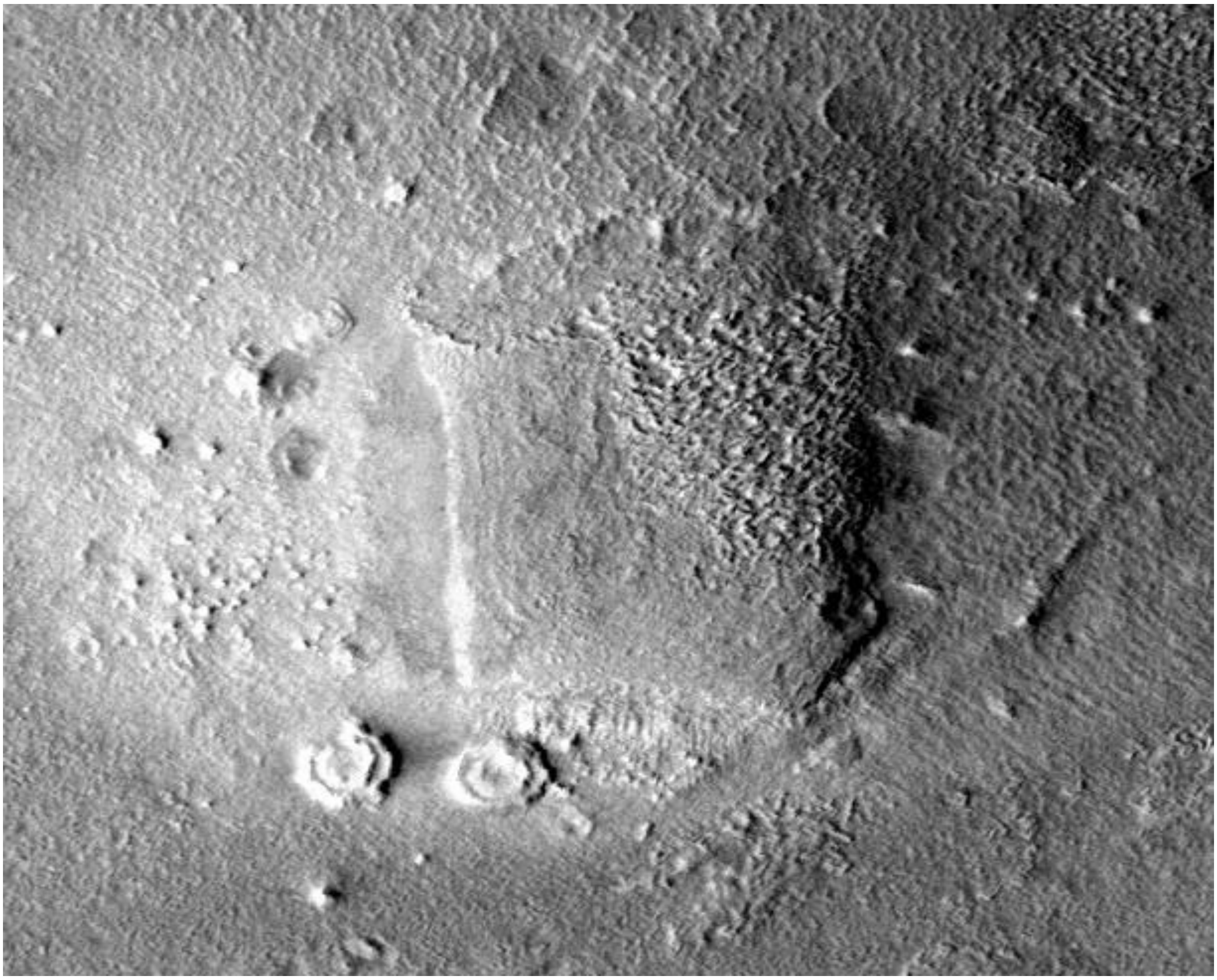

Figure 37. The peeled back section

In CTX image B20_017374_2216 the appearance of a peeled over layer is more striking, shown in Figure 38. The upper entrance is also clearly shown. The roof would have been very thin as the arcs under it of the possible Corbel dome are showing through it. The walls are highly degraded here, they may have been broken by the same forces that flipped over part of the roof. Other pits with walls are further to the East, the paleosea to the west may have flooded this area causing this damage. Figure 10 shows the positions of these formations, to the west of this the elevation is lower as the position of this former paleosea. This then may be why they end abruptly along this line, they may have been on the edge of the water or may have been destroyed by waves from it.

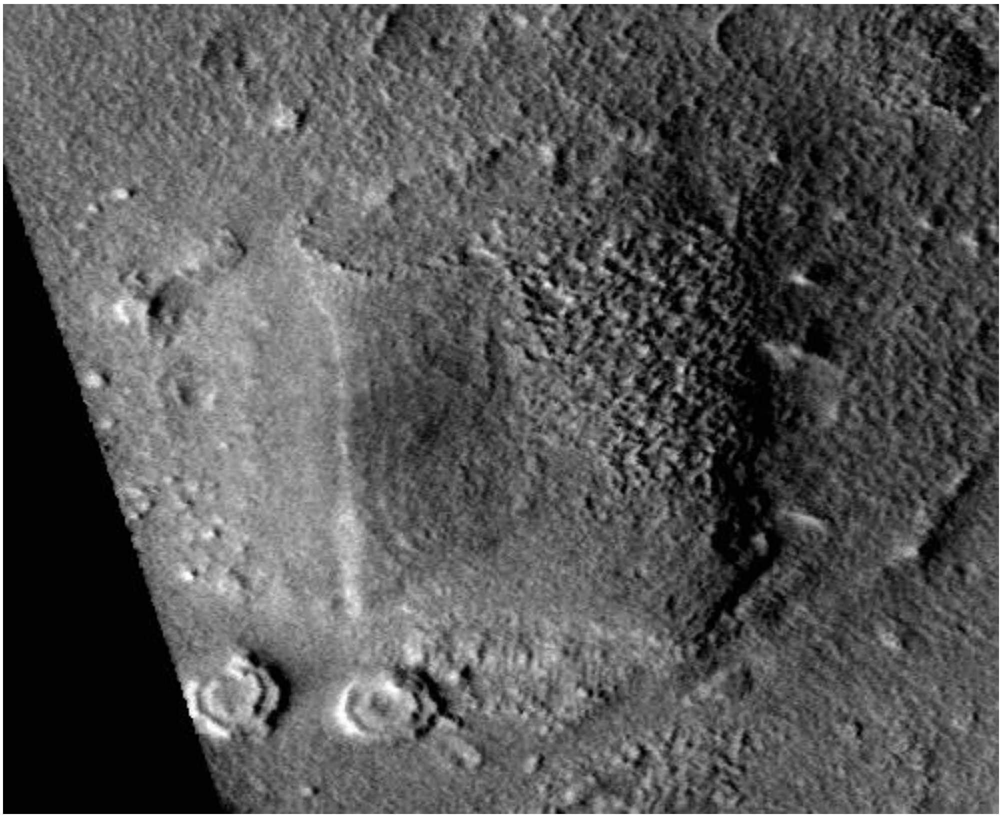

Figure 38. The peeled over layer is clearer

A tenth amphitheater shape

Figure 39 shows another amphitheater shape, against with an impression of the outer layers being lower. This makes 10 amphitheater shapes, they are so common in this area that all might have these arcs but some still have a skin of the roof over them. As with many of these formations, there seems to be a central plug forming the apex of the possible Corbel dome, this is similar to the collapsing Earth pingo in Figure 2.

Figure 39. A tenth amphitheater

An eleventh amphitheater shape

Figure 40 shows the eleventh amphitheater shape, the center ellipse seems to be much higher than the outer rings. These rings also seem to be much wider, with only about 4 in total including the central circle. It implies the arcs may not be very heavy, alternatively they had some temporary support while being added into place, or there could be a central pillar as seen in some of these formations. If these were polygons such as in Figures 2 and 7 then they would also have to maintain this shape without the rocks falling out leaving holes. They would also have to be very large polygons, perhaps tens of meters in size so the rocks themselves should tend to fall down without an ice core holding them up. About the only way for this not to happen is if they are stacked like a constructed arch or dome.

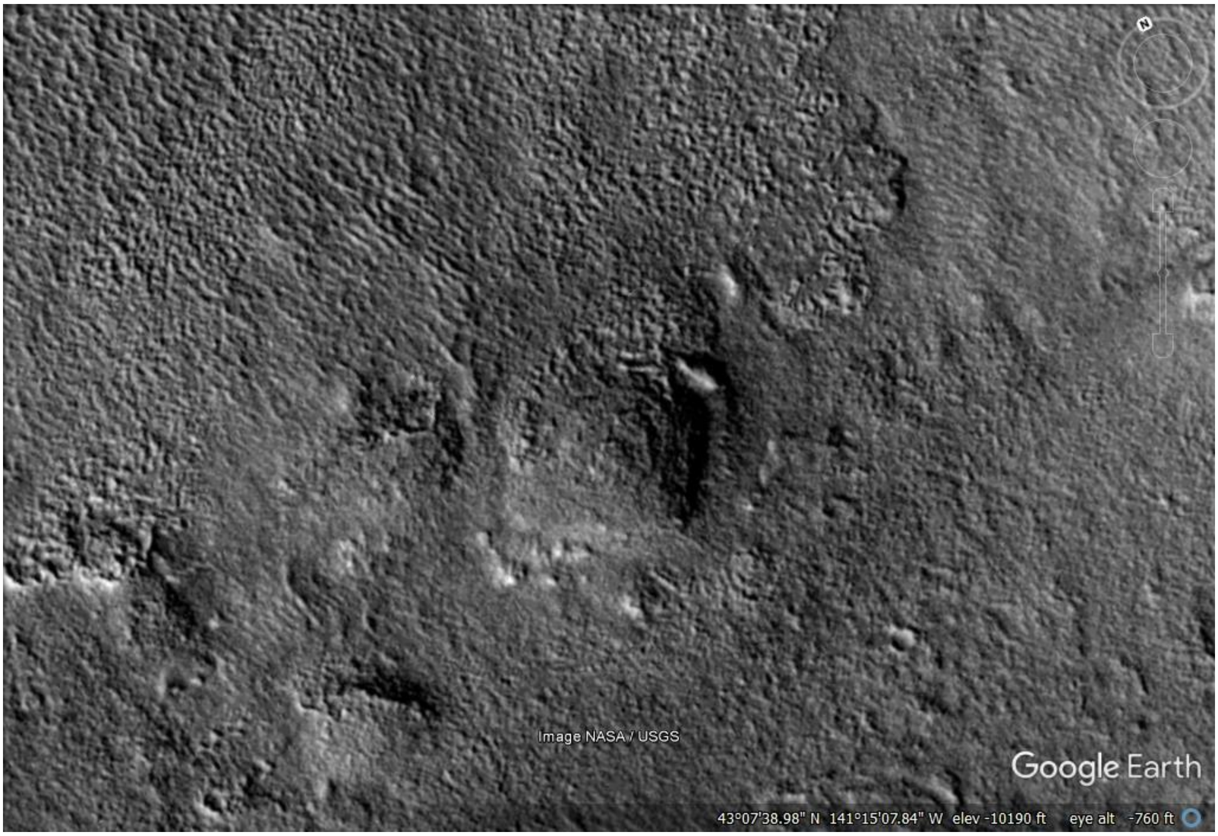

Figure 40. The eleventh amphitheater

A twelfth amphitheater shape

Figure 41 has the circular arcs of the twelfth amphitheater showing through the outer skin. Like with many of these formations the north side is much more degraded, the skin having disappeared. Two of the other hills in this image may also have these arcs.

Figure 41. The thirteenth amphitheater

A thirteenth and fourteenth amphitheater shape

In Figure 42 both hills have amphitheater arcs, the hill on the right has a darker circular shape on its surface. The hill on the left has the arcs showing through the degraded skin, these appear to be much power on the outer arcs looking like a Corbel dome. That would make 14 in total. Comparing the right-hand hill to Figure 2, to be a pingo this would have had to grow in an approximately symmetrical triangular shape but with this rounded ice lens inside it. This would seem to falsify the natural hypothesis.

Figure 42. The thirteenth and fourteenth amphitheater

A fifteenth amphitheater shape

Figure 43 appears more like an eye shape, the outer rings form more of an ellipse with the center being more circular. This would make 15 amphitheater shapes. Figure 2 has polygons arranged approximately in a circle, but this eye shape would have to grow out of the top of the pingo. On the left the eye shape appears to jut out from the top of the hill, it looks like it is a separate kind of formation to the hill under it.

Figure 43. The fifteenth amphitheater

A sixteenth amphitheater shape

Figure 44 has a single ring on the top of the left hill as the sixteenth amphitheater. The right hill is hollow inside. The middle hill looks like the hill on the right except it has not collapsed yet. It could be regarded as a progression of collapsing pingos, the one on the right being the lower diagram in Figure 6 as a pingo scar. The central plug on the left-hand hill is similar to on Figure 2, however there are no polygons or arcs around it which would have been part of it forming naturally. It might then be an artificial plug to cap a hole like in the right-hand formation.

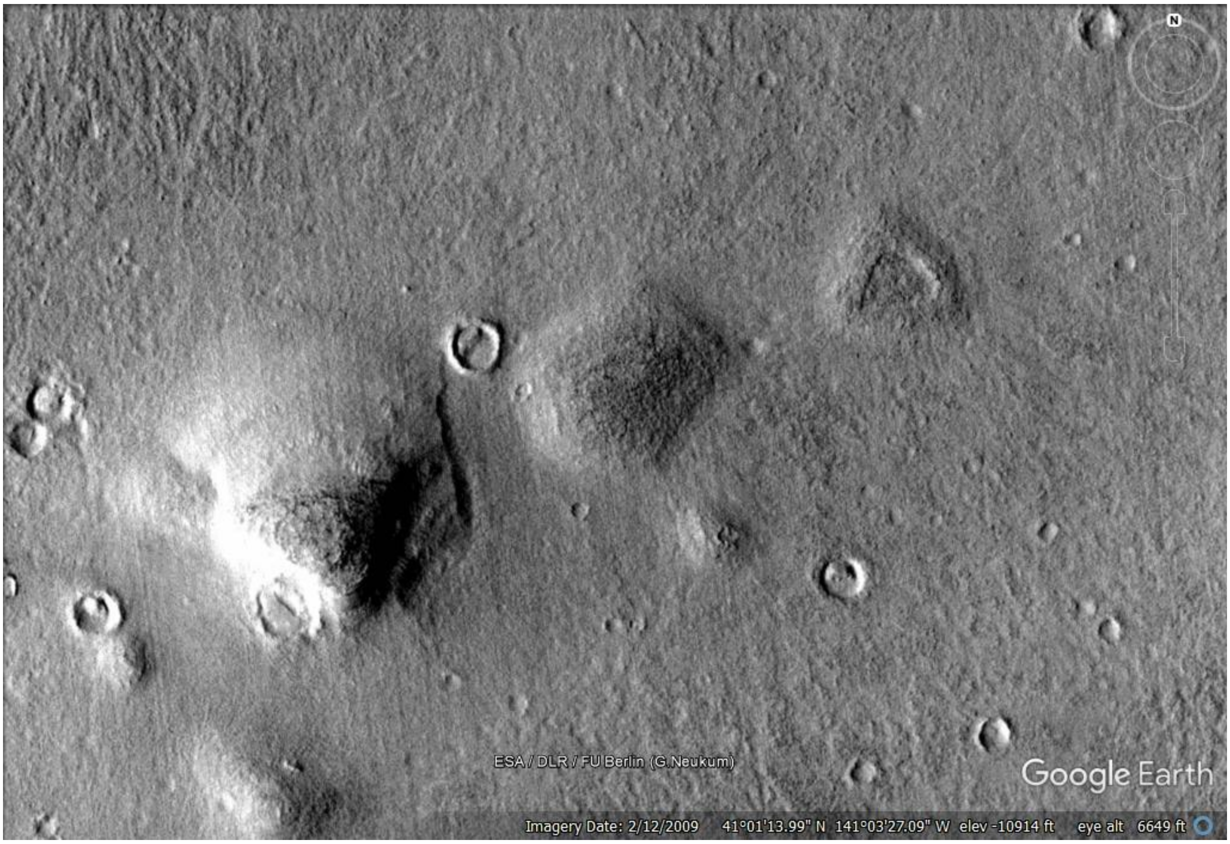

Figure 44. A ringed apex on the sixteenth amphitheater and a hollow hill

A seventeenth amphitheater shape

Figure 45 is similar to an amphitheater but the rings are less smooth in shape, this would be the eighteenth in this small area. The crater in the surface does not seem to have damaged the roof, nor did it punch a hole through. The northern side of this formation appears to have collapsed, if this was a pingo that would indicate the ice lens had sublimated. However, the remaining piece should also have subsided as this should have exposed the ice core to the atmosphere, it also has a near vertical left edge that is incompatible with frost heaving from an ice lens. A meteor impact like this should have heated the ice lens below it causing a slump or break in the surface. In each case however where there are craters on these formations there is no sign of melting around them. This is different to many craters on the ground in previously ice rich terrain, they tend to have water flows in and around them. This tends to falsify the natural hypothesis that these were pingoes with an ice core.

Figure 45. The seventeenth amphitheater

The ice wedges below in Figure 46 could account for the steep slope in Figure 45, however it would not form the circular arcs on their surfaces. The ice wedges here have been vertically carved by a river, there is no sign of fluvial erosion on the sides of these Martian formations. On the left and right the slope of the ice wedge is more gentle without the river carving it. It has the appearance of earth walls between section of ice, perhaps like the walls in Figures 11 and 13. More likely though this is a runoff from the surface leaving trails of sediment along the ice.

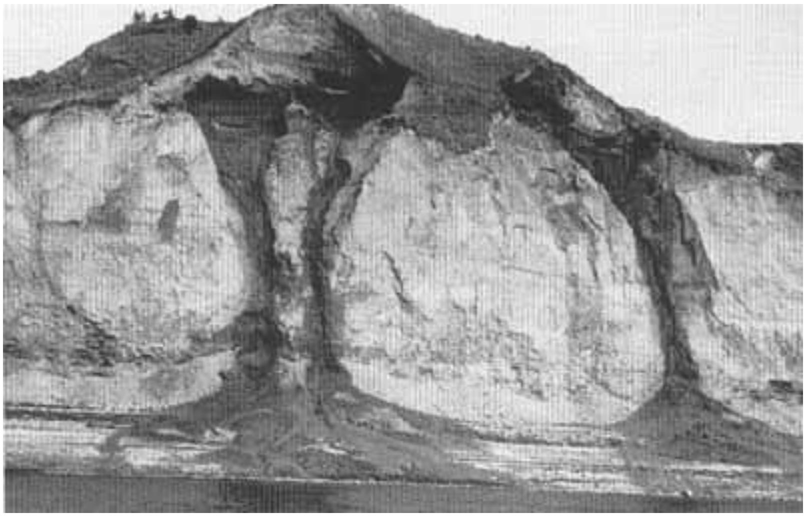

Figure 46. Ice wedges.

An eighteenth amphitheater shape

Figure 47 has the eighteenth amphitheater shape in this area, it is higher than some of the others and the roof less of a dome shape. When the roofs appear to be very flat they may need supports inside, some hollows have interior wall shapes. This roof is in good condition with no degradation of the outer skin. This is very unlike a pingo such as in Figure 3 yet it has the same kinds of arcs on its surface as the other hills with different shapes. A common process then would need to form these arcs on so many different hills.

Figure 47. An eighteenth amphitheater

The nineteenth amphitheater shape

This amphitheater has the roof degraded on one side in Figure 48, the arcs show through more there. There is more of an impression of the outer layers being lower unlike in Figure 45. Many of these have the outer skin more degraded on the northern side, but it remains intact on the southern side. This may indicate the pole was approximately in the same direction at the time or that there was a prevailing wind and storms from the north such as a sea breeze. Pingos are usually circular or elliptical, the circular arcs however are part of an L shape which is hard for an ice lens to form.

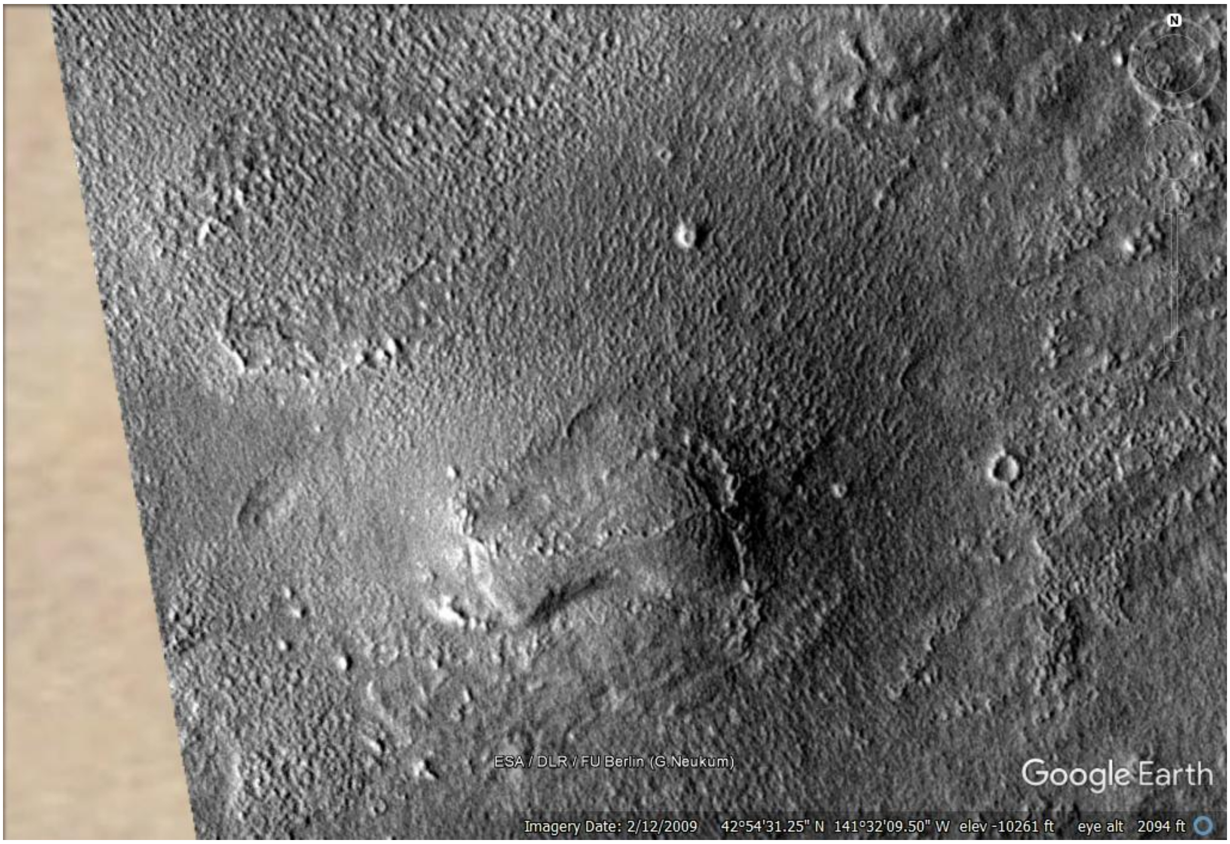

Figure 48. The nineteenth amphitheater

The twentieth amphitheater shape

While degraded on the northern side, like the other formations, this has the same arcs on its surface in Figure 49. The outer arcs appear to be lower, this is consistent with building up circles of bricks in a Corbel dome as shown later. It again has these arcs unlike the polygons in Figure 2, the overall shape is very different on the bottom to a rounded ice lens forming a pingo.

Figure 49. The twentieth amphitheater

The twenty first amphitheater

The arcs are very clear in this formation in Figure 50, also the outer rings appear to be lower. The hill on the bottom left may have some arc layers as well. The skin seems to have disappeared without any debris remaining, this may have been a mud covering over Corbel bricks. The lower formation has circular arcs, but this would need to be from a semicircular ice lens in a pingo. The upper formation has a similar pointed end to Figure 49.

Figure 50. The twenty first amphitheater

The twenty second amphitheater

Figure 51 has the arcs on the right-hand side rather than a full circle, this can still give strength to a roof. The small hill on the right also seems to have arcs on its surface.

Figure 51. The twenty second amphitheater

The twenty third amphitheater

Figure 52 has the arcs more distinct where the roof has lost its skin.

Figure 52.The twenty third amphitheater

The twenty fourth amphitheater

The arcs in Figure 53 are very complete in circles, also the roof appears to be very flat like a Palsa as in in Figure 4. However, Palsas don't have a mechanism to form these arcs, they have an ice lens which upheaves less making them flatter.

Figure 53. The twenty fourth amphitheater

The twenty fifth amphitheater

Figure 54 shows the arcs on the upper left.

Figure 54.The twenty fifth amphitheater

The twenty sixth amphitheater

Figure 55 appears to have two ellipses on its surfaces, perhaps two separate arcs to hold up the roof. Overall perhaps half of these hills have the arcs on their surface, it probably means nearly all of them would on reimaging or removal of this outer skin. It appears to have a similar eye shape to Figure 43.

Figure 55. The twenty sixth amphitheater

Image P19_008513_2178

In Figure 56 the bottom has partially collapsed showing the interior, all three hills seem be connected like with a corridor. The middle hill appears to have a large crack running along its right side, similar to cracks in the bottom hill. It implies the middle hill is hollow. Its shape is not like the pingo in Figure 3 being more like a rectangle. There is a finger of rock pointing into the center on the lower hill, if there was an ice lens holding this up previously then it should have broken. So, this indicates there is rock under this finger where the ice lens should have been.

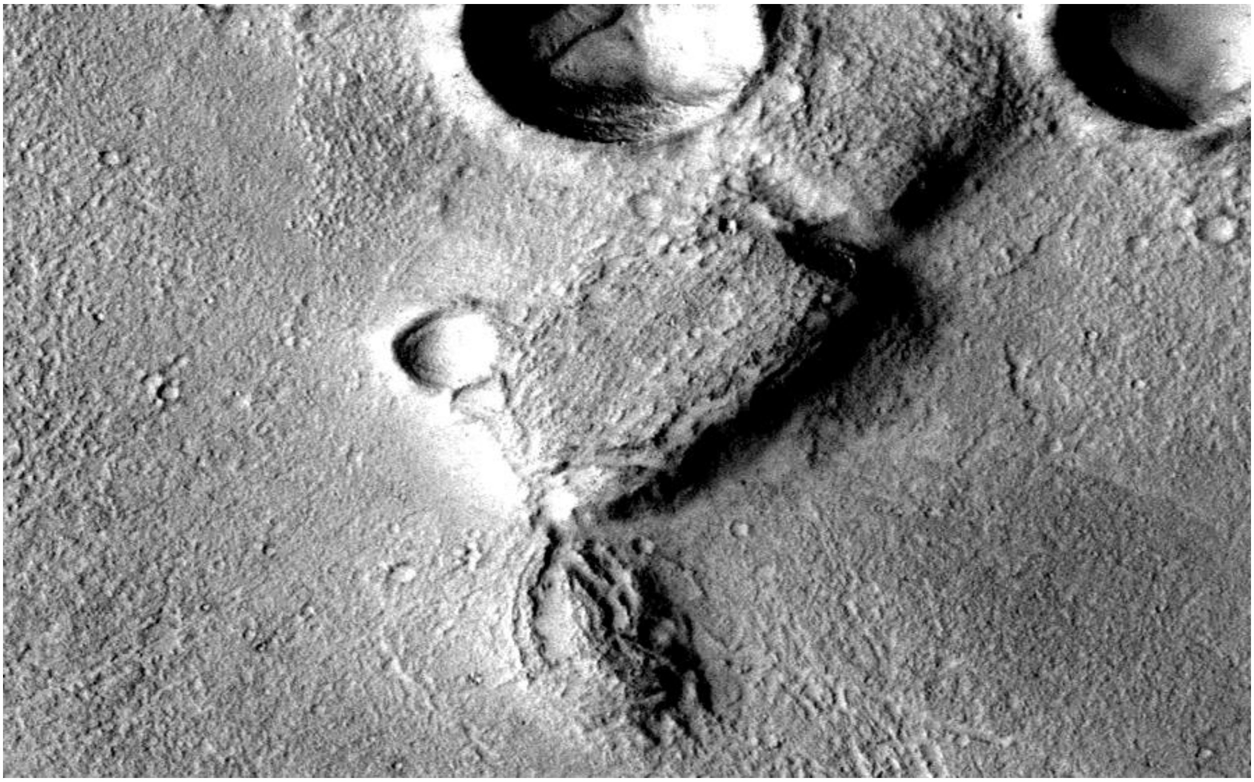

Figure 56. Collapsed hill

In Figure 57 the upper right section of the hill appears to be collapsing, showing a central ridge like in many of the walled pits. A collapsing Earth pingo such as in Figure 3 should not have these internal walls separating the pieces of the ice lens like this. It would then require an ice block under the whole hill without a lens shape of being higher in the middle. This is not how frost heaving works.

Figure 57. Collapsing hill

Figure 58 shows a pit on the left with a straight ridge running down its middle, this may have been part of a support for the roof. It is shaped more like a slice of bread with a circular top, then straight on the sides and bottom. This would be typical for making artificial walls that are straight, but an ice cored should be circular. Part of the pit has the mottled appearance like some of the hills losing their smooth skin. In the middle of the image there is a pit with part of a roof on it, this connects with an intact fragment to the upper hill. This has the same mottled appearance in its upper side like it has collapsed as well. On the bottom of the image would be an intact hill. It is similar to Figure 7 but the formations are not circular like a typical pingo.

Figure 58. Pits and partially collapsed hills

Figure 59 shows a triangular shaped put with walls around it, and a central wall support. There seems to be an entrance at the vertex of the triangle. The small hill seems to have the same kind of central ridge running through it, implying it may be hollow as well. It seems to have a small curve through it like the larger hill, it also lines up closely with it like a straight line could be drawn through the two of these ridges. The smaller hill has the same approximate shape as the larger pit. A pingo scar such as those shown in Figure 6 would not have this central ridge.

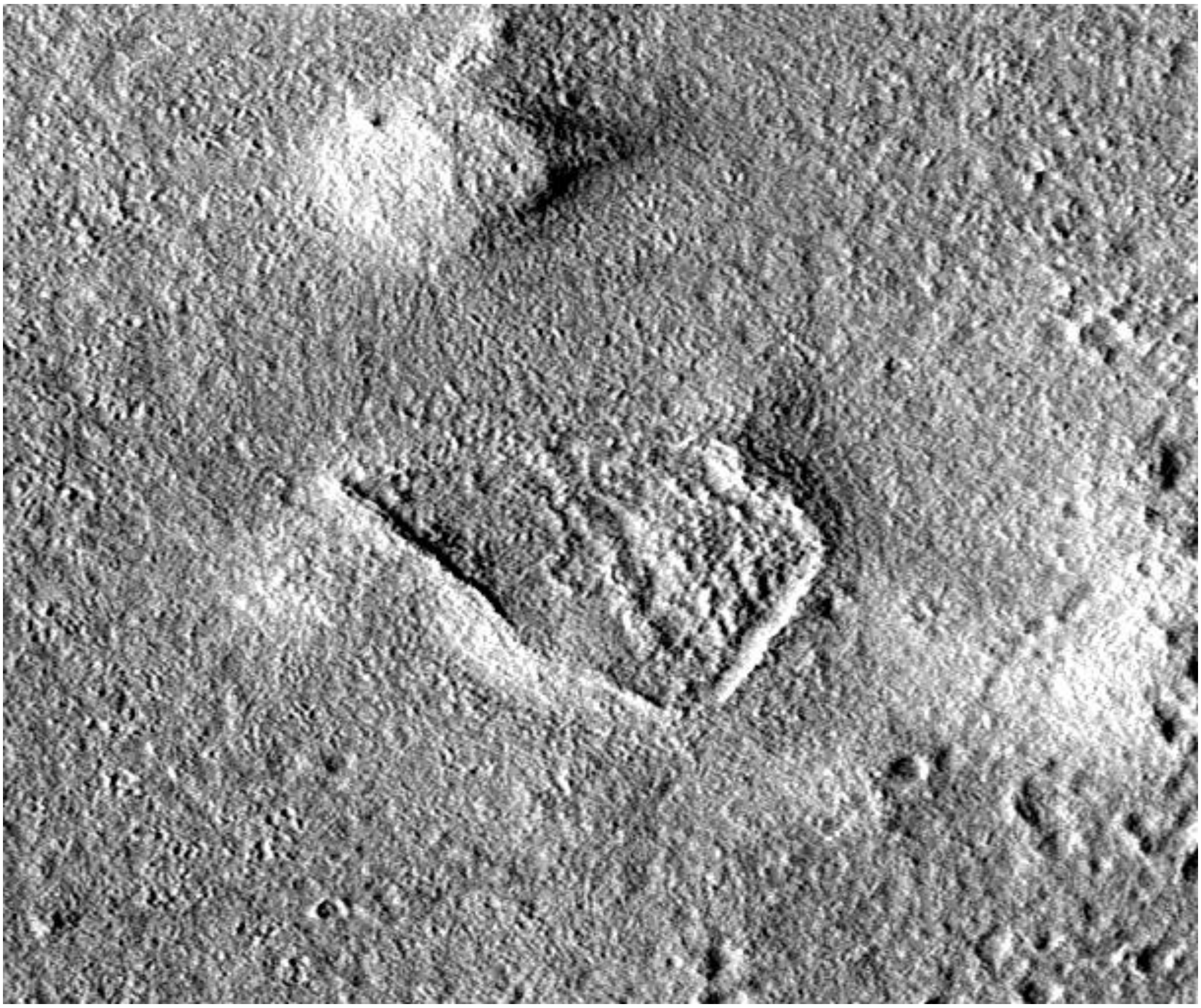

Figure 59. Open pit with walls around it

Three related formations

There are some many amphitheater shapes in the area it would be impossible to list them here. In Figure 60 on the left there are arcs on the surface. In the middle, there is a rounded dome shape surrounded by a flat area, some steps appear to the lower side of it. If an ice lens formed this circular center, then it could not have formed the flat areas around it. On the right is another hollow area with walls, perhaps a former hollow hill. This is not circular like a typical pingo scar.

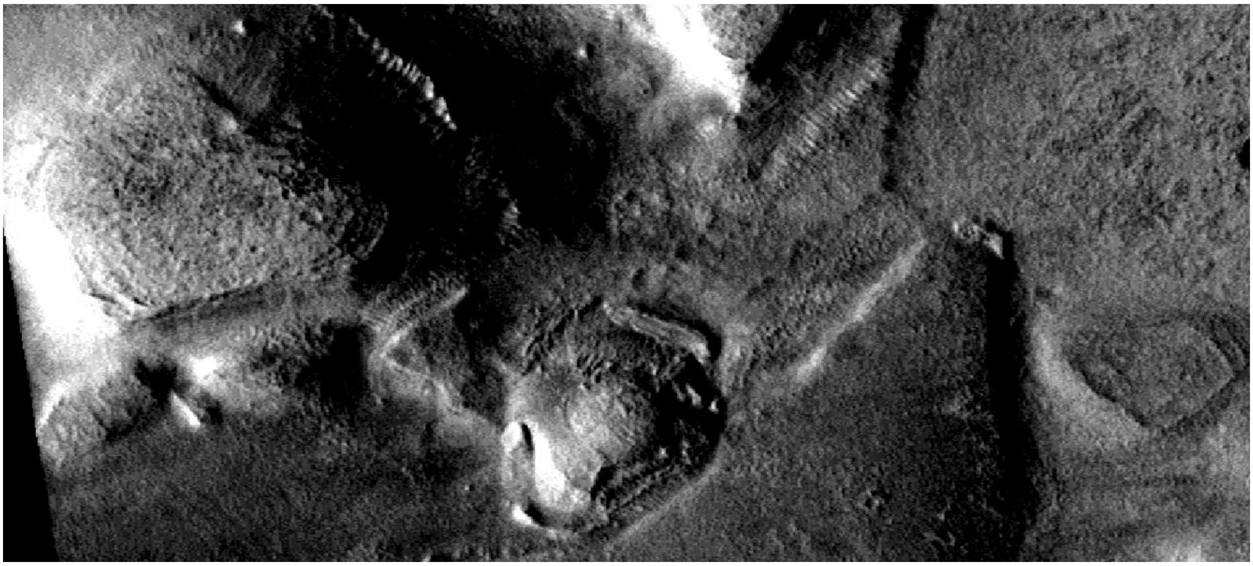

Figure 60. An amphitheater, a dome, and a hollow with walls.

Three more amphitheaters

This in Figure 61 makes 30 in total.

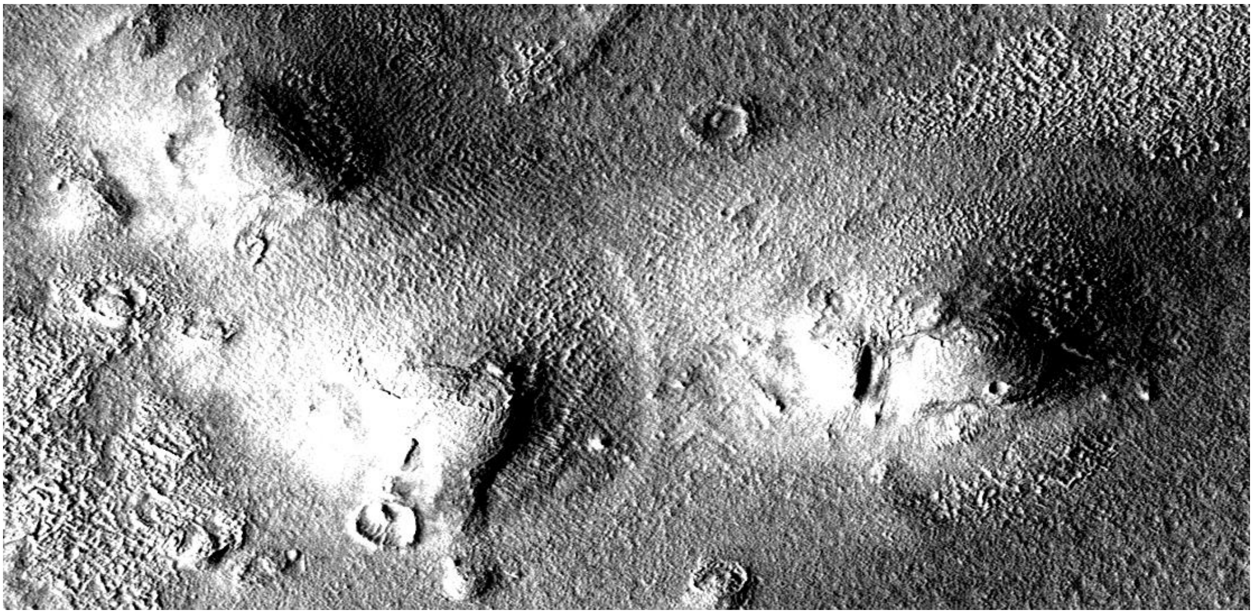

Figure 61. Three amphitheaters

Three more amphitheaters

This in Figure 62 makes 33 in total.

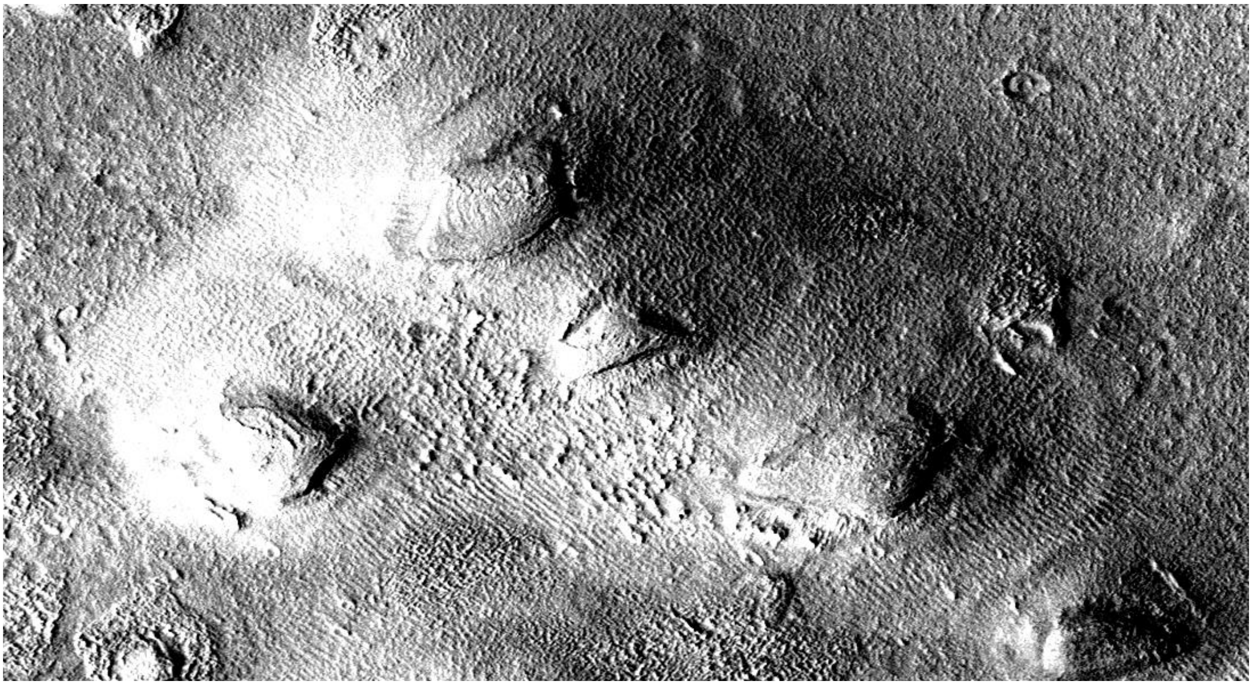

Figure 62. Three more amphitheaters

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So far there have been few HiRise images taken of these formations, Figure 63 shows another of these walled depressions next to a hill. This is again very unlike a pingo such as Figure 3, nor like the rounded shapes of palsas such as in Figure 4. A shows a decaying wall under the higher resolution, B shows the probably hollow hill it is connected to. C shows another hollow that connects to the larger two depressions with two walls like the one at D. E shows an apparently collapsed corridor going from one depression into the main hill, hard to explain geologically. It then looks like a corridor connecting the various rooms in the overall building. This should not be a fault or Riedel shear because it does not extend in both directions to show a slippage.

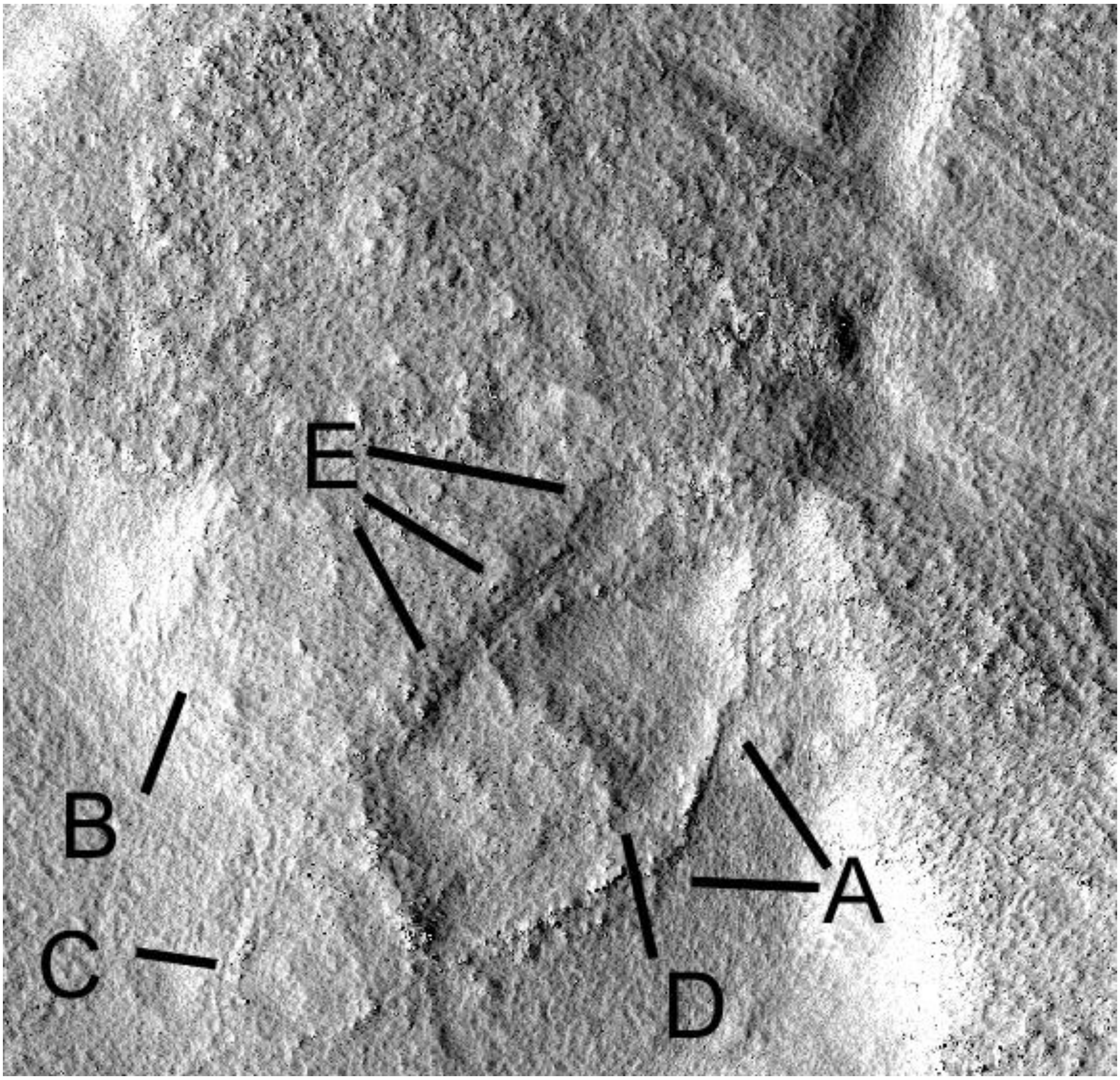

Figure 63. A corridor.

A square rule for the height of buildings and the thickness of the roofs

The large size of these buildings and steps implies these creatures could have been much larger. Assuming Martian gravity is 1/3 of our own then the load on their skeletons would have been 1/9 of ours. They could then have evolved to be 3 times taller with the same kind of skeleton, dinosaurs grew larger by having much thicker bones.

To compare then with our own, these buildings could be reduced in size 3 times. Figure 34, with the flap seemingly moved to the right, would be an equivalent of a 200 meter wide Earth dome. A creature then would use 3 times the space if they were like us, so these larger buildings would accommodate fewer of them.

Martian DNA and the height of the Martians

If Martian DNA evolved to make larger creatures then it might also evolve faster, for example larger brains might become sentient much earlier with more connections. If this was compared with our own evolution, then dividing Earth's evolutionary time by 9 would allow sentience to evolve within the billion-year period of the paleosea in Elysium and Amazonis Planitiae. It's not known if evolution would be faster under lower gravity, however smaller animals would also be more intelligent with larger brains. If this evolution was drive by more intelligent animals selecting mates more efficiently then it might grow much faster. Panspermia with Earth might also have transferred DNA with a propensity to be larger, this would explain how dinosaurs would have evolved, then died out in favor of smaller creatures as natural selection evolved to smaller creatures.

Figure 64 shows the size of man compared to the dinosaurs, this has always been regarded as a problem for evolution as to why they were so large. The theropod body size is believed to have shrank continuously over the past 50 million years, from an average of 163 kilograms (359 lb) down to 0.8 kg (1.8 lb), they eventually evolved into birds This according to Borenstein [30] is based on evidence that theropods were the only dinosaurs to get continuously smaller, this may have been a natural selection effect as they adapted to stronger gravity. It is unknown how large animals might have been on Mars, with higher radiation they might have been mainly in the paleosea where water would protect them. Some dinosaurs were partially aquatic however. Again, this is a speculation based on evolution in low Martian gravity and panspermia.

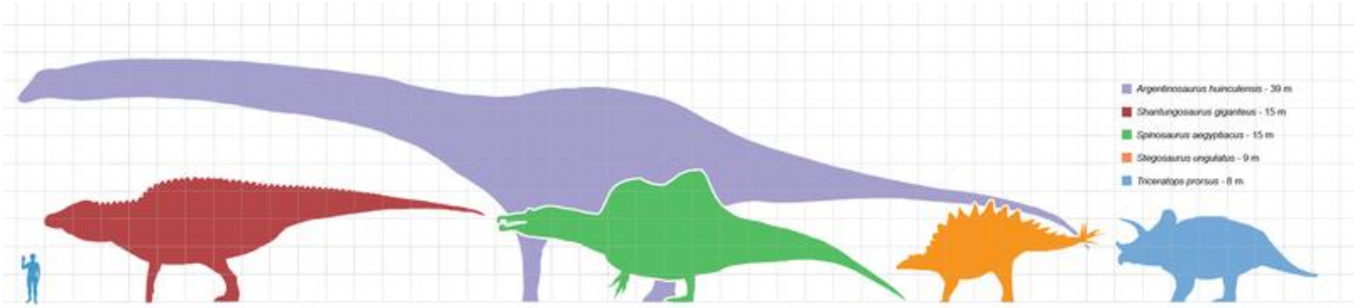

Figure 64. Size of the dinosaurs

Dome construction

Figure 65 shows a Corbel Dome construction, a tomb under the Treasury of Atreus, how the layers are cantilevered or corbeled in towards the center. This was used in the Bronze Age and so is a simple technology to develop.

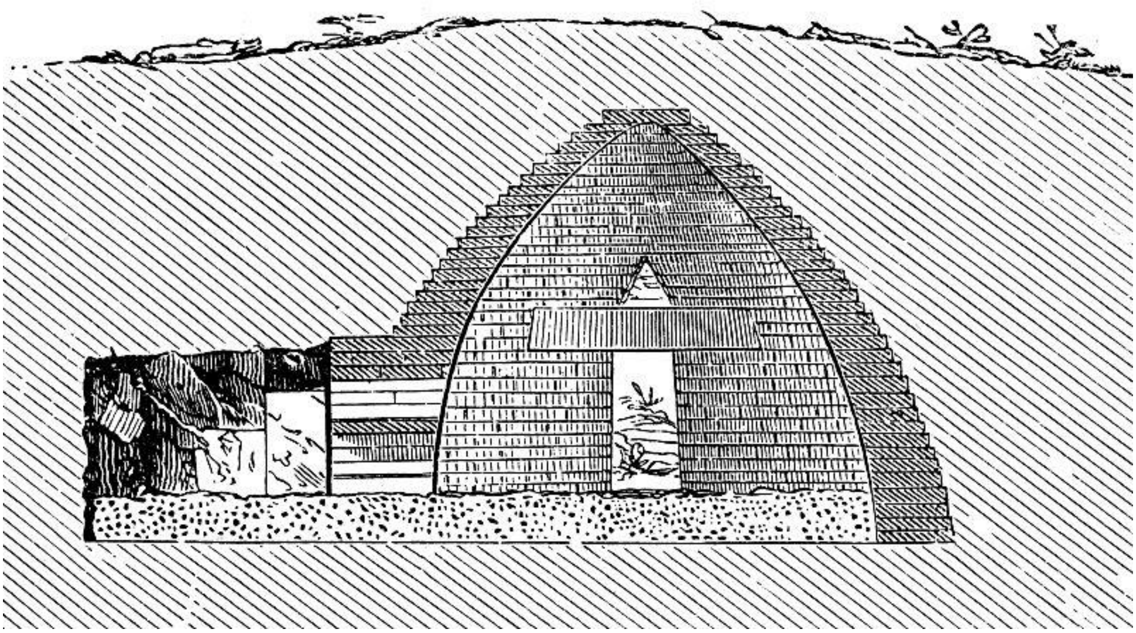

Figure 65. A Corbel dome.

Figure 66 shows inside the Treasury of Atreus, similar large spaces could exist inside these amphitheaters.

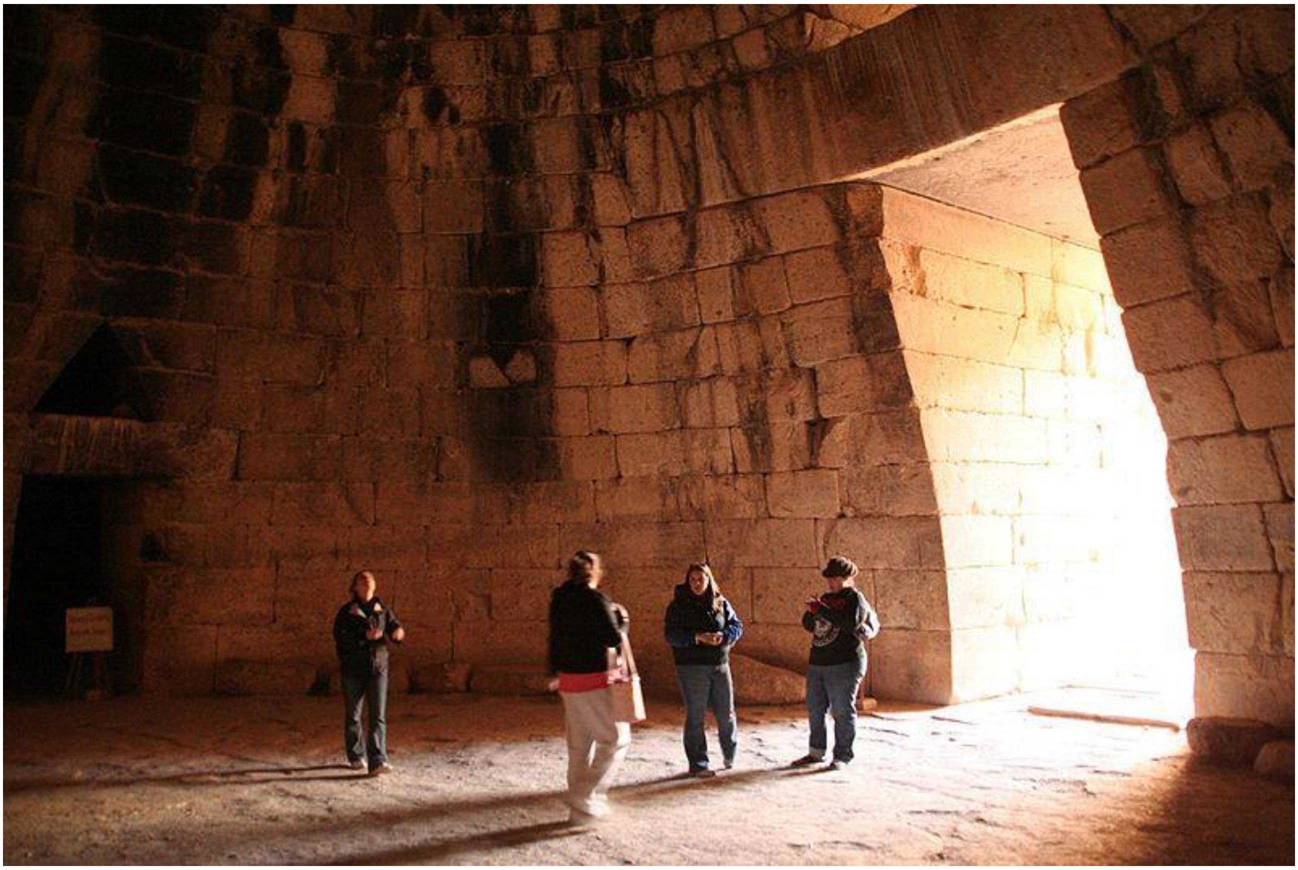

Figure 66. The Treasury of Atreus interior

Figure 67 shows the similar ringed shapes that appear on the tops of the amphitheater formations. This is the dome of the Treasury of Atreus.

Figure 67. The Treasury of Atreus dome

In Figure 68 a Corbeled dome is being constructed.

Figure 68. A dome under construction

Archeological significance

One of the main problems with possible Martian artifacts is their small number. This can give a very skewed impression of that civilization if it existed. For example, in the King's Valley there are many crowned faces and some fish images. Inside these domes may be more complete archeological evidence. Figure 69 shows paintings from Lascaux in France. Paint like this may not have survived, however shapes carved into the walls like the fish shown in Orme and Ness [25] managed to survive in the open. If similar shapes were carved into the interior of these possible domes then they might be in pristine condition, the conditions inside would have remained very dry. If paint was made of clays rather than organic materials it may also have survived.

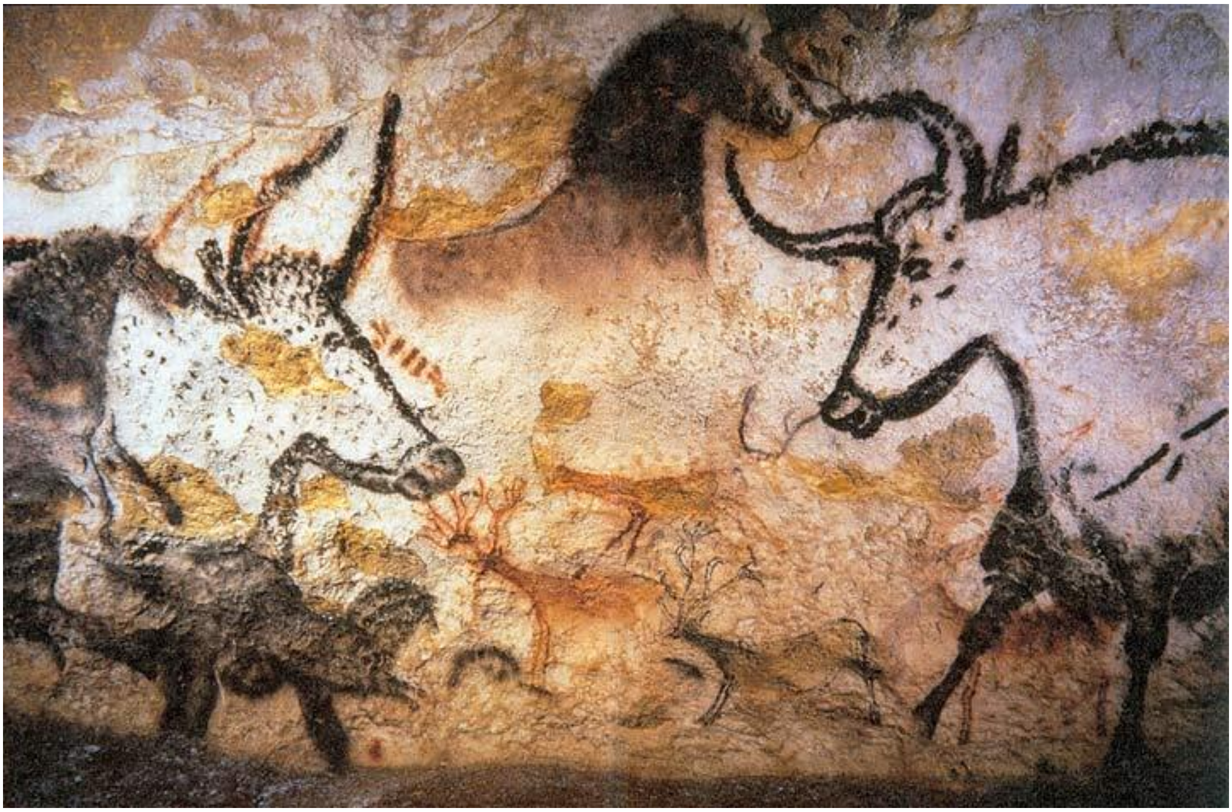

Figure 69. Lascaux cave paintings

In the same way if sculptures like the Crowned Face survived in the open then it is much more likely sculptures would survive inside hollow hills. Figure 70 shows the Palermo Stone from ancient Egypt, tablets like this with language symbols might well survive inside a sealed dome.

Whatever was used in the construction of the Crowned Face, or the rock that the fish were carved in, should have been able to survive as tablets or sculptures protected from radiation. It's not known if clays could survive, however if the roofs of some of these domes are made from mud bricks then sculptures inside of the same material should survive.

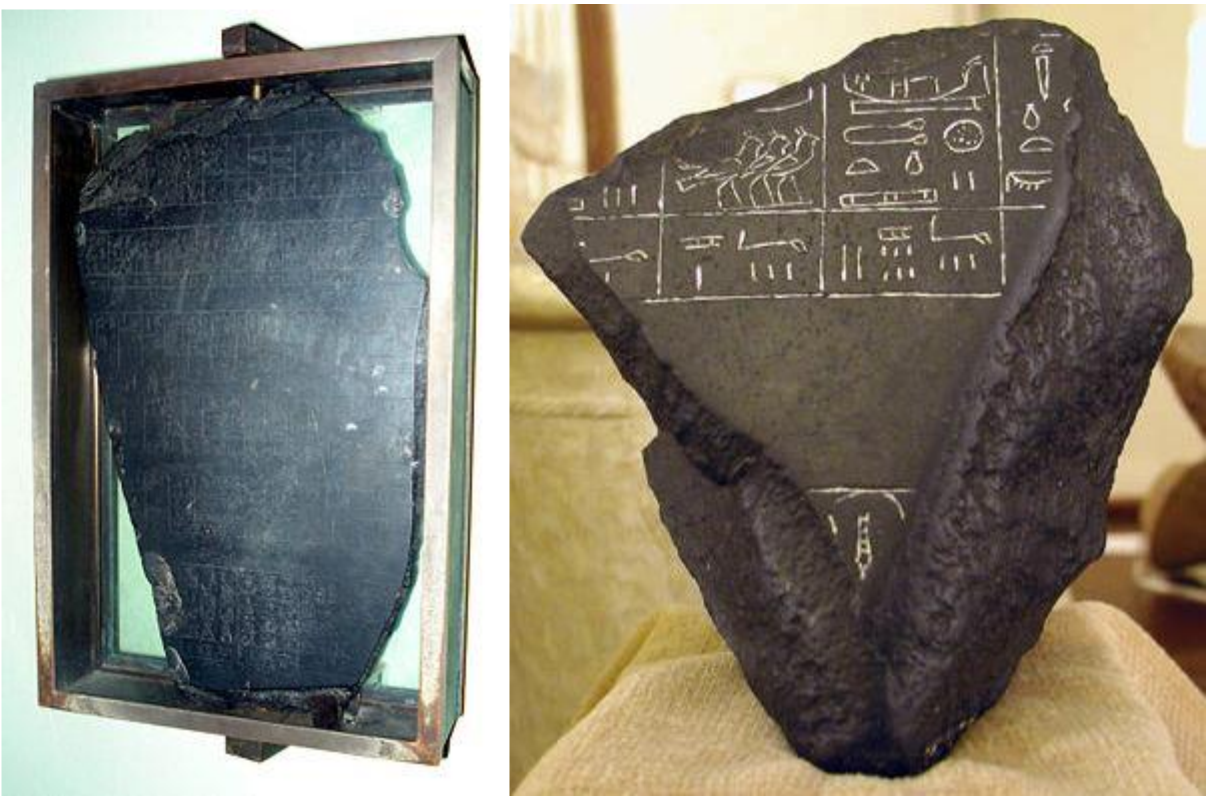

Figure 70. The palermo Stone

There could be graves inside if some were mausoleums, in that case then they might have been buried with many ornaments that explain who they were and where they fitted into their society. If these domes were inhabited then furniture, cooking implements, tools, etc may still survive especially if made from stone or clay. Pottery might survive if it was protected from the elements. Some animals and these creatures might even have fossilized perhaps under collapsed domes. We may then see their imprints in these rocks or actual fossils such as in Pompeii when Mount Vesuvius suddenly erupted. Some possible fossils were imaged by the Martian Rovers, if fossils would survive on Earth they should survive on Mars. Parts of these domes could also be made from concrete, the materials for this are readily available on Mars. If so then concrete furnishings and utensils should survive inside a dome if they are surviving outside it. Orme [11] describes possible dam shapes in some craters, fed by groundwater seeping from an Artesian basin. These water sources have been suggested on Mars, the King's Valley is one valley that may have been formed by sapping from groundwater. Some of these dam walls are in near pristine condition, the interior of these hollow hills then should be in good condition if the same materials were used.

Figure 71 shows one of these Martian dam shapes. A shows a rounded edge on top and some signs of layers, similar to in the amphitheaters and also in the Square Mesa formations. B shows how this dam wall can curve without any sagging through almost 90°. C shows possible vertical ribs in the wall giving its strength, there is also a well-preserved edge on top at D.

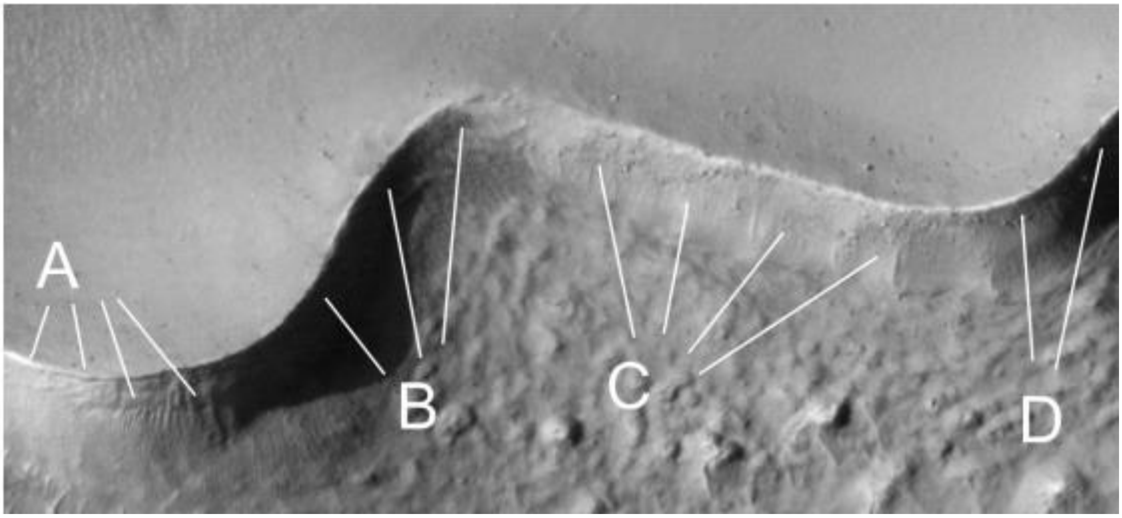

Figure 71. Possible Martian dams

Roof construction

Figure 72 shows part of a roof that may have flipped over, this indicates the roof would have to be flexible. One example of this on Earth would be using chicken wire with a mud or concrete rendering over it. As this flipped over there would be cracks but it would be held together by the wire mesh. Considering the level of technology in these domes wire mesh is unlikely, however a mesh of wood pieces or a thatching of straw could have been used. This would be similar to a primitive geodesic dome, the shape of the dome would be formed by this mesh of wood or leaves then the mud or concrete would be added over it. If so then a lot of organic material should have been trapped inside the mud, there may be imprints of leaf shapes giving clues of the ecosystem at the time. It may also be possible to measure the amounts of each element trapped there and determine the possible organic compounds they were made of. Carbon dating might also be possible from the carbon atoms trapped there, giving a time of construction. In Figure 67 some of these ferns are shown, these are found as explained in Orme and Ness [29] on the same great circle as Nefertiti, Cydonia, and the King's Valley. A shows a blank area indicating these are not from water flowing. B shows a fault that would have cut these formations after they were created. C shows some craters that expose the ground under the ferns. Plants of this shape could have been made into a thatched roof and then mud added on top, this in combination with Corbel domes could have created these hollow hills.

Figure 72. From The Ferns

Figure 73 shows how a thatched roof is constructed on Earth, these could have covered the pits with walled sides. By covering this with mud or cement a stronger roof could be made. As this seeped into the vegetation it could then have flipped over as in Figure 34.

Figure 73. A traditional thatched roof

Carns

Figure 74 shows an entrance in a formation called Carn Euny in Cornwall, a hollow hill in effect made from stones.

Figure 74. Carn Euny

Figure 75 shows how large the interior of a carn can be, this is comparable to these amphitheater formations on Mars.

Figure 75. Carn Euny interior

Figure 76 shows the exterior of a carn formation, this may be similar to the amphitheaters. Individual rocks are not visible in the Mars images, however some of these formations with the outer skin removed have a mottled appearance perhaps like rocks.

Figure 76. l'Isle Carn

Figure 77 shows how beehive houses are formed with mud, these are in Harran Turkey. This can be a similar process of building them to the amphitheaters.

Figure 77. Beehive houses

Permafrost

On Mars, there are many areas with subsurface ice, even near the equator. Elysium Planitia also contains ice deposits so there could be permafrost under these hollow hills. If so then caves or underground rooms might have survived in a frozen condition since they were formed, unless changes in the Martian obliquity warmed this ice. Smith and Mckay [6] discuss this obliquity changes, estimated at up to 45° with periods of around 100,000 years. Underground it would still take time for permafrost to melt, the existence of subsurface ice deposits on Mars indicates these are unlikely to melt completely. According to them permafrost 1000 meters down should not melt. The ancient ice-rich permafrost in the southern highlands of Mars 60–80° S 180° W is suggested to be the most promising because the magnetic field is strongest there. The reasoning is that this area is the most undisturbed, however Orme and Ness [33] advance a hypothesis that this magnetic field died out elsewhere after life evolved. The Argyre impact would have begun this warming of Mars the magnetic field would have died at some time after this continuing to protect life there. This has some support from the polar wander path proposed by Sprenke and Baker [23] which shows the magnetic poles moving, it is proposed this happen after the Argyre impact. Soina et al. [24] also suggest that Martian organisms may have survived in permafrost, with indications of this in Siberian permafrost of 2 million years.

It may be some fossils and implements are preserved in the frozen soil under these hollow hills. Cydonia would have been on the same ancient equator as the King's Valley, its current position in the mid latitudes could have allowed more permafrost fossils to have survived there. While organic material is unlikely to survive, there may be enough of the residual chemicals to carbon date and determine what organic compounds existed there. Willerslev et al [30] discuss how most DNA damage is caused by temperature, water and oxygen. Life that remained as Mars was cooling, and the atmosphere freezing, then has the best chance of genetic material being preserved to some degree, in some areas these temperatures fall far below zero. Generally, they suggest the smaller the organism, such as bacteria, the long the DNA would survive. However, we don't know how compatible this DNA would have been with our own, or whether it was more resistant to damage because of the Martian environment of high radiation. We also don't know how long ago this final end to Martian life would have been, some suggest that Elysium Mons finally cooled just tens of millions of years ago. Smith and McKay [6] discuss how dead Martian organisms might still be found in the Martian permafrost. Arctic permafrost as old as 8 million years may still contain evidence of organisms.

Also, imprints of organic materials like bodies may still survive. Figure 78 shows the Siberian Ice Maiden found in permafrost, though this is far younger than any possible Martian creatures.

Figure 78. Siberian Ice Maiden

A possible ancient ecosystem

Arkani Harmed (2009) examines the positions of former rotational poles. The Pre Tharsis pole is north west of Olympus Mons, this is consistent with the hypothesis of Orme and Ness (2011) where the shock wave from the Argyre Impact was directed at the then South Pole. This impact could have occurred either deliberately or by chance, determining this may need to wait until Mars is visited and perhaps colonized. In Figure 79 from Orme and Ness (2011) this former rotational pole (per Arkani Harmed, 2009) is approximately at A, there is a line from A to Argyre Crater indicating the direction of the proposed shock wave from this shallow impact. B and C show the 3 Tharsis Montes, it was proposed in Orme and Ness (2011) that rifting occurred from this impact also forming the rifts and volcanoes along E and I containing Solis Planum at H.

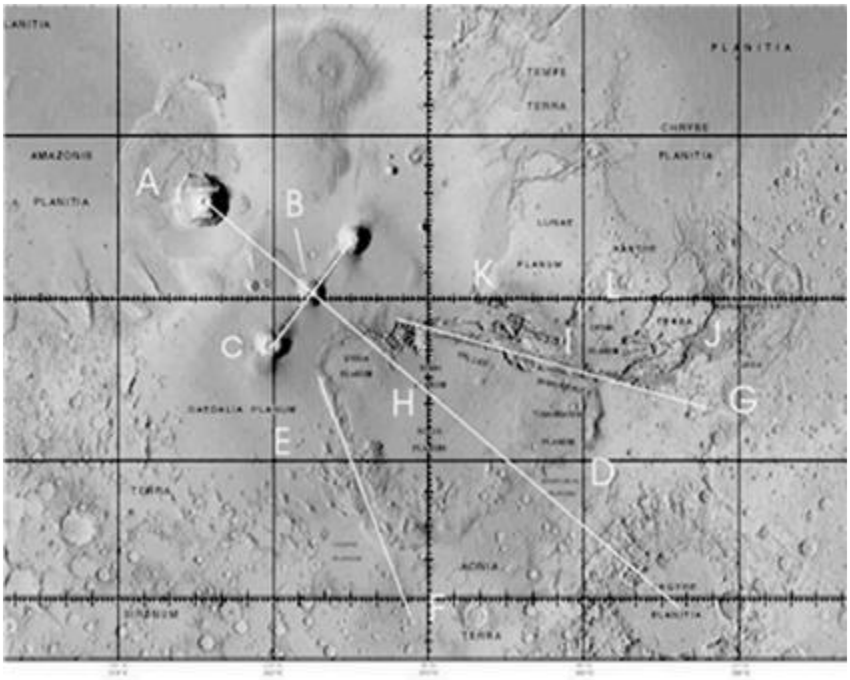

Figure 79. The Argyre meteor impact.

Several studies (Arkani Harmed, 2009) show the rotation axis of Mars has moved. The Coprates Trough, another name for Valles Marineris at I in Figure 79, was according to the author caused by tensile stresses from the polar wander. This is like the hypothesis in Orme and Ness (2011) except that Valles Marineris was probably a former chasma of the pole, the shallow shock wave from the oblique Argyre impact would have created a rift valley. This chasma being the weakest part of the pole would have rifted there from the shock wave, the other parts being covered with ice would have rifted less. E may have been another chasma on the pole. Solis Planum according to this theory may have been the location of the pole.

Schultz and Lutz-Garihan (1982) discussed how the rotation axis of Mars may have moved from Utopia Planitia to Amazonis Planitia, in Orme and Ness (2011) this opposite pole to Figure 79 was situated in Utopia Planitia, it then moved to Amazonis Planitia and then north to its current position. As it moved the pole melted forming a paleosea in Elysium Planitia and Amazonis Planitia. The South Pole would have been displaced by the rise of Tharsis Montes and also moved, this would have been into Chryse and Acidalia Planitia causing flooding and the formation of a second paleosea. There is no clear consensus on the path of this polar wander, Schultz and Lutz (1988) discussed an irregular polar wander path of 120 degrees.

A NASA Press Release on Nov 22 2016 announced the discovery of a large ice deposit in Utopia Planitia, perhaps part of this former pole. It ranges from 39 to 49 degrees North, and approximately 70 to 90 degrees east. Shallow Radar (SHARAD) was used, the deposit ranges from about 80 meters to about 170 meters in depth, with a composition that's 50 to 85 percent water ice.

The hypothesis of Tharsis causing the initial polar wander has been investigated, Melosh (1980) suggested up to 25 degrees of displacement of the pole if the Tharsis load was removed. In Orme and Ness (2011) the poles began to wander as the rise of Tharsis Montes, and Elysium Mons from antipodal volcanism or a second impact forming Isidis Planitia, caused these volcanoes to move towards the equator. The poles as they melted moved along the dichotomy boundary creating many fluvial and lacustrine morphologies such as valleys, lakes, sapping, atmospheric precipitation, the poles also creating the paleoseas.

Arkani-Hamed, 2004 also proposes that this initial pole position around Tharsis was when the core dynamo was weak or non-existing, this would have affected the habitability of Mars by deflecting cosmic radiation and the solar wind. Sprenke et al. (2005) discusses signs of a magnetic pole wandering, it is possible then this warming of Mars was accompanied by a lingering protection of life with this magnetic field. It was proposed in Orme and Ness (2011) that the Argyre impact was accurately directed at melting the pole, whether by accident or design, it is unlikely a deliberate targeting would have been intended to destroy the magnetic field. One speculative hypothesis is a Dyson probe may have been sent out from another civilization, this would have directed a shallow impact at Argyre and possibly Isidis as the most efficient way to terraform and then seed the planet. While unlikely, nothing would exclude this impact having happened by chance, and subsequent evolution may have developed sentient life for a short time.

Arkani-Hamed (2005) discusses how five giant impact basins on Mars (Hellas, Isidis, Utopia, Solis, and Argyre) trace a great circle and proposes these were an ancient equator. In Orme and Ness (2011) this great circle is traced between the two poles, Isidis Crater is near the opposite pole to that in the Tharsis Montes area. It may have been a second impact deliberately aimed to be a shallow impact at that pole. The alternate hypothesis is Isidis Crater already existed prior to the Argyre impact, it is unlikely two impacts would have occurred by chance aimed at opposing poles. This represents a test of the directed impact hypothesis, if both Argyre and Isidis occurred around the same time with their shock waves directed at opposite poles then the chances of this happening by accident would be remote. If the Isidis impact was earlier and not towards the pole then the Argyre impact, and the consequences proposed here, may have occurred by chance. The alien hypothesis then is not necessary; the possible artifacts found so far show no signs of technology beyond those of Ancient Egypt though they would have been constructed billions of years ago.

In Figure 80 an elliptical crater at the top of the image is shown pointing at a red circle, this circle is Apollinaris Mons. To the right of this volcano is another possible pole position, consistent with the polar wander in Orme and Ness (2011) and also with Schultz and Lutz-Garihan (1982). It has the appearance then of another shallow impact directed at the pole as it moved, also impacting on the edge of the polar ice and further melting it. It may offer some evidence of a directed shallow impact at this North Pole rather than having occurred by chance. This area would have contained a paleosea according to Erkaling et al (2014). On the right edge of this image is the initial pole position suggested by Arkani-Hamed (2005). The yellow pins to the left of the elliptical crater represent formations including one called the Square Mesa. These may have been constructed as artificial islands in this paleosea.

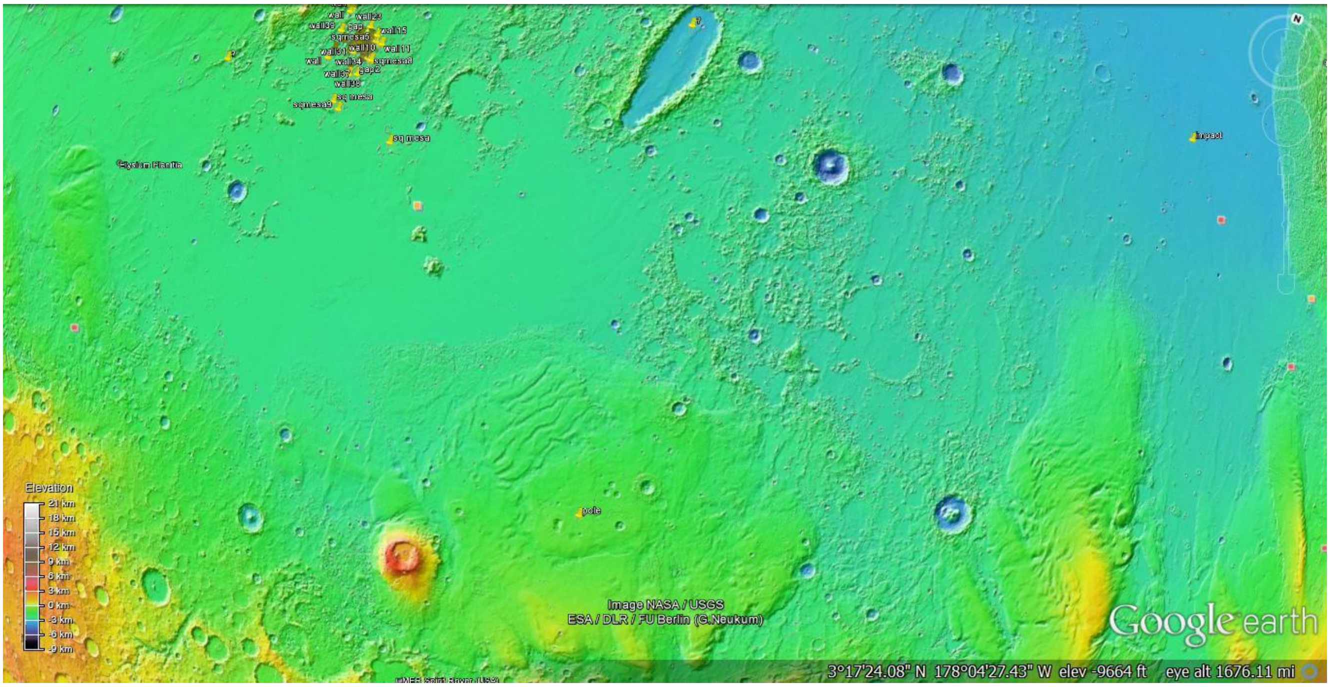

Figure 80. Appolinaris Mons and an elliptical crater.

Figure 81 shows how the 3 volcanoes of the Elysium Highlands; Elysium Mons, Hecate Tholus, and Alba Tholus, form a shape like a rift valley's triple junction symmetrical with Isidis Crater on the left. This may indicate Isidis was a second shallow impact directed at the pole in this area around the same time of the Argyre impact, then the Elysium Highlands would not have been formed by antipodal volcanism as in Orme and Ness (2011). Below the dark line connecting Isidis Crater to Elysium Mons are two other lines, these appear to radiate out from the crater in this direction. Similar radiating low areas also appear out of Argyre Crater towards Tharsis Montes, these can be seen between D and Argyre Crater in Figure 79.

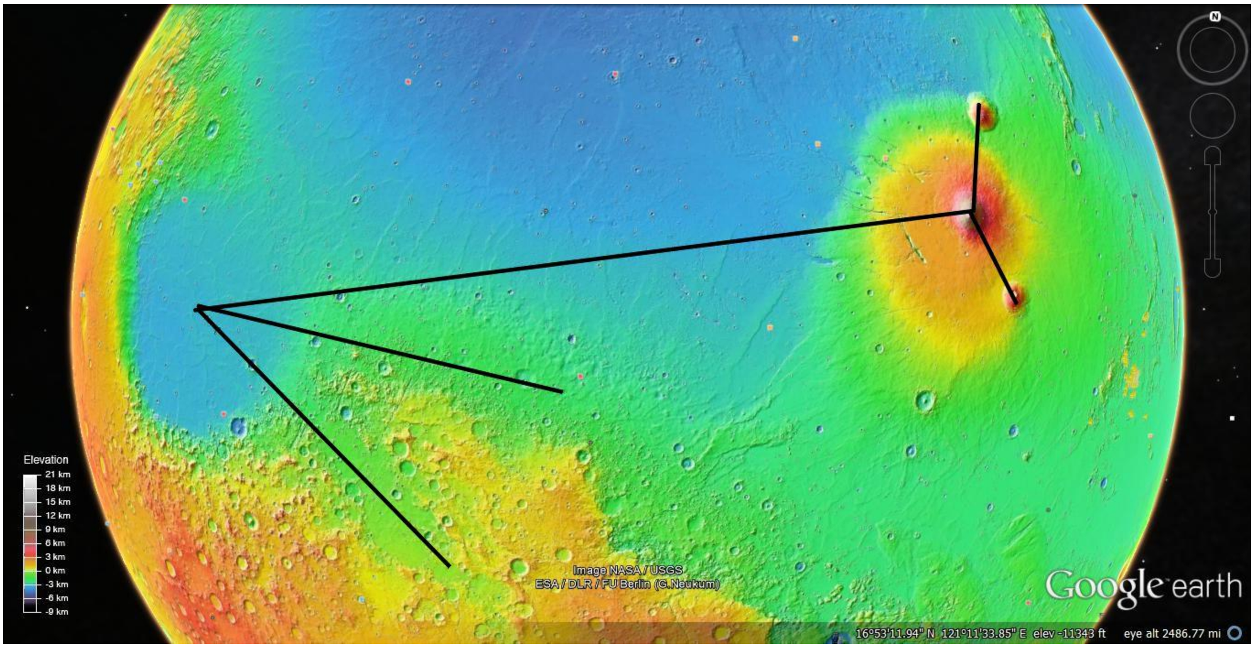

Figure 81. A possible connection between Isidis Crater and the Lysium Highlands

The yellow pin to the right in Figure 82 is the approximate position of a meteor impact in Amazonis Planitia, this would also give a symmetrical shape of the 3 volcanoes of the Elysium Highlands. This is shown in Figure 4 where the right hand side of the arrow would be the approximate impact, the shock wave going to the left creating the 3 Elysium Highlands volcanoes. This gives a similar arrow head shape to in Figure 1, with the 2 outer volcanoes of Tharsis Montes and Elysium Mons. Pedersen and Head (2010) give this approximate location for a meteor impact.

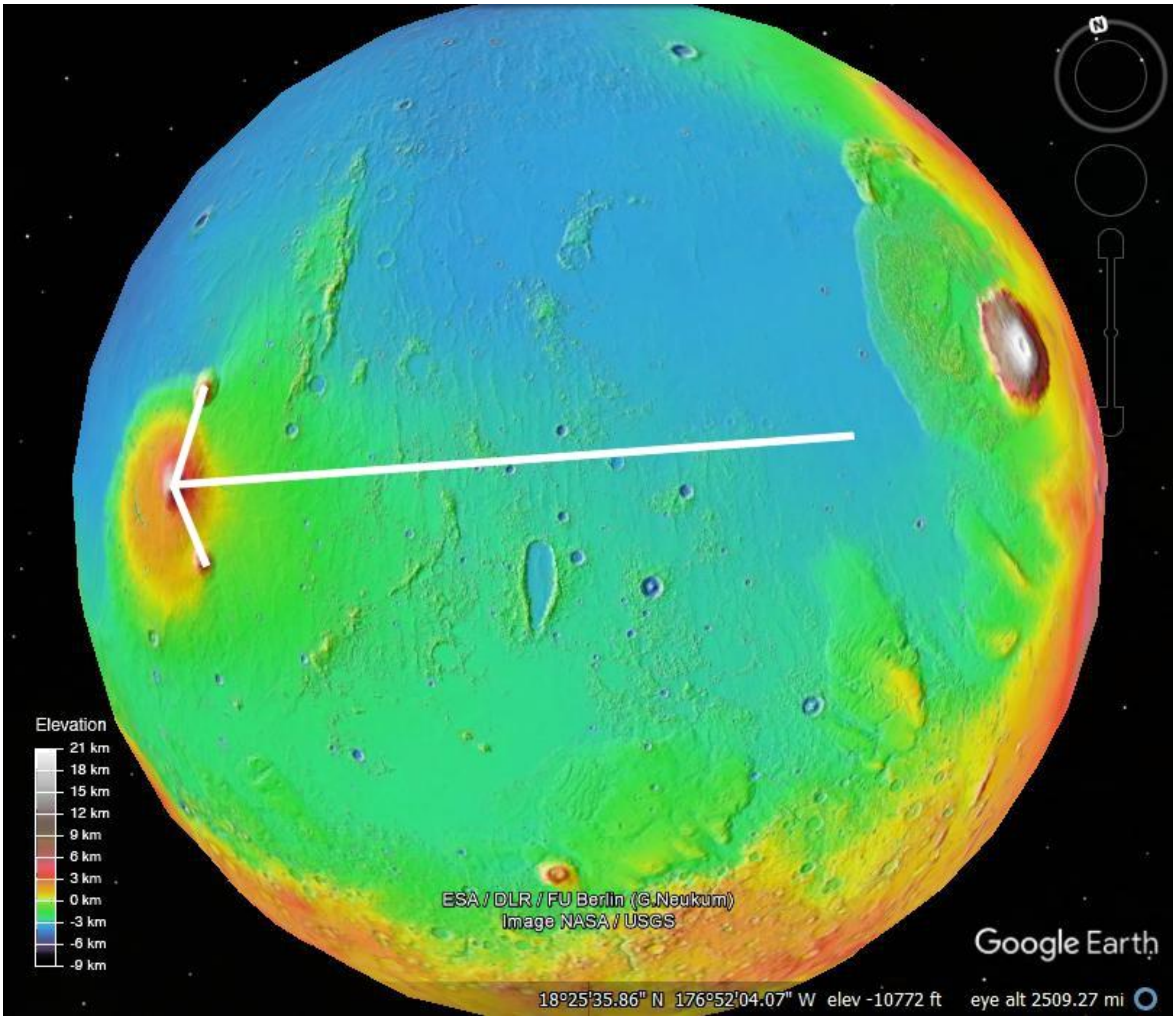

Figure 82. An impact in Amazonis Planitia may have been directed at the pole.

Figure 83 shows how this impact would have directed the shock wave from Argyre Crater on the left at A. This was discussed in Orme and Ness (2011), the red areas are drier as shown in this map of epithermal neutrons. They appear to radiate out from Argyre symmetrically with the middle of the red area being directed at this former South Pole. On the edge of this red area are Tharsis Montes and Olympus Mons, it is proposed these were formed from this shallow impact to melt the pole. B shows possible signs of drier areas radiating out from Isidis Crater, however the forming paleosea here would have prevented most of these drier signs from persisting. Alternatively the drier area at the head of the right hand arrow could have been caused by the impact in Amazonis Planitia.

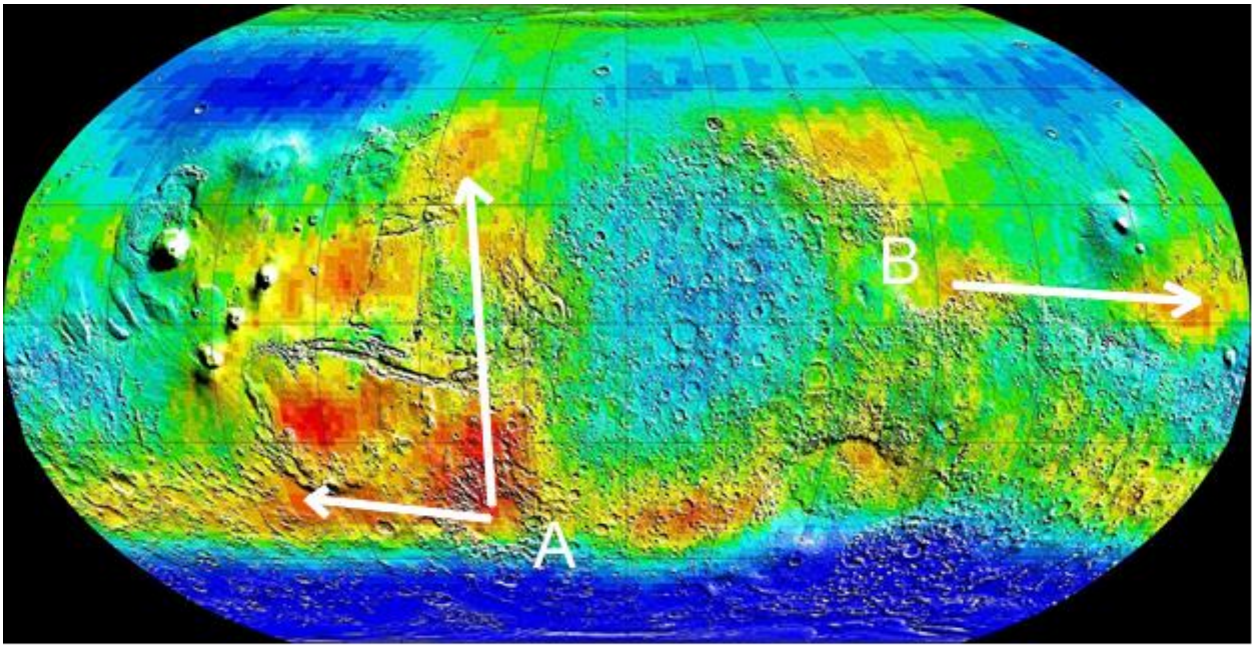

Figure 83. Epithermal neutrons show drier areas from these craters.

Arkani-Hamed (2005) proposes that Tharsis has controlled the subsequent polar wander of Mars, this was also proposed in Orme and Ness (2011) but arising also from the Argyre and possibly other pole directed impacts. When these impacts would have melted the poles, the release of water into the Northern Lowlands would have created paleoseas that also controlled the balance of Mars and subsequent polar wander. The large amount of water in these lowlands may have added to the complicated polar wander proposed by Schultz and Lutz-Garihan (1982). Arkani-Hamed (2005) also assumes that the Tharsis bulge, Alba Patera and Elysium Rise together provided the main driving force of the polar wander of Mars. He considers a quasi-rigid rotating planet with no elastic lithosphere, adding a small positive mass at the surface which in this case would be Tharsis, Elysium Mons, and Alba Patera. It disturbs the equilibrium, then the small mass reaches the equator. A small mass can result in a large polar wander if it begins at a high latitude (Gold, 1955), in Orme and Ness (2011) Tharsis and Elysium Mons would have formed at the poles and so would have had a large effect on the polar wander. Tharsis might have moved earlier to its current position along with Elysium Mons to near the equator, they may then have remained near the equator while the poles moved in an arc to their current positions. It may be that the melting of the poles and forming this northern ocean reduced this mass deficit around the current pole, filling it with water, and so the polar wander initially occurred along the dichotomy boundary. Later as this ocean increasingly sublimated to the poles the current North Pole may have moved into the center of this negative mass. It is then the converse of how a positive mass tends to move to the equator, a negative mass or hollow would tend to move to the pole, the North Pole to the Northern Lowlands.

Arkani-Hamed (2005) proposes the Tharsis bulge was formed by about 4.2 Ga which is consistent with the Argyre impact occurring then. He also proposes that Alba Patera and Elysium Rise were also formed at that time influencing the polar wander, this is consistent with the shallow impact hypothesis in Orme and Ness (2011). This early movement of Tharsis to the equator is consistent with the Argyre impact, the pole would instead have moved along the dichotomy boundary until Tharsis reached the equator, then it rotated while remaining at the equator in both hypotheses. Later as the paleoseas sublimated, when the volcanoes cooled, the poles would have moved to their current positions. The possible artifacts on Mars were shown in Orme and Ness (2011) to form a great circle implying a South Pole position west of Hellas Crater. This may have been a long-term position of the pole with Tharsis remaining near the equator and then rotating as proposed. Because of the large amount of water in these paleoseas, both their mass and the volcanoes may have directed this polar wander. Arkani-Hamed (2005) also proposes this polar wander occurred over 300 million years, this can be compared to the estimates by Erkaling et al (2014) of a paleosea in Elysium Planitia lasting 1 Ga.

McAdoo and Burns (1975) propose the loading of the lithosphere by this polar wander resulted in the surface fracture of Coprates trough complex, also known as Valles Marineris. In Orme and Ness (2011) this is proposed to be a rift valley formed from the previous chasma of the pole in this area. This surface fracture would then have occurred in this position because of the previous polar chasma here, the other parts of the pole may have prevented some rifting from the weight of their polar ice. Some similarities are noted by McAdoo and Burns (1975) to parallel graben or rift valleys, they mention the East African Rift System also remarked on in Orme and Ness (2011) as being like Valles Marineris. The characteristics of a rift valley, according to McAdoo and Burns (1975), are similar to the antisymmetric, S-type figure of Coprates. In Orme and Ness (2011) this shape was also proposed to come from the asymmetric shape of the original polar chasma from the Coriolis Force on rotational poles.

Schultz and Lutz (1988) suggest the youngest near-equatorial deposits occur southwest of Olympus Mons (15°W, 0°S); more eroded deposits with a slightly greater age occur east of Apollinaris Patera (180°W, 6°S). The first deposit according to the authors is similar in position to A in Figure 1, however much of the former pole position here would have been erased by the rise of Tharsis. In Orme and Ness (2011) the pole originated in the Tharsis area and then moved to Lunae Planum. The signs of a pole in this area would have been obscured by the formation of a paleosea. Apollinaris Patera in Figure 2 is near the possible pole deposit discussed (Orme and Ness 2011). Very old deposits also occur south of Elysium (210°W, 0°S) and are mirrored in the opposite hemisphere by the chaotic terrains of eastern Valles Marineris. In Orme and Ness (2011) these are different poles; however, the actual path is open to conjecture by many authors. This eastern Valles Marineris would have been the pole that moved to Lunae Planum creating floodwaters, then to Acidalia Planum and to the east along the dichotomy boundary. The deposits in Elysium would have come from a pole in Elysium or Utopia Planitia. Schultz and Lutz (1988) propose that frozen volatiles in pre-Lunae Planum were absorbed when higher lithospheric/atmospheric temperatures favored melting. In Orme and Ness (2011) this would have come from the Argyre impact and the rise of Tharsis increasing temperatures and air pressure, this would have caused floodwaters in Lunae Planum.

Schultz and Lutz-Garihan (1982) discuss how 180 grazing impacts are found on Mars, representing 5% of all impacts. They interpret these as being satellites that degraded over time, some of these forming great circles. They also estimate 95% of the mass of these grazing impacts occurred before the formation of Lunae Planum, this is consistent with Orme and Ness (2011) where Lunae Planum would have been formed along with Valles Marineris by the rifting associated with the Argyre impact. It was also proposed (Orme and Ness 2011) that some of the ejecta from the shallow impact of Argyre would have gone into space, with the shallow trajectory some of this may have formed elliptical orbits and then more circular orbits over time with atmospheric drag. Eventually these satellites would have reentered as meteors forming more grazing impacts. They estimate the total mass of these impactors would have been over 225 km in diameter which is comparable to the size of the Argyre meteor, however much of the mass from the Argyre and possibly Isidis impacts may have gone into orbit after their grazing impacts at the poles. Phobos and Deimos, it is suggested by Schultz and Lutz-Garihan (1982), may have come from this mass. They also discuss how only low grazing impacts of less than 10 degrees form asymmetric ejecta and less than 5 degrees form elongate crater shapes. If the Argyre impact was of a similar angle then the ejecta could have gone into orbit, and then decayed forming these other grazing impacts.

Sprenke et al. (2005) discuss how the geoid of Mars is dominated by the Tharsis rise, to investigate this they produced a non-hydrostatic model without Tharsis. They concluded that stable spin axis positions would be 15 to 90 degrees from the current poles, this is consistent with their having been at Tharsis and at Elysium Mons. In their Figure 4 this places the pole at one time south of the Elysium Highlands near the King’s Valley, this area containing the Crowned Face is discussed in Orme and Ness (2011). They also discuss a 6% component of flattening, how Mars would become more flattened at the poles and how this would change to a new flattening as the pole wandered. Their results are consistent with their former paper (Sprenke and Baker 2000) on polar wandering discussed in Orme and Ness (2011), these give a polar wander path based on magnetic anomalies, geomorphology, and grazing impacts.

Pierazzo and Melosh (2000) discuss melt production in oblique planetary impact events, similar to the proposed Argyre impact directed at the former pole position around Tharsis Montes. They investigate impacts from 15 to 90 degrees, however Schultz and Lutz-Garihan (1982) estimate that oblique craters require a shallow impact of 5 to 10 degrees. They (Pierazzo and Melosh 2000) find the crater size is generally proportional to its volume. Compared to the 90-degree impact, the reduction in melt volume is about 50% for impacts at 30° and more than 90% for a 15° impact. They also say these estimates do not include shear heating, which can contribute to the amount of melt production especially in very oblique impacts. The Argyre and possibly Isidis impacts then would create shear heating along the surface, also rifting the ground producing fractures and volcanoes.

Pan and Ehlmann (2014) discuss detections of Fe/Mg phyllosilicates and hydrated silica in Acidalia Planitia, these may have formed by localized vapor weathering, thin-film leaching, or transient water. This area according to them is less likely to be in a Northern ocean. It is consistent with Orme and Ness (2011) where the pole would have moved through this area, being still partly ice the water erosion would have been transient, moving to the east. This area also shows no clear signs of possible artifacts except for the Nefertiti Formation, while Amazonis Planitia has many possible artifacts as well as more signs of an ancient paleosea. If this was reversed it would be evidence against some of these formations being artificial, being associated with a paleosea makes them more likely to have used this water as part of an ecosystem. They also found many indications of mud volcanism in Acidalia Planitia as did Oehler and Allen (2010). This is supported by Acidalia receiving large quantities of sediments from Chryse Planitia through Hesperian outflow channels. In Orme and Ness (2011) these sediments came from the flooding that occurred as the pole melted from the Argyre impact. This basin wide mud eruption may be like those mud volcanoes found in Isidis Planitia from the opposite pole melting. It can be attributable to overpressure in response to rapid outflow deposition related to events such as tectonic or hydrothermal pulses, destabilization of clathrates, or sublimation of a frozen ocean or the former pole. In Isidis Planitia as well then this sublimation of the polar ice, particularly before the atmosphere had thickened to allow long lived paleoseas, could account for the large numbers of mud volcanoes in both areas. The authors also suggest significant release of gas may have been involved, and this extensive mud volcanism could have provided potential habitats and upwelling groundwaters. Amador et al. (2010) also suggest there were geysers and springs associated with these mud volcanoes.

Carter et al. (2015) discuss how Mars >3Ga has widespread hydrous clays and fluvial/lacustrine morphologies, however the likelihood of widespread oceans on Mars is still being debated. In Orme and Ness (2011) this paradox would be resolved by the moving pole spreading water in some areas, then as the pole moved on these areas again became desiccated. Because the pole would be a colder area this can appear to be a cold and sometimes wet Mars, while other areas heated by the rise of Tharsis Montes and Elysium Mons would indicate a warmer Mars with long lived paleoseas. For Carter et al. (2015) Mars perhaps sustained liquid water flow between the middle Noachian (>3.85 Ga) and the end of the Noachian (3.7 Ga), this smaller time frame can be consistent with Orme and Ness (2011) where some areas had a much shorter experience of standing water because of the polar wander. Other areas nearer the Tharsis Montes, Olympus Mons, and the Elysium Highlands would have retained this paleosea for much longer.

Figure 84 shows a dark area similar in size and length to Valles Marineris on the opposite side of Mars. Figure 85 shows the same shape from the Mars Orbital Camera gallery, the oblique impact from Figure 80 is on the right edge. This would be consistent with the pole in Figure 83 being to the right of Elysium Mons.

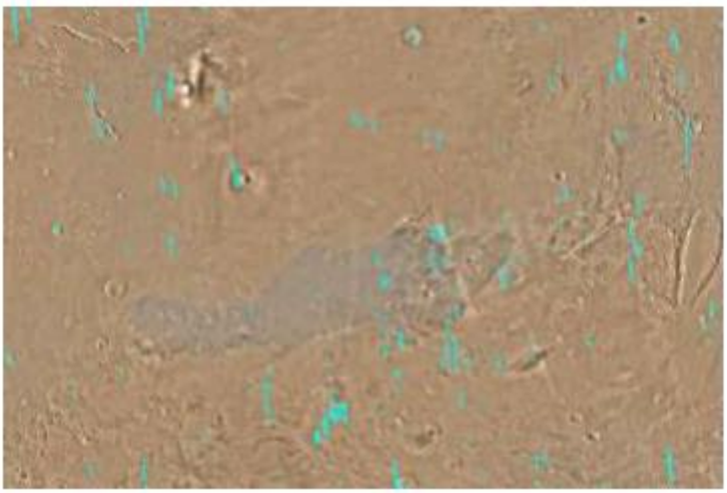

Figure 84. A possible former polar chasma.

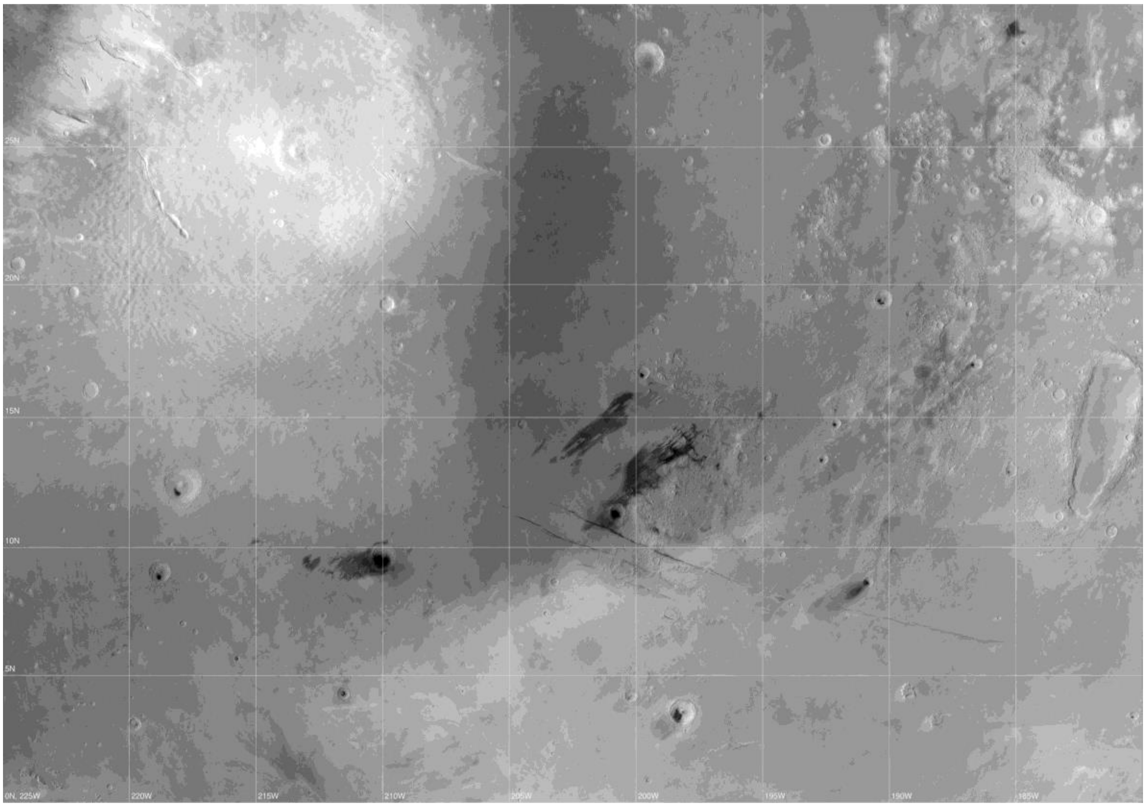

Figure 85. At higher resolution.

Figure 86 shows how this chasma could be at a similar angle while being distant from the pole center. This shows the south pole and Chasma Australe.

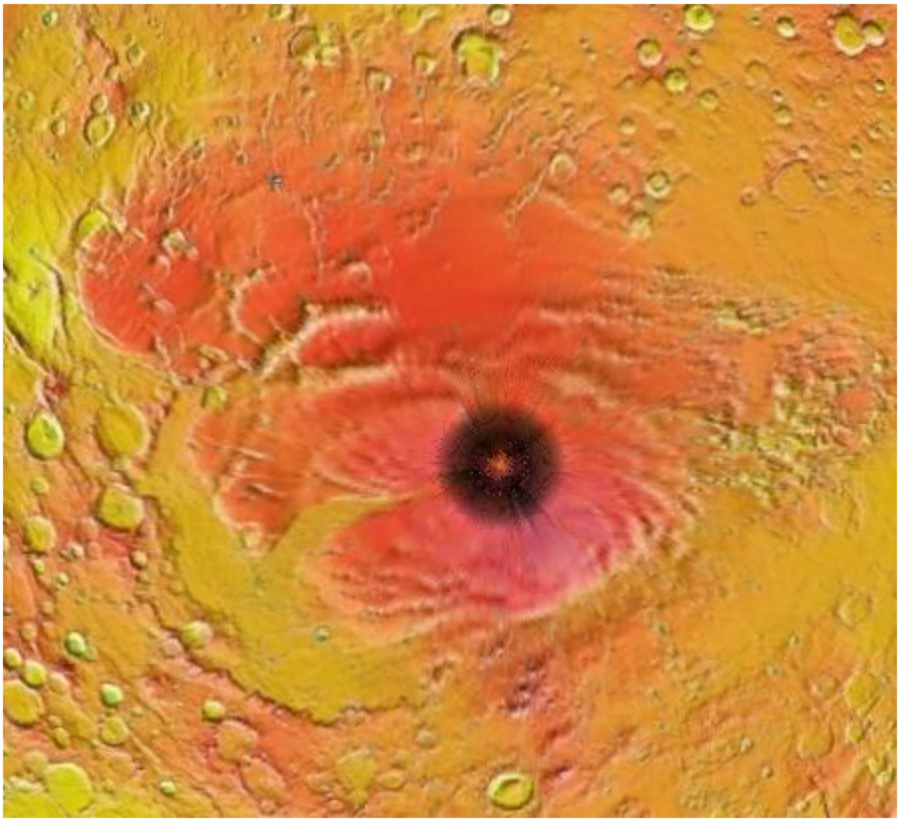

Figure 86. The south pole could have had a polar chasma in this position.

Figure 87 shows Valles Marineris from the original MOC gallery, Figure 8 shows it in the updated gallery. These shapes are almost exactly opposite each other; Figure 6 is at 12N 200W and Figure 88 has a section of Valles Marineris at 12S 50-70W. This gives about 150 degrees of longitude between them, 180 degrees is directly opposite so with the flattening of Mars from polar wander this is close. The dark area in Figures 85 and 86 may be from the original polar chasma of the pole, if as it melted dark soil flowed down the chasma creating this area. Valles Marineris also has signs of dark soil having flowed down it in Figure 88, to the right the ground is much darker perhaps from this floodwater having carried more dark soil to Argyre Planitia. Figure 86 would have been a paleosea so much of this dark soil would have been dissipated, the current rotational poles also attract dark soil blown to them in autumn from dark dunes.

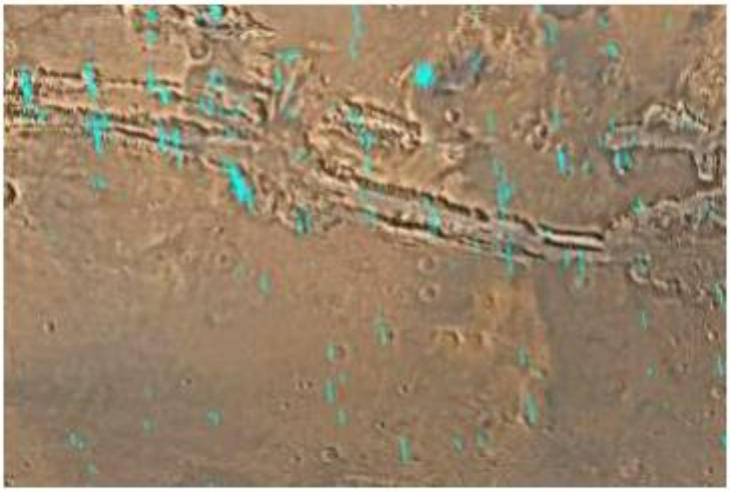

Figure 87. Valles Marineris.

If so then the pole would have been around 5N 210W, this pole position is consistent with Sprenke et al. (2005), also with Schultz and Lutz (1988). It is also consistent with Valles Marineris having been a rift valley (McAdoo and Burns 1975) but formed in a polar chasma as in Orme and Ness (2011).

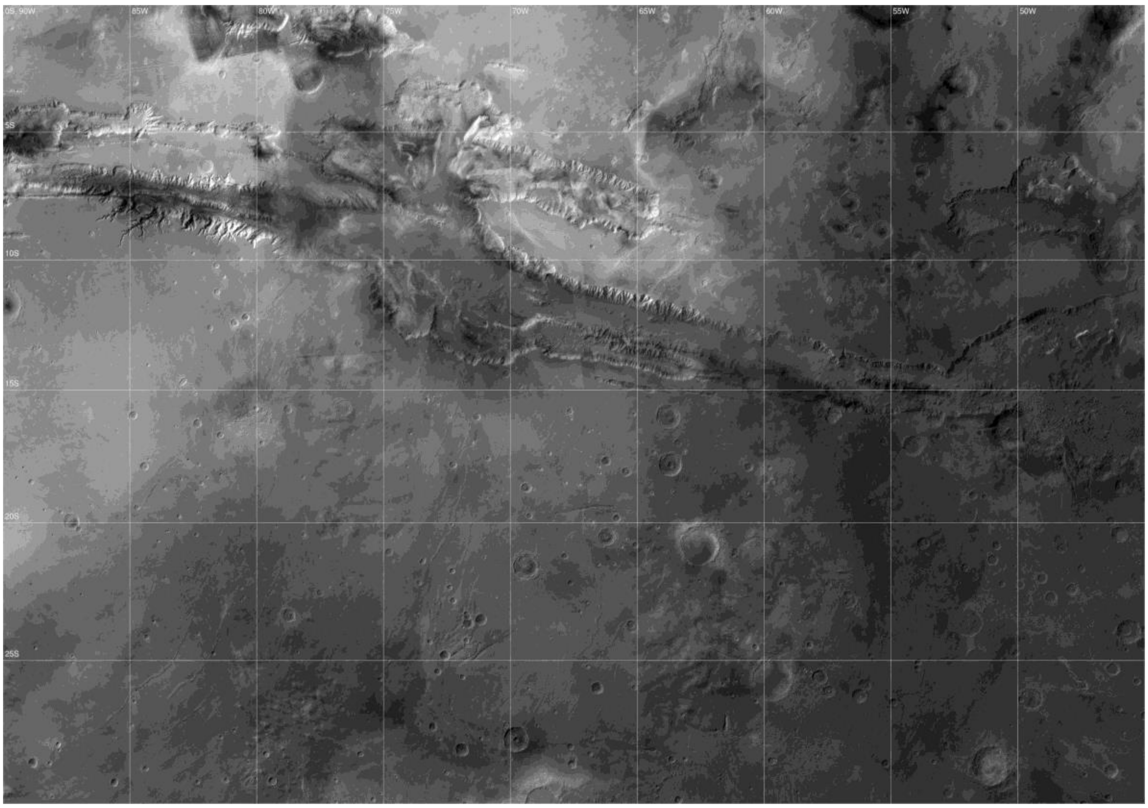

Figure 88. Valles Marineris containing dark soil.

Scanlon and Head (2015) discuss remnant buried ice associated with the Arsia Mons glacier deposits, these may be associated with the ice from the former pole in this area. As the pole melted from the volcanic activity glaciers could form as warm air drew humid air to the area and created rain. Some areas would then direct this as floodwater to the west where the hollow hill formations are found. Other parts would be colder and form glaciers; this could also have happened as the volcanoes cooled. They propose these were formed tens to hundreds of millions of years ago during spin-axis obliquity, however it could also be from this former pole much earlier as proposed by Orme and Ness (2011). They also suggest there could be a core of ancient glacial ice here. There could also be a long- term preservation of water ice by a debris cover (lag) formed from sublimation of dirty ice, also buried beneath volcanic tephra and Aeolian deposits. It could contain preserved biosignatures, this is consistent with the paleosea next to it containing possible artifacts. Their Figure 3.1 shows pits and knobs like the formations discussed here.

Conclusions

Amazonis Planitia has strong evidence for a former paleosea, these formations would be on the edge of the sea also being fed by fluvial valleys with meltwater from Olympus Mons and Tharsis Montes to the east. Along with the King's Valley and the Square Mesa formations they represent a concentration of possible artifacts in an area highlighted by NASA for astrobiological investigations. These depressions are like each other in depth, they have high walls around them of around the same thickness. There is little random variation in these walls in each structure but the overall shapes are very different to each other. The sides are generally curved which would give strength to a wall, this is the principle of an arch or dam. These formations seem to have holes in these walls as if there were doors there, usually only one per room shape. They are either not similar to pingos, the main natural explanation, or have been modified from them.

Putting a roof or dome on these shapes would be easy for us if we colonized Mars, there are also possibly hollow hills near them. If so, then they might have hollows in them we could perhaps pressurize with air and then inhabit. This might then allow for more rapid colonization of Mars if all these hollow hills could be repaired or used as is. There are so many possible structures like this that perhaps tens of thousands of colonists could pressurize these and use the material to protect them from radiation. If they were not strong enough for pressurization, because of their extreme age, then perhaps a thin dome could be placed over them, the structure would still provide radiation protection. Of course, if they were artificial structures, they would likely hold immense amounts of important archeological materials. Investigating these could then unlock many mysteries about the inhabitants, what culture they had, where they came from or how they evolved, and perhaps what happened to them. Resolving these issues then might be a priority before using them as important archeological evidence might be destroyed.

The hollow hills may have had mud roofs that survived, the roofs that collapsed might have been washed away or fallen into the depressions explaining their absence. For example, tidal waves over this area might have carried off some roofs while leaving others intact. Rain might also have dissolved the roofs into mud filling parts of the depressions. Once these waves had gone the remaining roofs might last for a long time. Some hills in these areas may be hollow, many have circular arcs in their upper surface like Corbel domes. Some have collapsed sections that are angular, this can indicate beams holding up the roof.

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The Square Mesa and related formations

Undergraduate science student, University of Queensland, Brisbane, Australia, 4000,
Gregory.orme@uqconnect.edu.au

Abstract

The Square Mesa and related formations are hypothesized to have been islands in a paleosea that lasted over 1Ga. Similar life compatible geology may exist to that found by the Curiosity Rover in nearby Gale Crater. The biotoxicity of Martian soil should have allowed for life to evolve in this area, lithopanspermia may have allowed for microorganisms such as lichen to be transported from Earth to Mars into this paleosea. The wall like shapes on these formations occur only on some islands but not on others close by in the same geological conditions and processes involved in their creation. The Square Mesa shows signs of bricks of the same size repeating, also layers of constant thickness.

Keywords

Square Mesa, Lacustrine, Aeolian, King's Valley, paleosea, biotoxicity, bricks, Elysium Mons.

Introduction

The Square Mesa is a pyramid shaped formation in Elysium Mons discovered by the author. Also shown here are similar formations, they generally have a sandy interior surrounded by a wall like casing possibly composed of rocks, bricks, cement walls and other similar shapes. There is considerable evidence that these formations were surrounded by water in an ancient paleosea. Ivanov et al. [4] find that Utopia and Acidalia Planitiae have indications of the former presence of large reservoirs of water and mud. This is shown by them using impact crater ejecta morphology, in the areas of the former paleosea these become pancake like. Etched flows are considered to be from mud and are found around this pancake ejecta. The age of these reservoirs is estimated to be 3.57Ga in Utopia Planitia and 3.61Ga in Acidalia Planitia.

In Orme [29] it was hypothesized that a very shallow meteor impact formed the Argyre Crater, this would have directed the shock wave towards the south pole situated at the time around the future Tharsis Montes. The melting of this pole would have caused flooding and lakes in Valles Marineris and Chryse Planitia extending up into Acidalia Planitia. This would have caused antipodal volcanism with Elysium Mons, Hecates Tholus, and Alba Tholus. Since the current north pole would have been in this area it would also have melted created a paleosea in Elysium Planitia, Utopia Planitia and perhaps extending to connect to the paleosea in Acidalia Planitia. This impact could have had two causes, intentional or accidental. One hypothesis is that aliens visited out solar system around 4 billion years ago to terraform it and seed it with life. The second hypothesis is that this impact hit the pole by coincidence and created a long lived paleosea that allowed primitive sentient life to evolve and then die out. Ivanov et al. [4] suggest this was a single ocean in the Northern Plains, however these two paleoseas warmed by volcanic activity may not have joined up or they could have later separated. This hypothesis is testable if the paleosea evidence is stronger around these two former poles with fewer signs of a water ocean between them.

Discussion

Plescia [2] examines Cerberus Fossae, a fracture system found in the south eastern area of Elysium Planitia. This would have acted as a conduit for lava and water into Elysium. This water release would have occurred in Athabasca and Grjota Vallis in the north west, and in Rahway Vallis in the south west. According to Orme and Ness [29] this water would have come from the melting pole in the area, the heat caused by the antipodal volcanism forming Elysium Mons and the increased air pressure from the frozen gases at the poles would have caused floods and atmospheric precipitation. This would charge groundwater reservoirs causing sapping as well as rain forming these fluvial valleys seen in Elysium Planitia and Libya Montes. This would also have formed the King's Valley which it is proposed contains possible artifacts, it drained into Elysium Planitia as discussed in Orme [14]. Sprenke and Baker [13] discussed a pole in this area from fitting paleomagnetic pole positions in eastern Valles Marineris as the opposing pole, and another around the Southeast slope of Elysium Mons.

According to Plescia [2] this water was released catastrophically and noncatastrophically from this location close to the King's Valley. It connects then to the proposals of this ancient paleosea being adjacent to the King's Valley for a billion years, in Orme [14]. This fluvial system extends for more than 2500km across the Cerberus Plains through Marte Vallis and into Amazonis Planitia. Orme and Ness [29] proposed the Argyre impact created the Tharsis Montes and Olympus Mons on the former south pole, this floodwater from the melting pole would also have drained into Chryse Planitia along Valles Marineris and in the current west direction into Amazonis Planitia.

These paleoseas would have remained liquid from the volcanic heat as Elysium Mons, Olympus Mons, and Tharsis Montes rose. Because they would have been on the current poles this would have created weather patterns including Hadley Cells as colder air was drawn back to the poles then reheated by the volcanoes. This would have led to a continuing series of floods, groundwater recharging, and atmospheric precipitation of rain and snow. Prescia [2] assesses this flooding to have occurred in the late Amazonian when these proposed artifacts were formed. The Square Mesa and related formations would then have been islands in this paleosea. The hypothesis is these were formed around sandy islands by shoring them up with rocks, bricks, etc around their sides. Some may also have been formed by dredging sand out of this sea. According to [2] the Cerberus Plains are the youngest volcanic surface on Mars, however in Libya Montes the terrain is Noachian and among the oldest. According to the impact hypothesis the resurfacing of the Cerberus Plains would have occurred from the effects of the Argyre impact and the subsequent antipodal volcanism.

Kossacki et al. [15] discusses a possible Martian paleolake in southern Elysium as recent as the past few million years ago. They assess this timescale because of the pristine features, much of this depends on whether variations in the Martian obliquity would have periodically caused melting on the poles, and then a rise in air pressure. However, the obliquity hypothesis is used to explain the fluvial valleys such as Athabasca Vallis in Elysium, instead of this the Argyre impact hypothesis would have this floodwater coming from the melted pole. This would have created a paleosea lasting a billion years with remnant paleolakes lasting longer as the sea sublimated. The northern ocean then would have been formed from this impact, it melted the poles but as Tharsis, Elysium Mons, and Olympus Mons cooled this would have sublimated back to the poles as they wandered according to the path suggested by Sprenke and Baker [13]. Later changes in obliquity might then have not caused substantial flooding and rises in air pressure. This would also allow these possible artifacts to survive for billions of years if the air pressure did not allow for substantial erosion. It allows for some falsification of the artifact hypotheses if these formations could not have survived this regular change in obliquity and increased erosion.

Kossacki et al. [15] also investigates whether there is remnant ice from this paleolake, there could also be ice remaining from the former pole. This paleolake then may have been part of the pole, it would have become a lake from the heat of Elysium Mons, then solidified as ice to be sublimated as the atmosphere froze. HiRise images show platy deposits resembling ice covered Earth seas, seen in Figure 1.

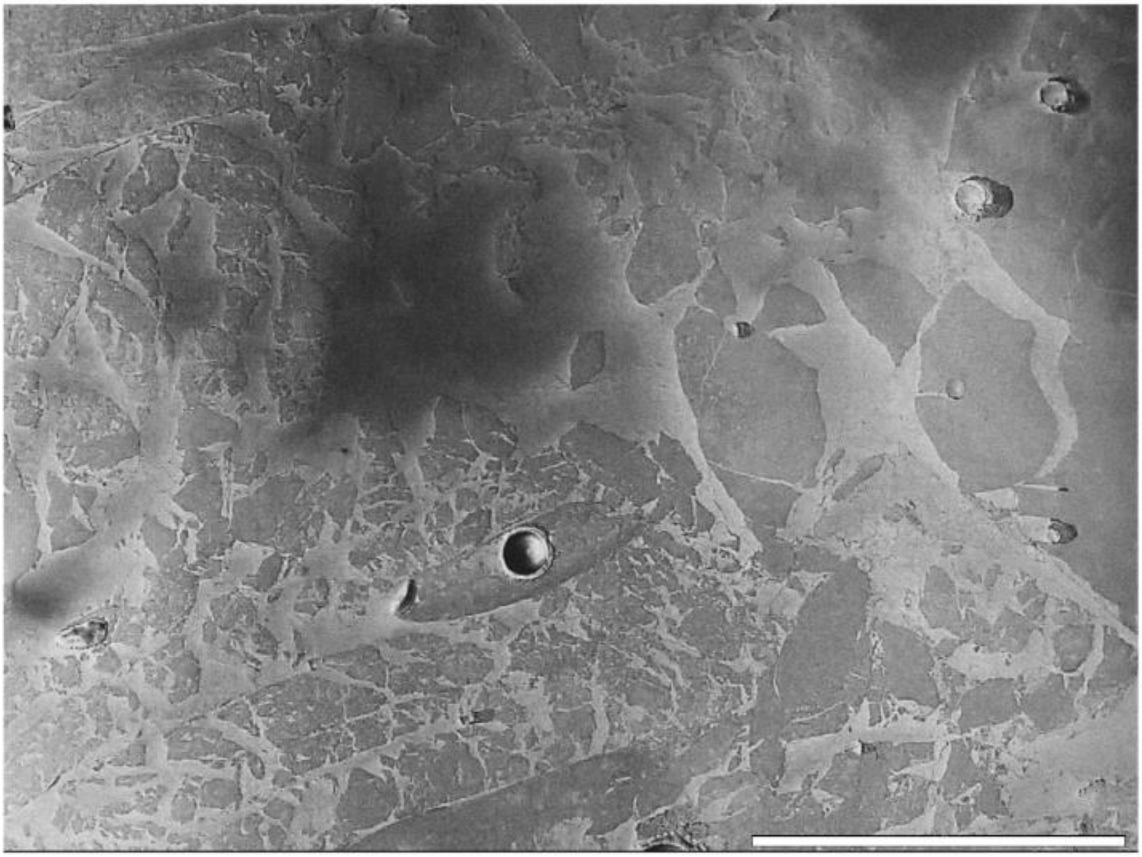

Figure 1. Platy deposits.

Their work is consistent with this hypothesis of a former pole; they test whether a frozen mud lake remained after this long-term sublimation of the larger frozen paleosea. Fine grained sediment would form an ice and dust mixture allowing some of the ice to be buried with continuing sublimation. This ice deposit is considered to have been tens of meters thick, it would then be consistent with the Square Mesa and other formations which would have been constructed in a shallow paleosea. If this ocean then was very deep in this area then the hypothesis would fail, the island like formations would have been underwater with no need for shoring up their sides. The platy formations in figure 1 would have a similar thickness to this paleosea depth around these possible artifacts.

Kossacki et al. [15] suggest that this regolith layer of original lake sediments has a thickness of 5-50 meters. It may be the Square Mesa and related formations are partially buried with this much sediment, the actions of this sublimation may have been similar but there are no platy deposits around them. This suggests the paleosea may have been warmer and more ice free nearer to Elysium Mons and that this was controlling much of the evaporation and sublimation of the water. Kossacki et al. [15] use the analogy of pack ice flows and the clear water between them, closer to Elysium Mons this would have been less common. Much of this paleosea may have been covered by a fine layer of dust or volcanic ash as it froze, this may mean there are large deposits of ice still under Elysium and other parts of the Northern Lowlands. They suggest that the ice would have sublimated from this sediment in approximately 4000 years. It is suggested in Orme and Ness [29] that this original impact at Argyre Crater could be replicated by us, aiming a shallow meteor impact the current north pole might flood the Northern Plains recreating this paleosea. A similar impact on the south pole might fill Prometheus Basin and Hellas Crater with floodwater as the poles melted, also the frozen air on the poles would sublimate creating higher air pressure and a weather system around these volcanoes as would have occurred with Tharsis and Elysium Mons approximately 3.8Ga ago. In that case much of the Northern Plains might have ice trapped in this regolith and rejoin these oceans.

Balme et al. [25] also examine these platy deposits, Athabasca Valles is suggested to originate from the Cerberus Fossae, kilometer wide fractures perhaps related to the formation of Elysium Mons. The pole then may have melted preferentially around these Fossae causing these floods, they would be similar to fractures around Tharsis Montes that are also related to flooding from that pole. Some have suggested these platy deposits are flood lavas not paleosea deposits, the authors find no relation to vents and conclude the platy deposits were sourced from the Cerberus Fossae and were transported down Athabasca Vallis. Mapping of rubble piles also appears to have been transported from Athabasca Vallis.

This is also consistent with the Argyre impact hypothesis and the subsequent rise of Elysium Mons melting the pole and forming these Fossae, ice would have melted around them and then been transported down Athabasca Vallis filling this paleosea in Elysium. This area also has MOLA grid slopes of less than 0.05° implying a level surface of water. It also implies that the surface of the platy terrain has dropped by tens of meters, this is again consistent with the elevation of the Square Mesa and related formation using walls of about this size in this former paleosea. As the water sublimated then the terrain would also have dropped around these possible artifacts leaving them higher above the flat terrain of the former paleosea. The edges of the basin are also seen to be tens of meters higher than these plates implying this amount of sublimation and settling, some plates have grounded on top of obstacles and remain connected to margins like land-packed ice. Murray et al. [25] calculated a depth in the basin of 31-52 meters. By analyzing inundated to unbreached craters they found a rim height range of 41 to 65 meters. Some inundated craters formed closed basins implying the lowering of surface through sublimation.

Platz and Michael [3] discuss the eruption history of the Elysium Volcanic Province, how volatiles released in these eruptions greatly increased the density of the Martian atmosphere. This is consistent with the hypothesis of the Argyre impact melting the poles, the volcanic outgassing would have continued for under 200ma. They model the lava flows in Elysium that range from 3.4Ga consistent with this impact. They then suggest that continuous volcanic activity occurred with a peak at 2.2Ga, consistent with a paleosea in Elysium Planitia, Utopia Planitia, and Amazonis Planitia remaining liquid because of this. Further away from Elysium Mons the platy deposits are found implying the paleosea became colder forming pack ice. On Earth this occurs approaching the poles, on Mars this may have occurred moving further away from Elysium Mons, Tharsis Montes, Alba Patera, and Olympus Mons. According to them this volcanic activity rapidly waned 1Gya ago, this may have led to the paleosea freezing and sublimating.

It is possible then from this evidence that a paleosea existed in this area for up to 2.6 billion years, if so then it may have been long enough for sentient life to evolve. Exchange of genetic material with Earth may have also occurred with panspermia, this time of greatest activity by Elysium Mons would have coincided with the evolution of eukaryotes or celled organisms with a nucleus on Earth. More advanced life on Earth occurred in the Cambrian Explosion about 542 million years ago and the dinosaurs about 231 million years ago. There is then a disparity between the time this paleosea existed and the evolution of life on Earth but a long evolutionary period on Mars is supported to some degree by the evidence.

In Orme and Ness [29] it was hypothesized that polar wander occurred after this initial Argyre impact following the path of Sprenke and Baker [13], the south pole would have stabilized at a position west of Hellas Crater. This corresponds to a great circle or equator on which 4 main possible artifact clusters are found, namely Nefertiti, Cydonia, the Ferns, and the King's Valley. Initially then Elysium Mons would have created this paleosea from the former north pole in Utopia Planitia, then this area moved to the equator allowing the paleosea to remain liquid for much longer. This paleosea would also have extended to Chryse Planitia which would have also been in this equatorial zone, alternatively the two paleoseas may have been disconnected with Cydonia Mensae approximately between them. Acidalia Planitia would have been further away from all these volcanoes and the equator, and so would likely have frozen first as it contains more of these platy deposits.

Morris and Mouginis-Mark [23] find that evidence of volcano-ground ice interactions give insights into the timing of these volcanic processes and their effect on climate. Hrad Vallis is a 800 km long fluvial valley that it has been suggested was formed by an explosive magma-ice interaction. This would be consistent with the Argyre impact hypothesis where the rise of Elysium Mons on the pole created this valley from floodwater. They identify 12 craters with signs of an interaction with hot mud flows and ice. The lobate deposit that Hrad Vallis originates from is suggested to be a mudflow, however it also has more craters on it than the underlying unit. This may be because the underlying terrain was still covered with polar ice for a long period. Fluvial valleys like these would have fed the paleosea, this is close to the Square Mesa and other formations.

Balme et al. [16] investigate Martian stone circles in Athabasca Vallis and find they could only have formed in a periglacial environment. Domed and ridged polygons in the area have also been interpreted to be periglacial. It is considered to be unusual that these sorted stone circles are found near the current equator, however this periglacial environment could have been associated with the former pole and the later icy paleosea. They imply a Martian climate that was 40 to 60 Kelvin higher on Mars than the present and that supported a sustained freeze and thaw. These are shown in Figure 2. They are different from thermal contraction polygons found elsewhere on Mars that require only temperature changes. Climate models of different obliquities and temperatures offer no resolution to this problem, this also implies that these fluvial signs are more likely to have come from this volcanically active time rather than regular changes in obliquity since then. They suggest several hundred seasonal cycles or Martian years would be needed to form these stone circles. Because these are found in the flood plains of Athabasca Vallis they are more likely to be the source of the ice and the particulates required. Near-surface ice and liquid water must be preserved for enough time for these polygons to form, hence the several hundred Martian years suggested. Similar landforms have also been described across the Cerberus Plains up to a 100 kilometers away, they support a regional warming of the climate. This could then be from the nearby volcanic activity while other areas of Mars would have remained much colder.

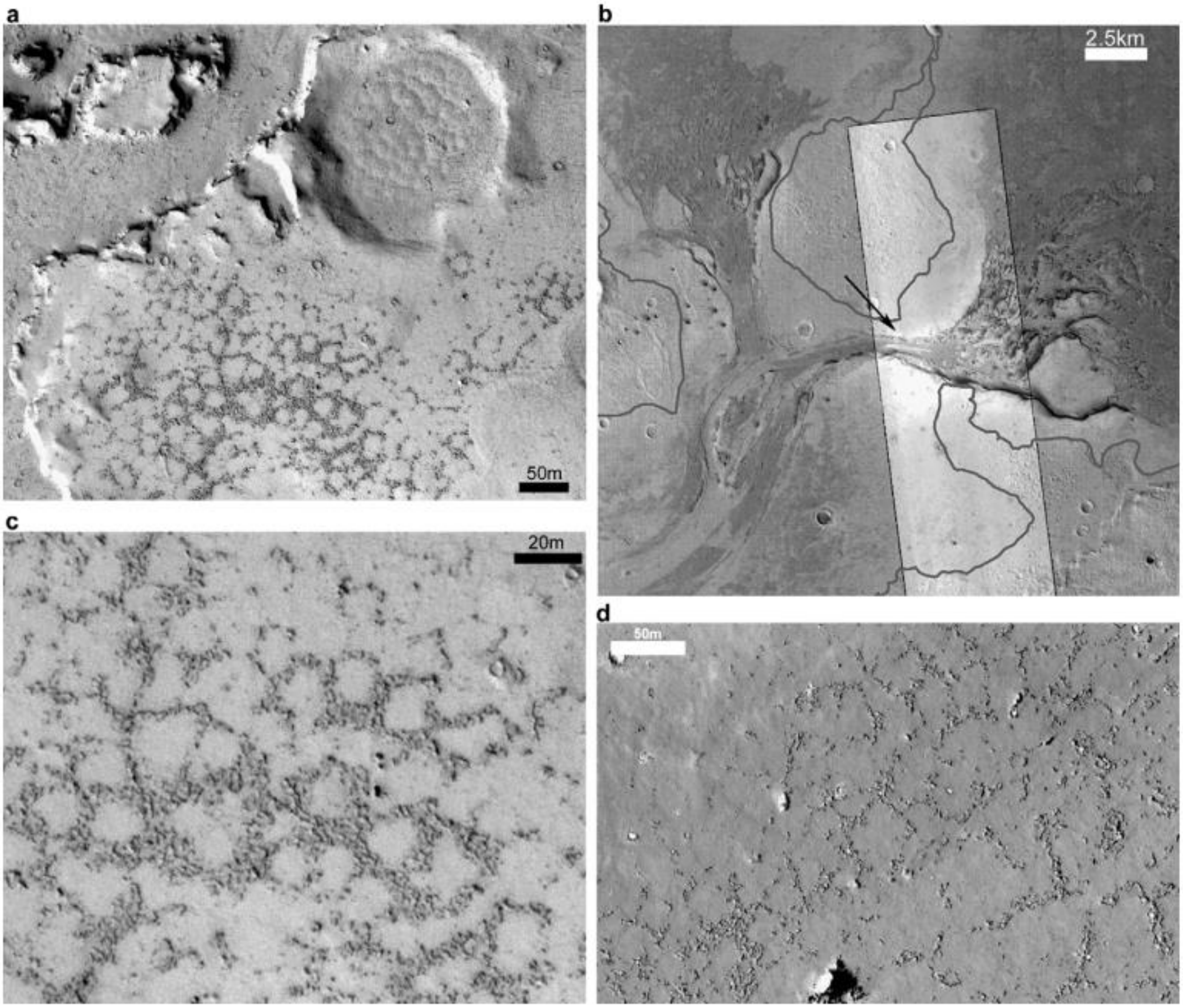

Figure 2a-d. Stone circles and polygons.

Viking spiders

Some additional evidence for a pole in Utopia and Elysium Planitia are the Viking Spider formations discovered by the author. These are similar to the spiders found at the current south pole. In Figure 3 these are shown to be close to the Viking 2 lander hence the name.

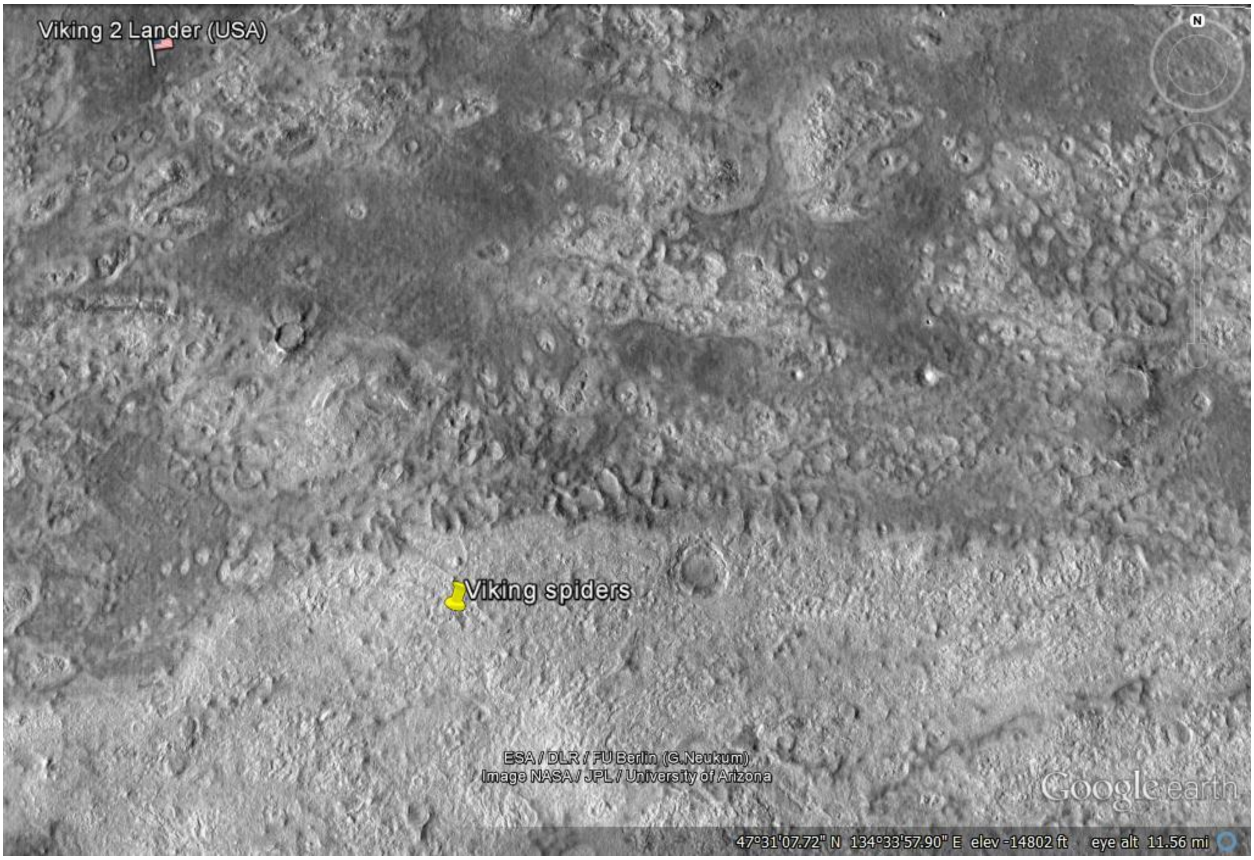

Figure 3. Viking spiders near the Viking 2 lander.

The characteristic spider shapes are shown in Figure 4. Because much of this area was a paleosea only a small section of the polar terrain containing these spiders may have survived. Ness and Orme [18] proposed these spider shapes were formed by CO2 gas being expelled, however this had the problem of how to explain the branch shapes forming.

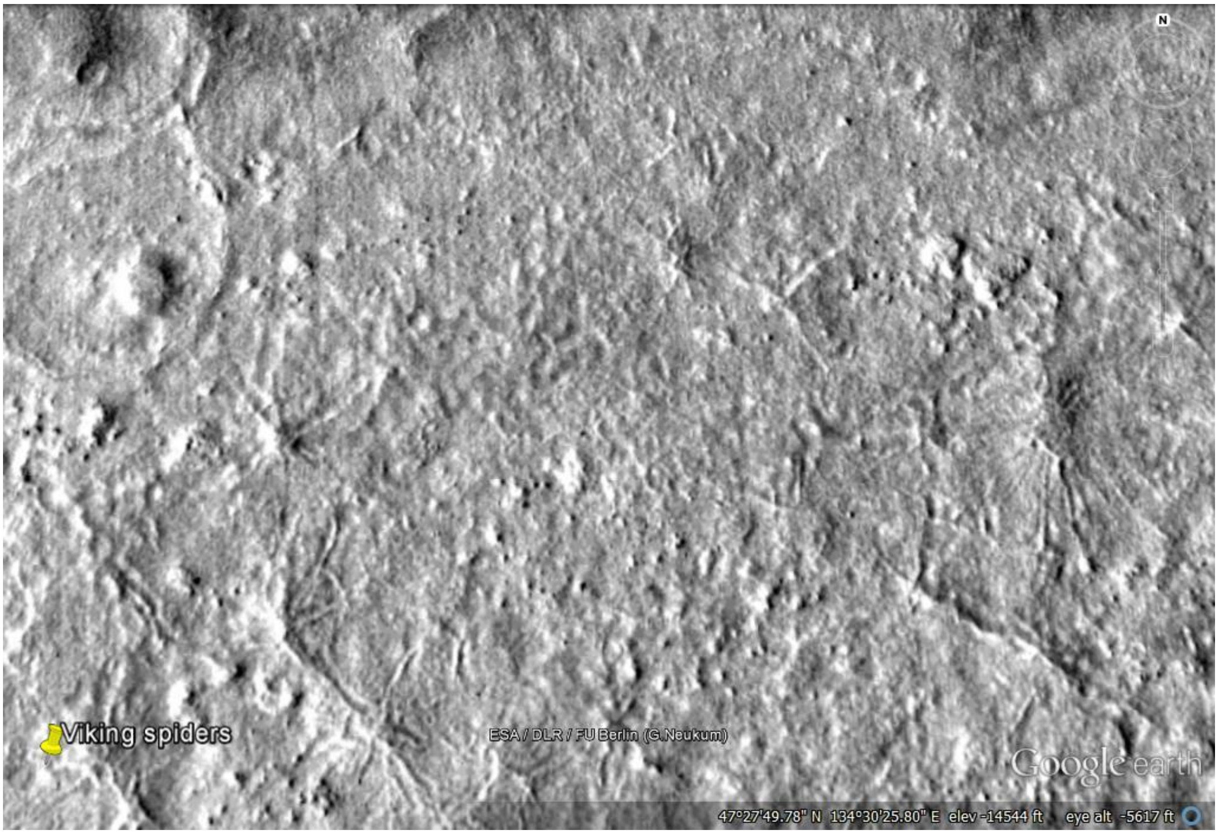

Figure 4. Viking spiders.

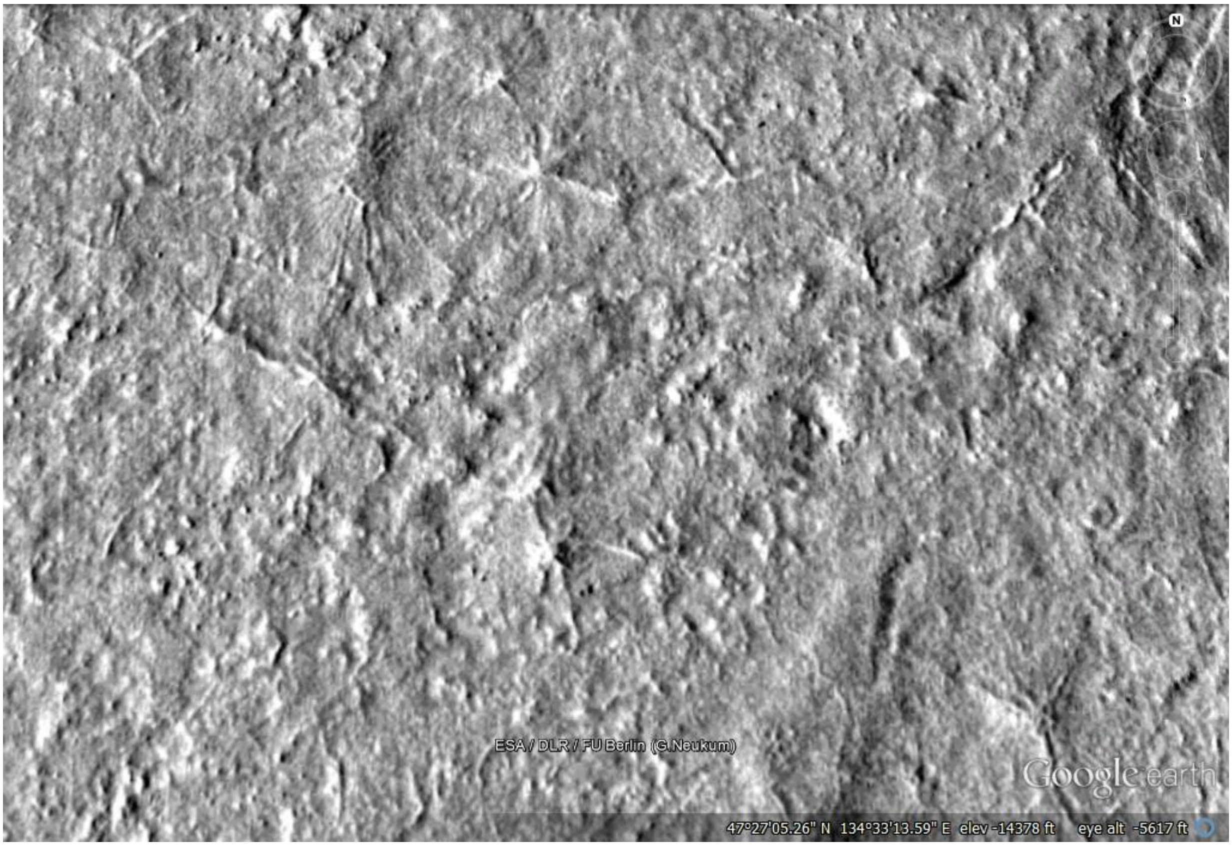

Figure 5. An adjacent Viking Spider area.

Prieto-Ballesteros et al. [19] investigate these araneiform or spider formations on the south pole. They propose these form from the seasonal melting of salty solutions under a transparent ice layer. Piqueux et al. [20] suggest that abrupt explusions of gas explain the fan shapes around the emission center, but they do not explain the carved branched pattern. This CO2 jet hypothesis requires spiders to be in the cryptic region on the south pole, this would be analogous to the area near Viking 2 as shown in Figure 3. Balme et al. [16] discuss polygons in this area of Elysium, my proposed hypothesis is these spider shapes are formed by the expulsion of CO2 gas along the polygonal fractures as shown in Figure 6. 6a shows the spider pattern from tracing out a path from a center where CO2 gas would be sublimating, this would be covered by transparent ice and heated by the spring sunlight. Figure 6b shows a similar spider pattern on the Martian south pole, the dark dust would be pushed by this CO2 or a brine along these polygonal fractures forming the same pattern as in 6a.

Freeze thaw and thermal contraction polygons are common on the current south pole and would form the pattern shown. The sunlight in spring through a transparent ice layer would sublimate CO_2 gas causing it force its way along the polygonal fractures creating the branched pattern. Ness and Orme [18] showed how polygons are always found near spiders but virtually never next to them. It implied that the spiders would be formed either in a similar way to polygons or formed from them. Spiders are also found in a narrow strip on the edge of the pole, this may be where the spring sunlight is warm enough to force the CO_2 gas to open these polygonal fractures. Closer to the pole this sunlight may not sublimate enough CO_2 and further from the pole it may instead cause a CO_2 geyser.

Prieto-Ballesteros et al. [19] propose the seasonal changes in temperature on the south pole melt briny ices, Piqueux et al. [20] proposes CO_2 gas is released without brines. These spider areas according to both would be covered by an ice layer, the sunlight reaches the CO_2 and/or briny layers causing sublimation and melting creating the spider channels. In some cases, this CO_2 gas or brine would be ejected from the ground and dispersed like a geyser on the surface. Neither however has an explanation for the branched shapes.

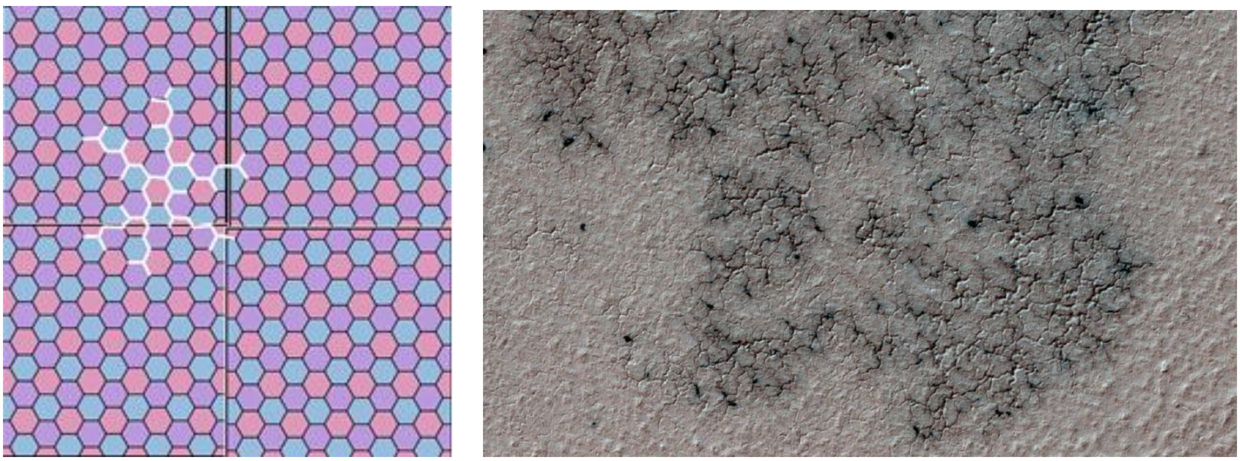

Figure 6a-b. CO_2 gas is forced between the polygonal fractures creating the spider pattern.

De Villiers et al. [8] proposed the sublimation of a seasonal sheet of translucent CO2 ice, then the outflow of CO2 gas would produce these dendritic branched channels. They produce a similar pattern to the spiders by deforming the surface material upwards as if under pressure from CO2 gas, then allowing it to rapidly collapse downwards. Figure 7 shows Martian spiders on the current south pole, these should be compared to the Viking Spiders in Figures 4 and 5. It is proposed the Viking Spiders are strong evidence of a former pole in this area that Sprenke and Baker [13] matched to a paleomagnetic pole. This would then explain much of the water and ice signs found in Elysium Planitia, and how the paleosea was formed from this water. The paleosea in Chryse and Acidalia Planitia by extension would have been formed by the opposing pole melting, this was positioned around Valles Marineris by Sprenke and Baker [13]. Directly opposite the Viking Spiders is Argyre Crater that is hypothesized to have caused the melting of the pole around Tharsis Montes and the antipodal pole around Elysium Mons.

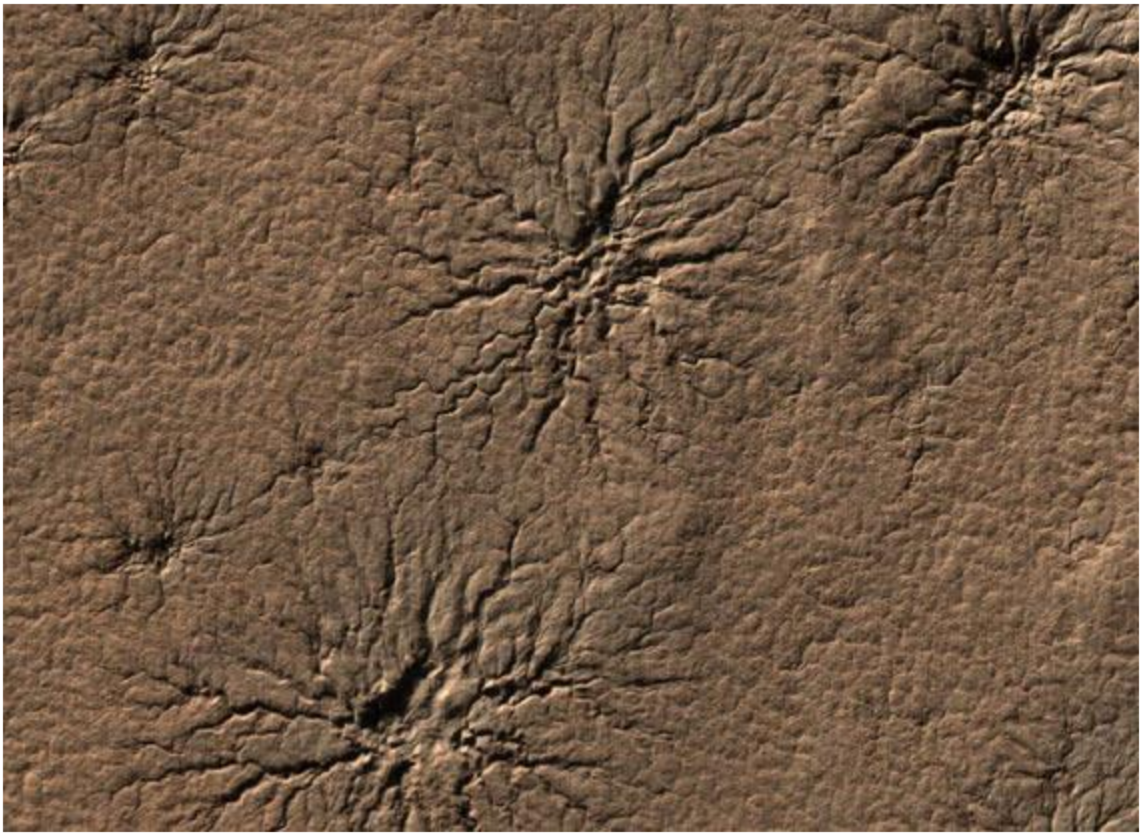

Figure 6. Araneiforms or spider formation.

The Square Mesa formations

Elysium, Utopia, Isidis, and Amazonis Planitiae have considerable evidence of containing a paleosea for a billion years or longer. Because of the evidence in the King's Valley Libya Montes it is an additional hypothesis that this paleosea contained islands with possible artifacts as well. A logical mode of construction would be to create sea walls around them using rocks or bricks as we would do on Earth. These formations are presented according to this hypothesis. Figure 7 shows a cluster of these former islands with wall like shapes around them, it is proposed the heat from Elysium Mons, Hecate Tholus, and Alba Tholus as well as Olympus Mons to the east kept this area of the paleosea more liquid. The null hypothesis is these wall like shapes are random or natural geological processes, there is the intention therefore of falsifying this null hypothesis by showing how they differ from other natural former islands.

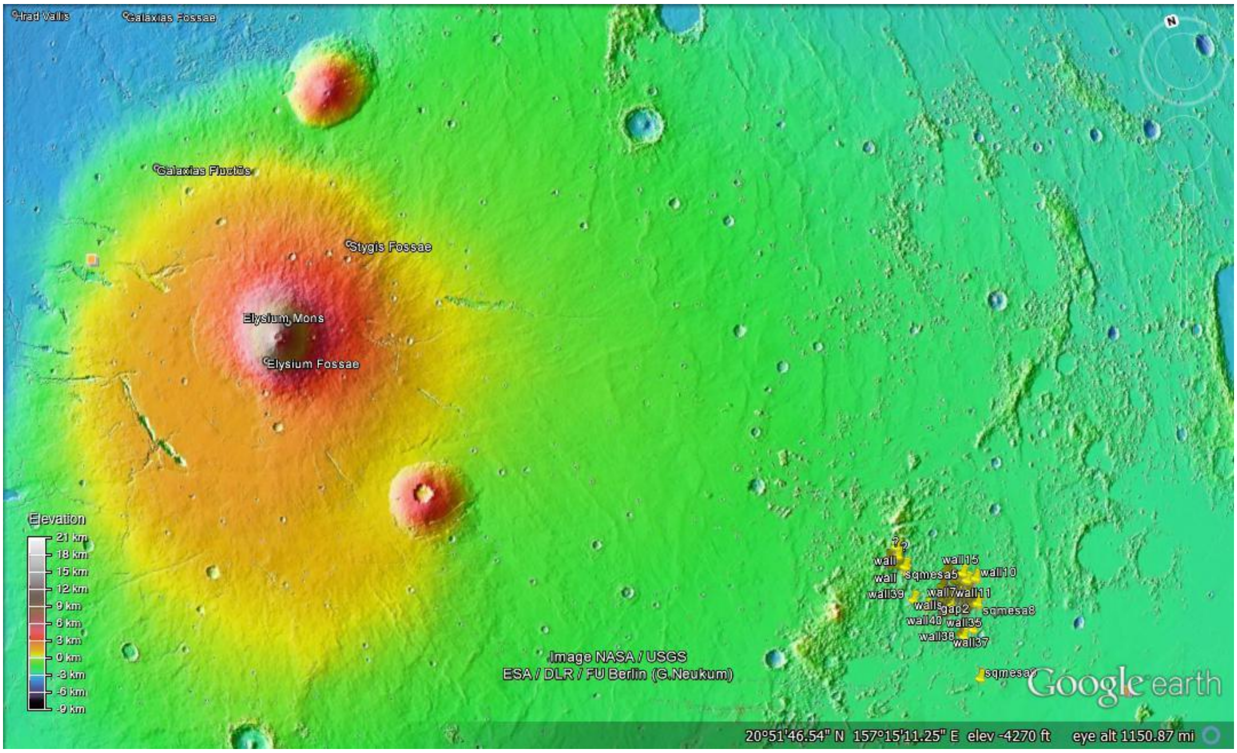

Figure 7. Elysium Mons with the formations on the right.

Figure 8 shows the Square Mesa, the hypothesis here is that it was formed around a natural island or the sand was dredged up above the waterline. Then these wall like shapes would have been added to the sides to prevent subsidence and damage from wave action. There are few signs of actual buildings so a further hypothesis would be these were made of perishable materials. The ecosystem would have been based on fishing and perhaps some sea vegetables, the King's Valley shows possible murals of fish as shown in Orme [14]. Life on Mars at this time may have evolved or as a second hypothesis it may have been introduced as a terraforming mission perhaps by a visiting alien probe. Haynes and McKay [21] discuss how we could terraform Mars in its current state, they call this process ecopoiesis or the "making of an abode for life". A hypothetical probe then might have faced a similar challenge to what we do today. The proposals in Orme and Ness [29] can offer some insight into how this terraforming may have occurred artificially or by accident.

Haynes and McKay [21] identify the cold as a major problem, but that Mars has substantial quantities of the materials needed for life. They also suggest planetary engineering to warm the planet, release carbon dioxide to thicken the atmosphere, and to release water. If there are no indigenous life forms there then biological engineering would tailor it to these new conditions. The hypothesis then is that this same process that we intend to do was already done by visitors, or that with indigenous life there already a chance impact created a long term habitable climate. As described in Orme and Ness [29] this shallow meteor impact at the pole may have accomplished the goals outlined by [21].

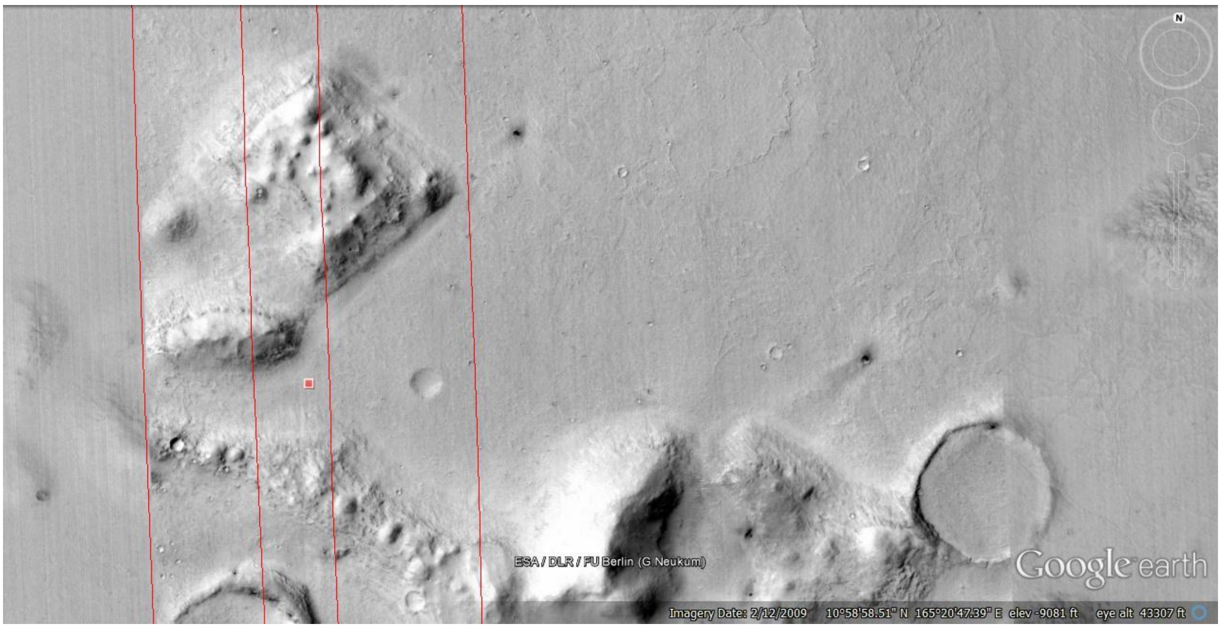

Figure 8. The Square Mesa.

The Square Mesa was discovered by the author and presented to SPSR, the Society for Planetary SETI Research [24] of which I am a member. The consensus was that this formation had some merit, and that it was a prediction that when reimaged it should look more artificial and less explainable by this null hypothesis of natural geological processes. This was recently done by HiRise. Figure 9 shows a close-up of part of the Square Mesa wall, it appears to contain layers as shown.

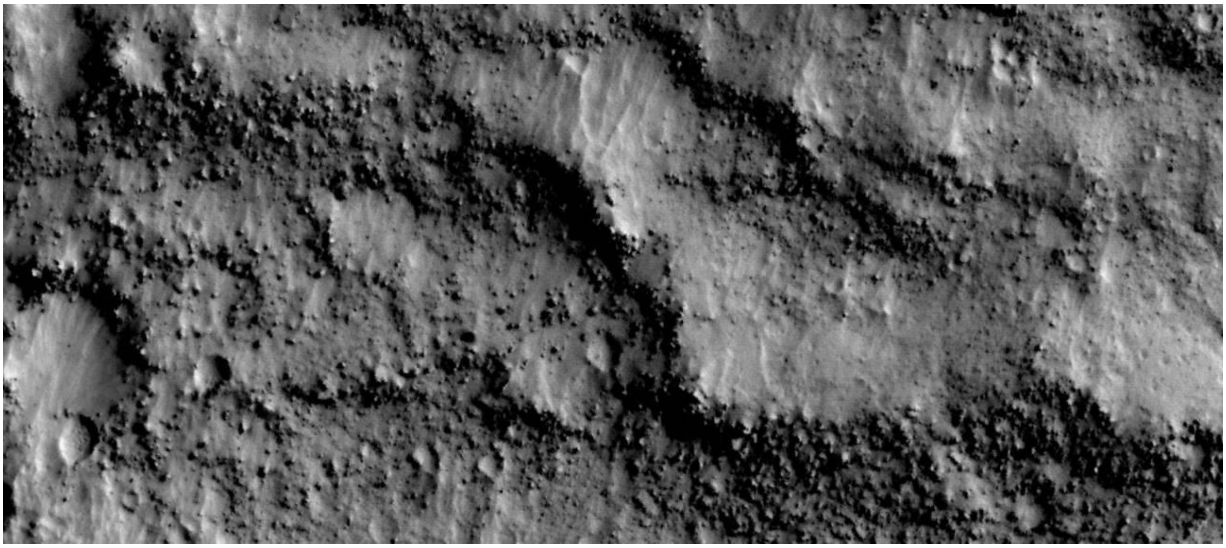

Figure 9. Layers in the Square Mesa.

Figure 10 shows more layers in another part of the wall, these appear to be of a constant thickness and are horizontal as might be expected from construction with bricks. It is highly eroded and so if artificial it would be ancient.

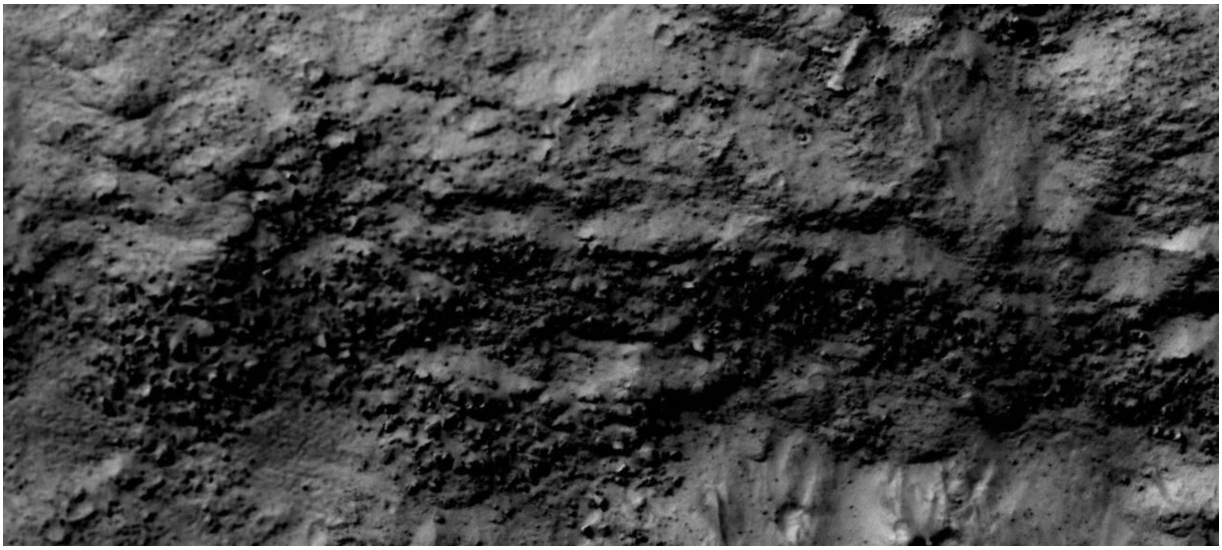

Figure 10. Interleaved layers.

Figure 11 shows more layers in the Square Mesa; this are more of a step like configuration like flat plates of rock. It gives the impression then of the same kinds of bricks or stone blocks mounted in three different ways. Figure 8 shows how the central area is much more amorphous, these layers appear to only be around the outer edge. Layers can form a complete landform but it is harder to explain how geological processes could surround a sandy hill like this.

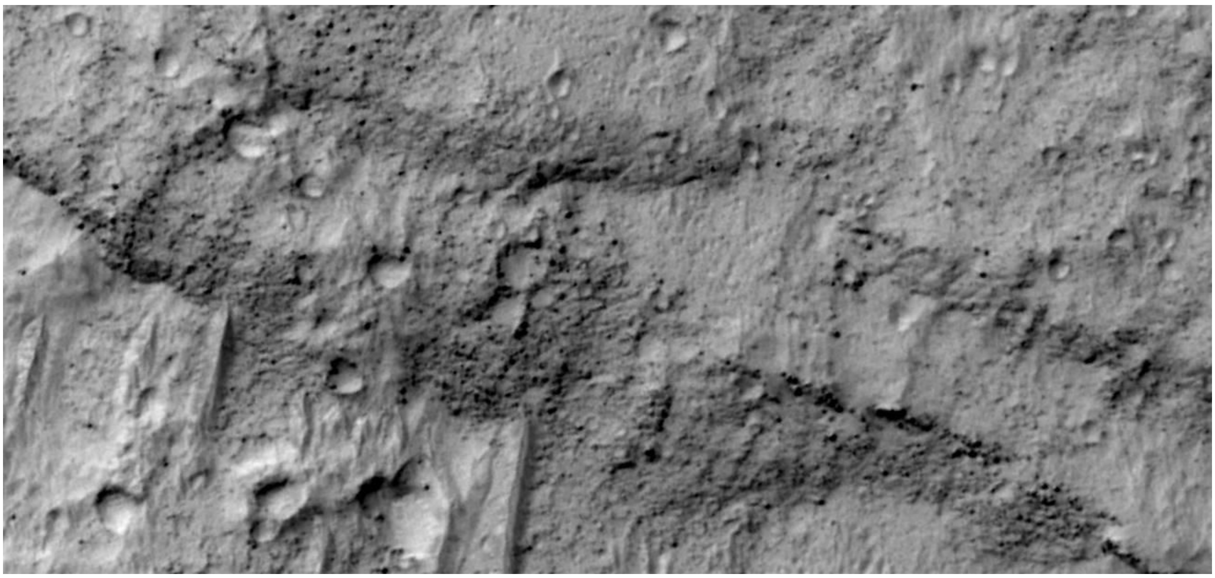

Figure 1. Layers like steps.

Figure 12 shows more layers. They appear to be more covered with sand, the actual blocks show little erosion. These layers seem to have a constant difference between them on the slope rather than being random.

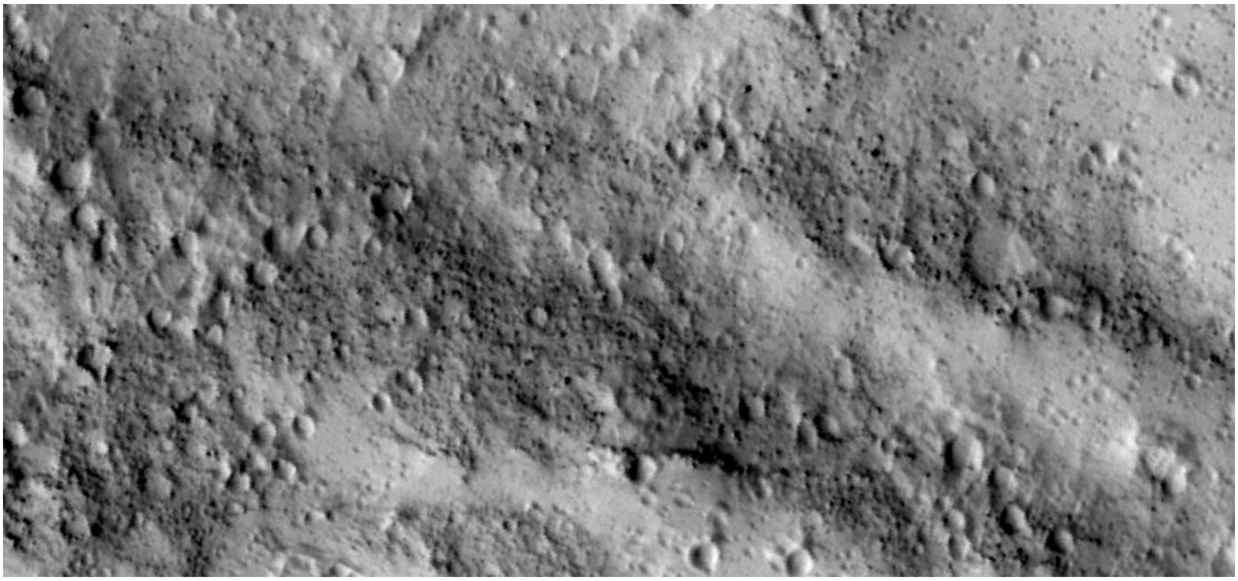

Figure 12. Layers under sand.

These continue all around the formation as in Figure 13, all horizontal. Again the distance between them seems to be the same.

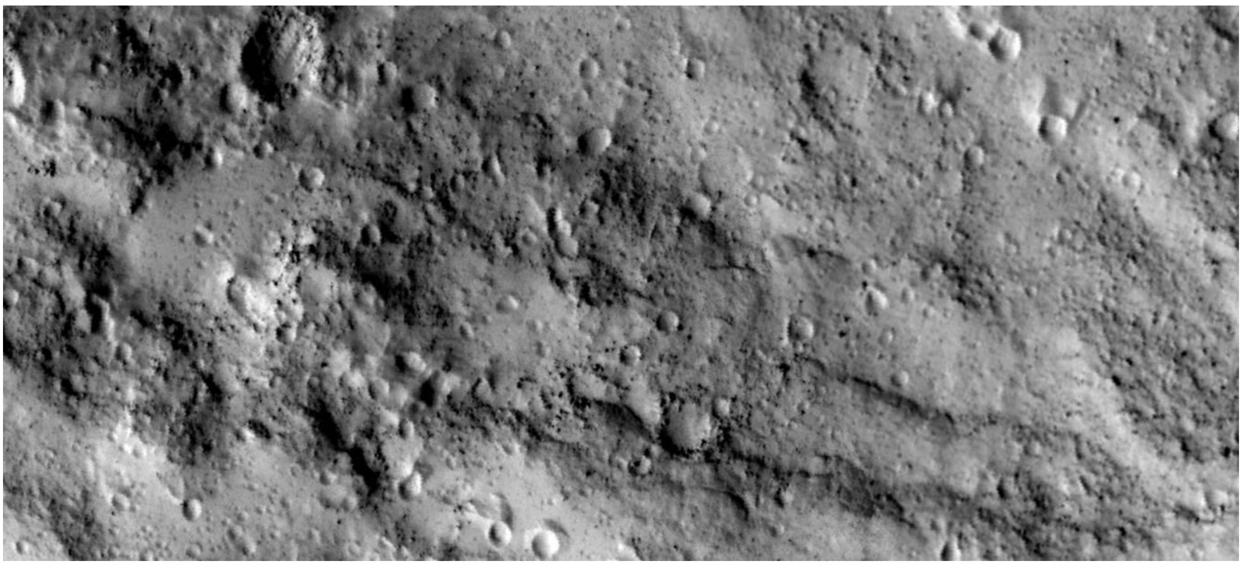

Figure 13. The same distance between layers.

Separate blocks of stone may be visible here in Figure 14. The central block with the small crater is very distinct. It is about the same size as the block directly below it. It appears then the same size blocks might have been used here.

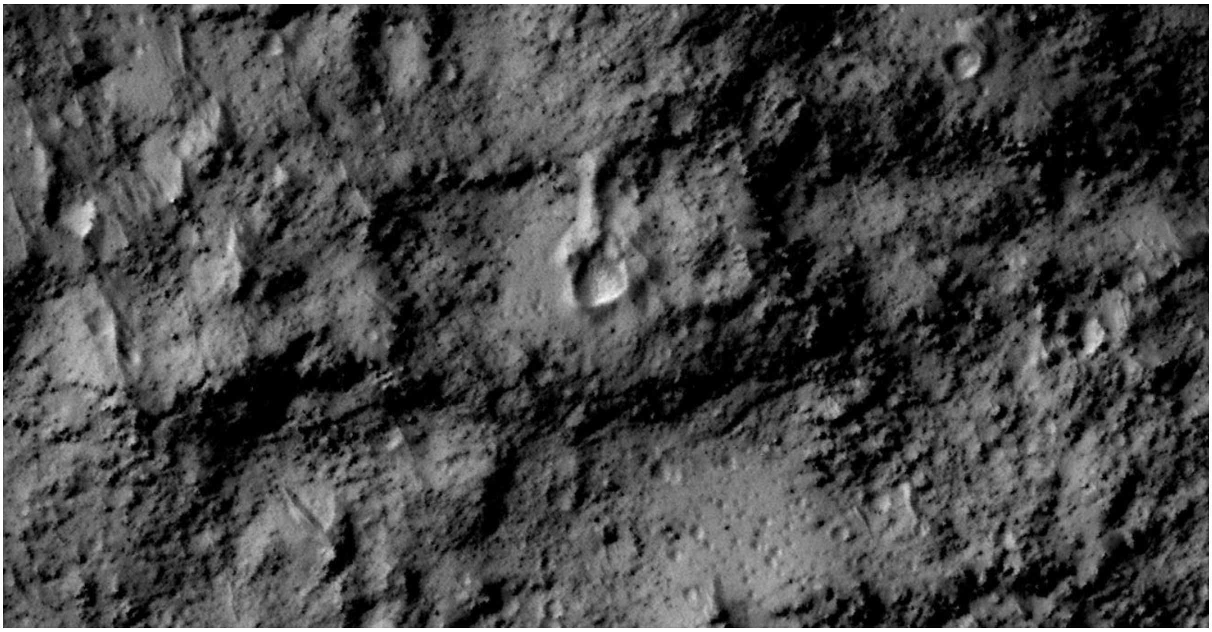

Figure 14. Similar sized blocks.

This shows sand spilling over the top of the layers in Figure 15, as if a broken wall is allowing the stored soil to come out. This is hard to explain as a natural formation, how this sand would get inside a hollow set of layers of stone blocks. Also the layers appear to continue on under this sand spill as if they are the same layers.

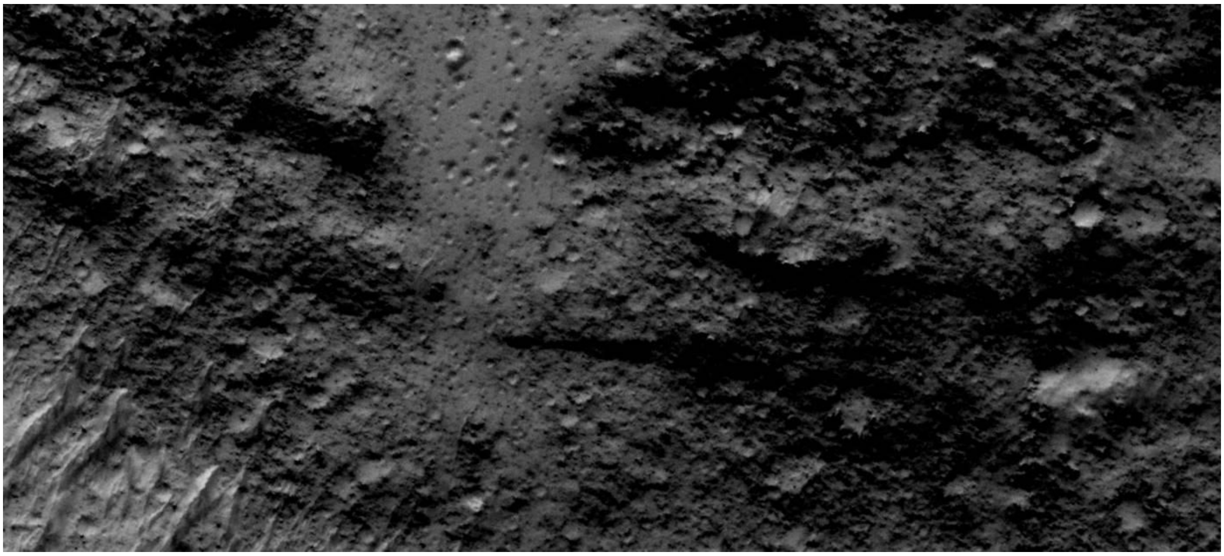

Figure 15. Layers under a sand spill.

More layers in Figure 16, these follow a curve in the shape. Similar layers are discussed in Orme [12], dam like shapes found in some craters. The walls here can then be a similar construction, here they hold in sand rather than water in a dam. It was also a prediction that these layers in the possible dam formations would be a recurring motif for constructions elsewhere, if not random.

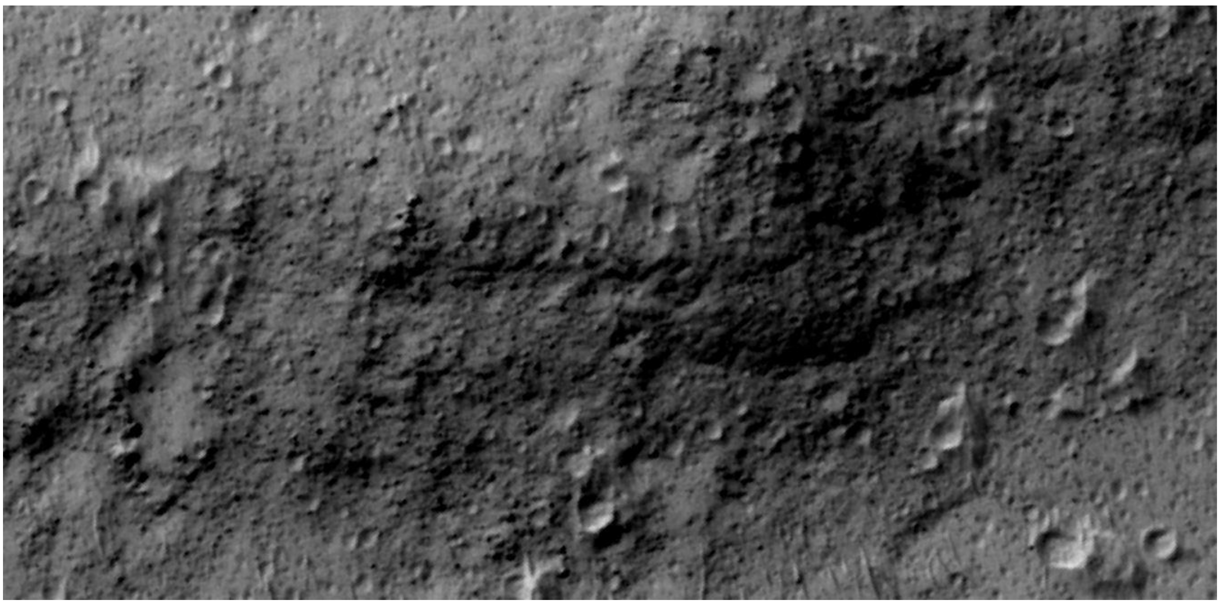

Figure 16. Curved layers.

A corner of the square mesa is shown in Figure 17 with concentric circles as grooves in the rock. These layers can then form straight lines and also curves. It would seem to be like curved sections of brick forming these curves, this is a common motif in the possible dams in craters that have this curved shape as well as some with visible layers. Another possible construction method would be forming layers of concrete, letting them dry, then molding another one on top. A similar idea could have been used in the dams as this would reduce cracking between stone blocks allowing spills. Cement would be easy to make on Mars as discussed in [12], the materials are readily available.

Figure 17. Curved layers on the Square Mesa corner.

Figure 18 shows a channel out of the Square Mesa like soil has broken open part of the wall. It is difficult for this sand to get inside this formation naturally, then erode its way out. It also shows the material inside this wall is much softer like sand, it appears to have come from over the top of the wall while other parts of the wall have a relatively constant amount of sand on them.

Figure 18. An eroded crack in the Square Mesa.

In Figure 19 there is a nearby formation that seems to have a wall of constant thickness around it. It may also be a band of concrete with a constant height cast into a curved shape, possibly like in the dams. This also appears to have sand inside it, making it difficult for a layer like this to form around this sandy center.

Figure 19. A layer of constant height.

Figure 20 shows layering in the crater wall that should not exist according to how craters are made. When they are formed by an impact any stone formations are usually pulverized. The crater walls are then made of this ejecta. Two layers here appear to have the same height along them.

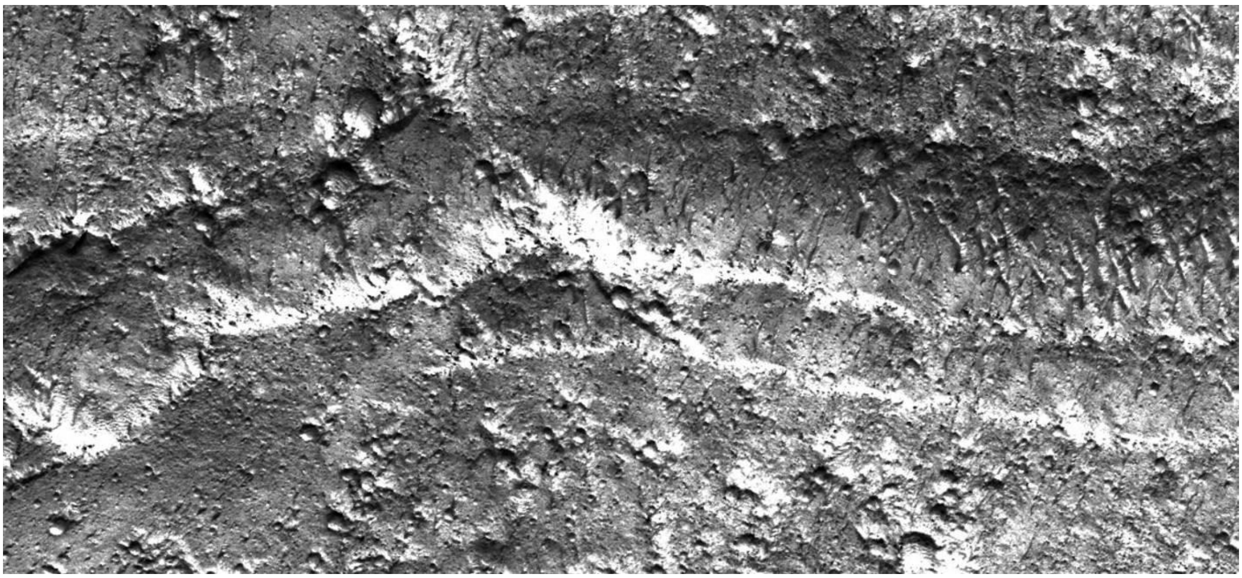

Figure 20. A constant height in the layers.

Figure 21 shows more layering in the crater wall, it appears to be like horizontal layers getting narrower towards the top. These could then be poured concrete in layers, then another narrow layer poured on top. The top layer is also very flat but a crater rim is usually rounded. It appears as if layers can be traced from one side to the other. A crater might have been used as a dam or pond for fish, an impact should not be able to produce these layers going right through both sides of the rim.

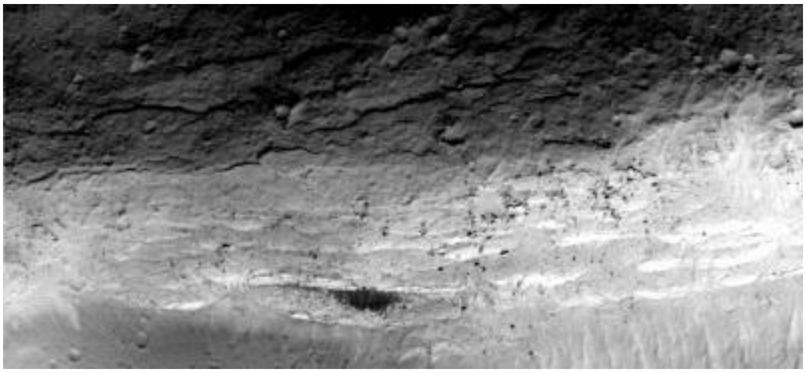

Figure 21. Layers in a crater rim.

Figure 22 shows how another crater has its walls built up asymmetrically. An impact should form a rounded shape. This is not the right shape for a crater to be formed by a shock wave on impact, however no layers are visible so it may be natural.

Figure 22. Unusually shaped crater.

Figure 23 shows more layers in the Square Mesa. The detail in the HiRise image shows virtually all of it has some layers around its sides. The middle layer appears to be of constant thickness along it.

Figure 23. A constant thickness in the middle layer.

Figure 24 shows layering in the upper part of the crater, also on the formation on the right. This concave area of the right formation shows very similar distances between the layers. It seems to be a very common feature of these, it can occur in some natural layers but here these do not extend into the islands they surround. Sometimes then a hill might have formed completely of layers with a constant thickness, this can be eroded down into hill shapes looking like steps. However, in this case there are many islands and hills with no layers, then some with this casing of layers around them.

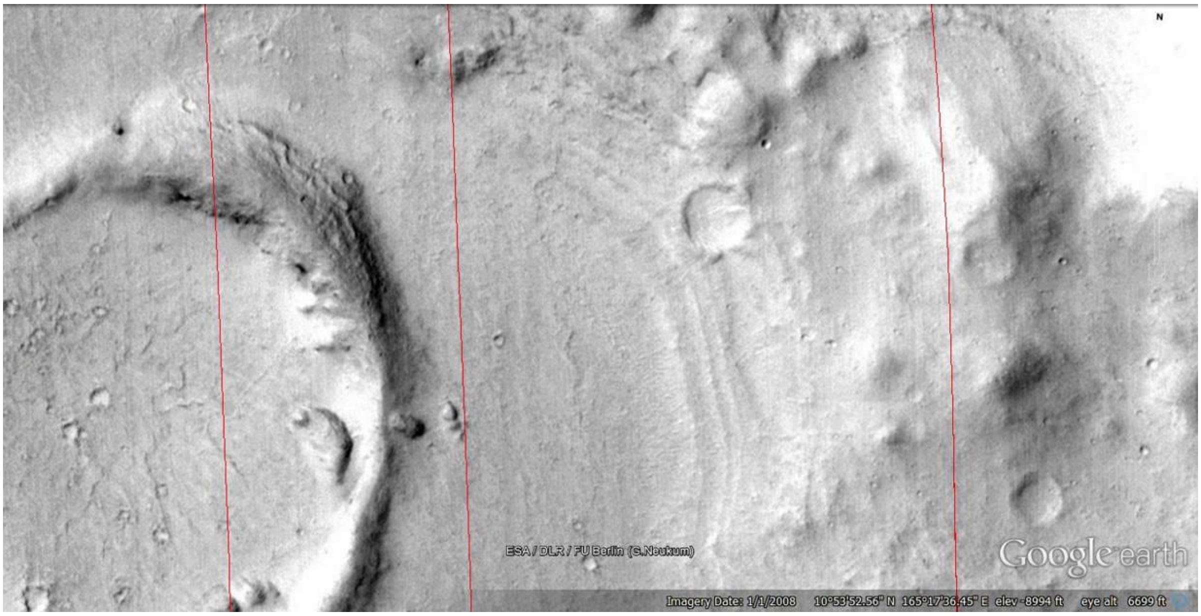

Figure 24. An equal spacing between the layers.

Figure 25 shows a wall like shape surrounding some mounds on the left. There are other very similar mound son the right but without a wall around them. Similar geological processes should have produced both sets of mounds, however the wall does not seem to have altered them when forming if it was natural.

Figure 25. wall surrounding mounds.

Figure 26 shows a wall shape all along this formation. This wall is particularly wide and goes over the side of the crater on the right. This is not a water level as it goes up the outside of the crater and inside, it cannot then have been formed by regular wave action. A geological process should not be able to form these wall shapes outside this hill and then merge into one inside a crater rim. Because a crater is formed by an explosive impact this wall shape must have formed afterwards. This is shown by A where the wall goes into the crater. Some eroded areas and craters show smooth soil under this wall. There are also some vertical cracks in these walls.

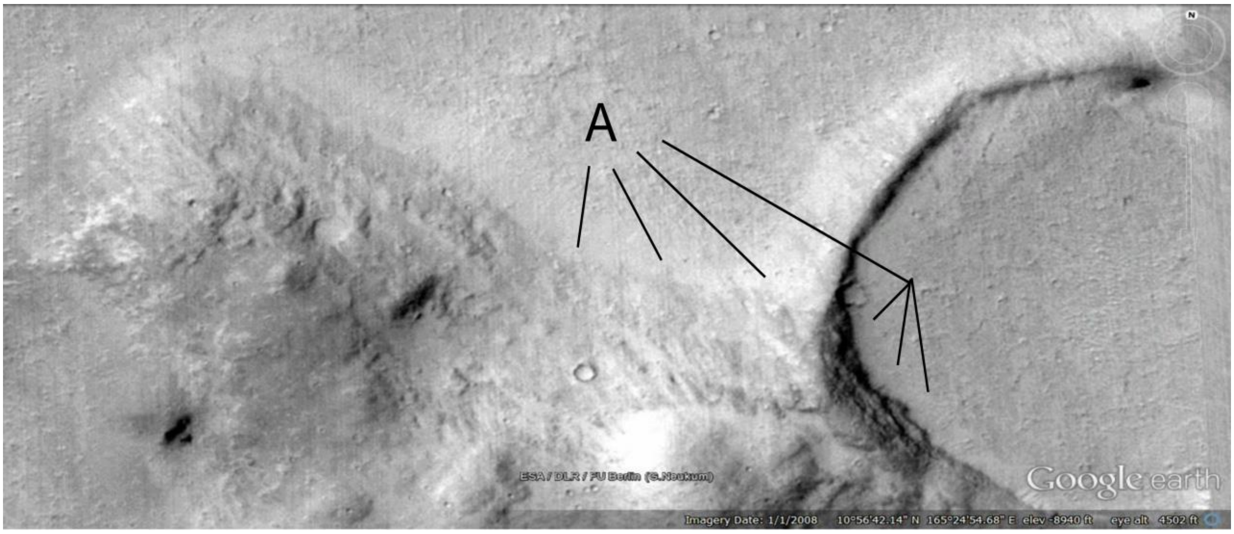

Figure 26. The wall merges into the crater rim.

In Figure 27 on the bottom there is no wall around the island, if natural then the wall should have formed all around it. The vertical cracks seem more evenly spaced as if blocks are separating, on the right this is combined with the layers appearing.

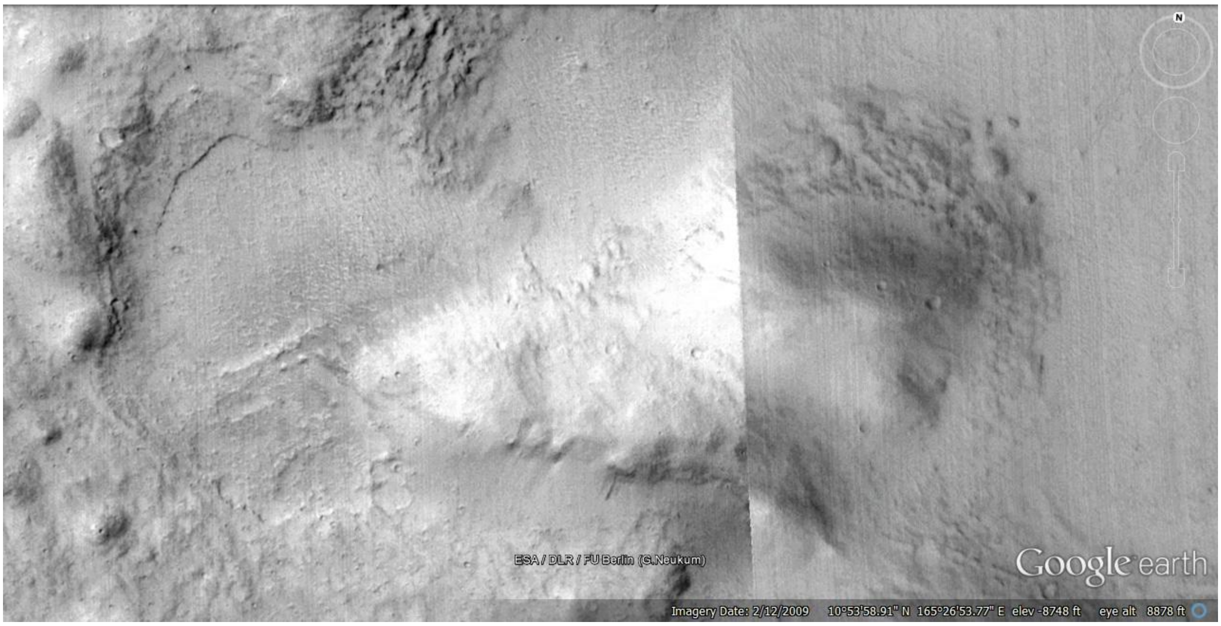

Figure 27. Vertical cracks and layer lines exposed.

In Figure 28 the walls have a different albedo to the rocks like they are a different material, here the hill on the left is lighter and sandier looking. Many of these formations have different possible ways of being created, a crater is formed in a different way to an island or a mesa. But all seem to have this same kind of wall material with similar angles. It would be hard to measure but the shadows imply these angles are very similar throughout the area unless the island shape is steeper. The surface appears more mottled here perhaps from individual bricks.

Figure 28. Individual bricks in the layers.

Figure 29 looks like a sandy hill or scooped up soil buttressed by the beveled wall around it. It appears more concave at the top like the sand has been blown away to some degree. On the upper part of the image the wall is more complete, this shows how it degrades going downwards. The middle of the wall seems to disappear allowing a concave area to form. It appears then like soil was being held in and was lost when the wall broke. The bottom of the image shows little or no wall on this side, it appears like a sandy island that formed without this wall making process. It is a recurrent motif for these walls to form on only one side more exposed to the paleosea, on other islands there is no wall at all.

Figure 29. A broken wall.

Figure 30 shows around the middle the wall is much wider indicating it is not caused by water erosion. It does not follow a possible water level. The right side of the island appears to have more soil between the rock peaks than it normally should, like it is being held in there by the walls to make a smoother surface. In many areas layers appear in this wall, also some vertical cracks like between blocks. The bottom of the image shows no wall, a geological process forming this would have to account for its absence on some sides of these islands.

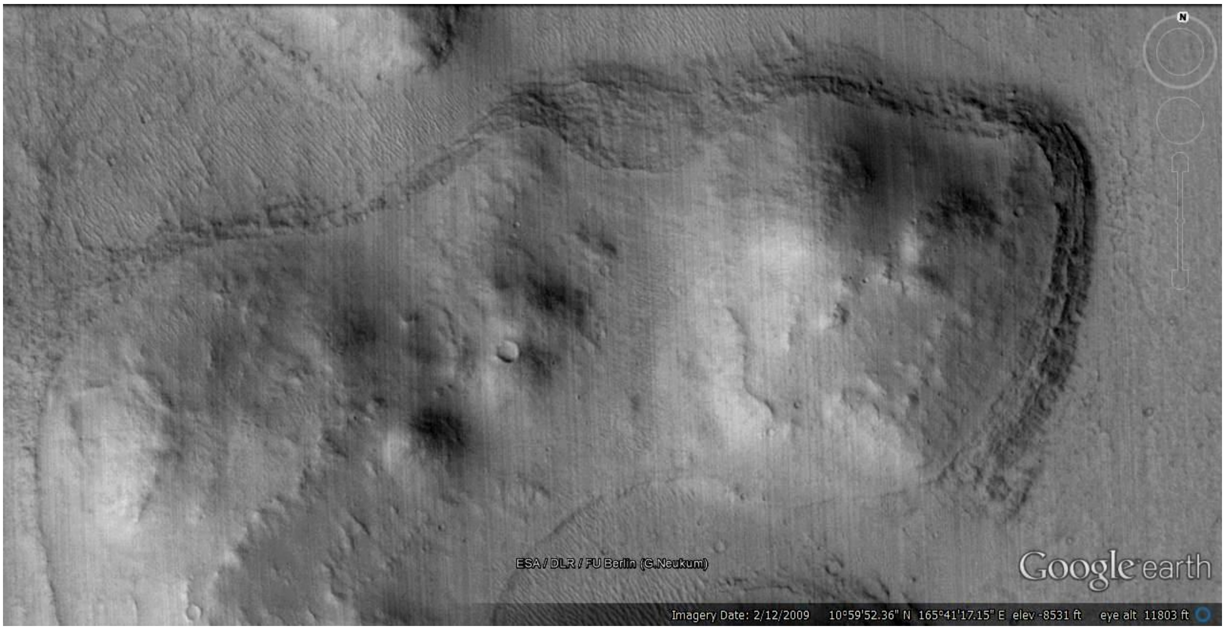

Figure 30. More blocks appearing.

In Figure 31 the inside soil might have been washed out of this just leaving the wall. It is a similar walled material but with nothing inside it, the same geological processes would have to create free standing walls as well as the sides of these hills. If the hill inside eroded away then it would have to leave the wall not eroded, also this wall is about as well preserved as many others with interior hills and soil. The wall seems to have broken up into blocks or perhaps cracked pieces of concrete. The hill on the left is similar to many others in this area yet has no wall, a geological process would have to create a wall on some hills and not others.

Figure 31. A wall with a hollow inside.

Another wall with soil inside it is shown in Figure 32. Compare this to the previous image, the formations are very different but the walls are similar. The hill on the right has no wall around it but both appear to have been formed with the same geological process.

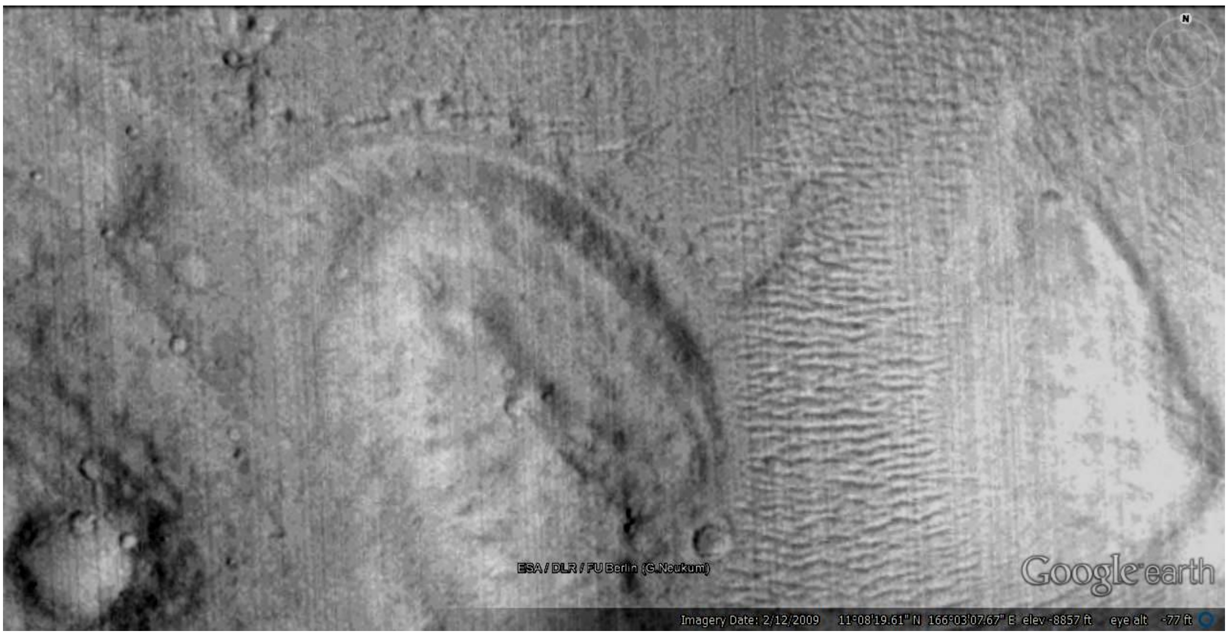

Figure 32. A hollow around the wall insides.

In Figure 33 there is a cigar shaped island with these walls around it. The craters show how the wall material is thin. The groove in the top has a straight edge, others are found in this area with similar grooves. This may then be a flat platform created on top of these walls.

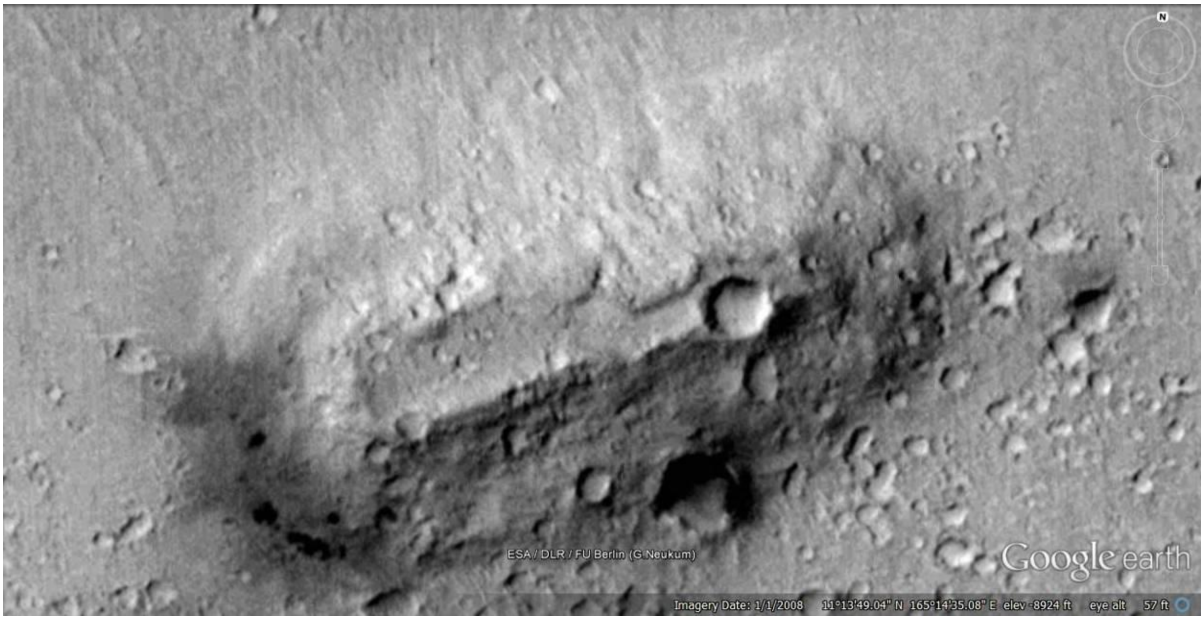

Figure 33. A flat platform.

In Figure 34 this wall may have kept water out of a depression like using a dyke. The same geological processes that made walls around islands would have to produce free stranding walls like this and around hills. It has a mottled appearance like the wall has broken up into smaller rocks.

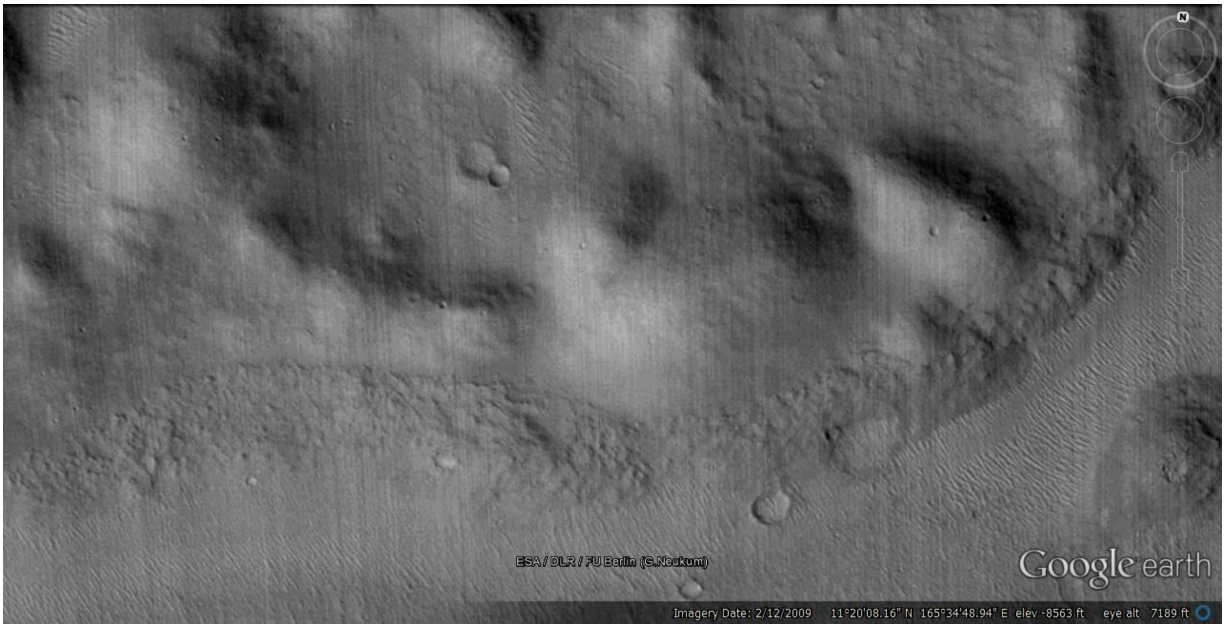

Figure 34. A wall acting like a dyke.

Another wall extending from a hill, acting like a dyke, cutting off water from a much larger area in Figure 35. This has broken through in the middle of the image.

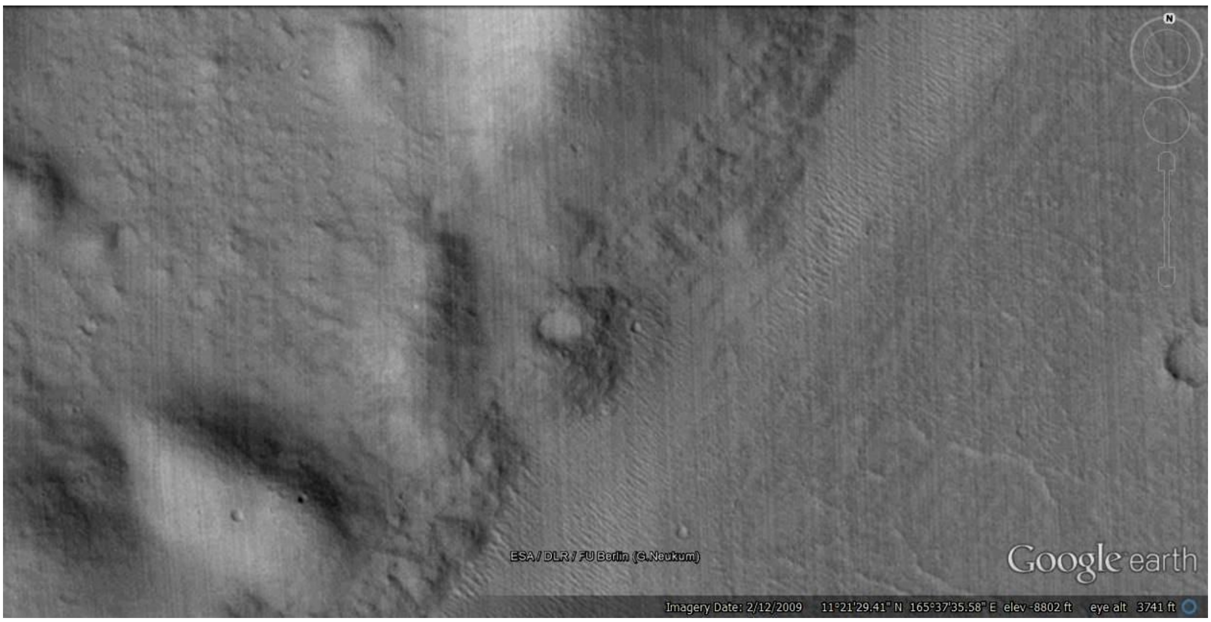

Figure 35. Another dyke wall.

This much longer wall in Figure 36 would also keep water out of between the mounds like a dyke. It could have been like the Netherlands, making larger walls in some areas to keep the sea out. Many layers can be seen.

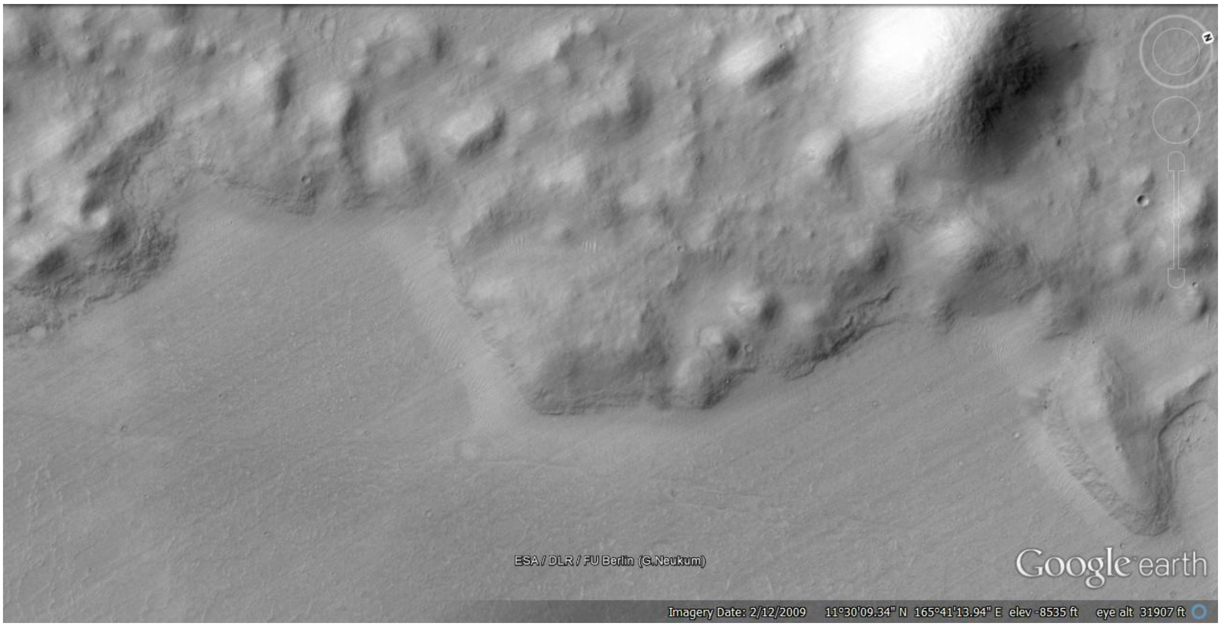

Figure 36. A longer dyke wall.

Parts of the walls in Figure 37 show layers like some of the Martian dams, they may be similar materials. The rounded corners are similar to one the square mesa with a series of concentric arcs. These layers then form any shape as if made of bricks and perhaps cement. The bottom right corner is like a corner of the Square Mesa. The bottom left side appears to have no layers, the island here looks like it is eroded and cut by wave action. The same geological processes should form layers all around the island.

Figure 37. Curved layers around the hill.

This shows a large central depression in Figure 38, it is surrounded by the same kinds of walls as on the left. There is no change in the wall structure between the two, to occur naturally this wall would have to form on the hill and then form a ridge to seal off this depression. There is a small island above this but it appears to have no walls, though it should have formed the same way.

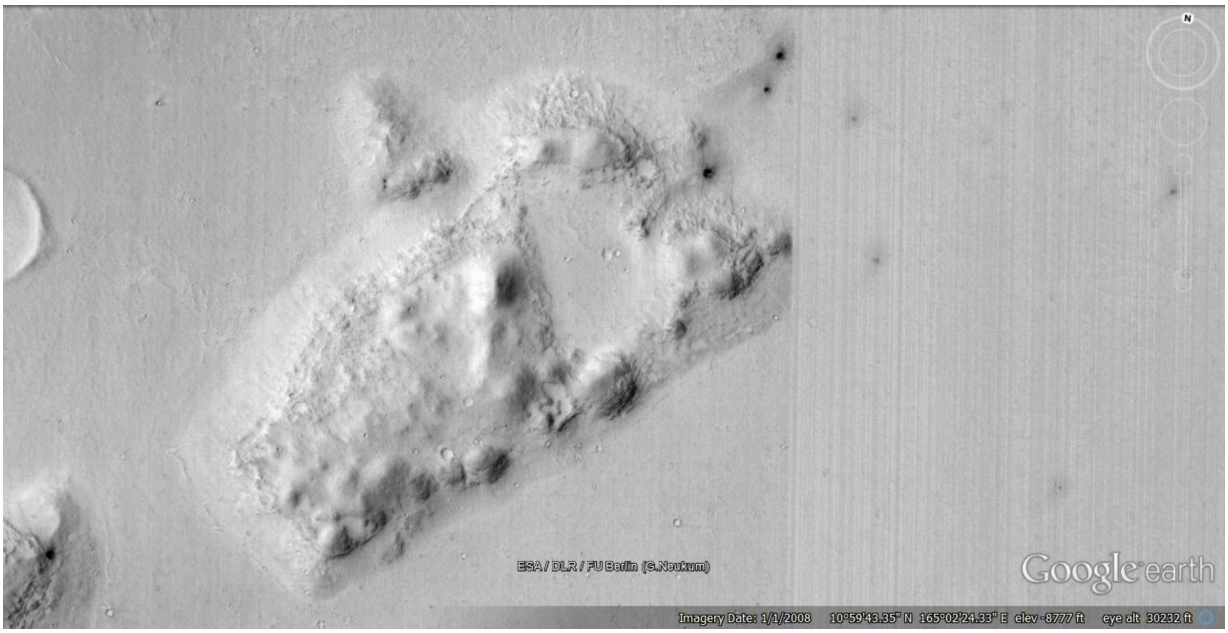

Figure 38. A depression surrounded by walls.

Figure 39 is similar looking to the Square Mesa in the middle island, the right formation appears to have this wall going right over its middle at A. The rest of this island is similar to the one on the left but has no wall, though it should have formed the same way. The middle island on its top shows vertical cracks in the wall, at the bottom this has broken up completely or never existed. This has left some rocks at B which appear to have rolled down from this gap, they may then have made up part of the wall. The left island also has this wall around the upper side but it is either eroded away or never existed on the bottom.

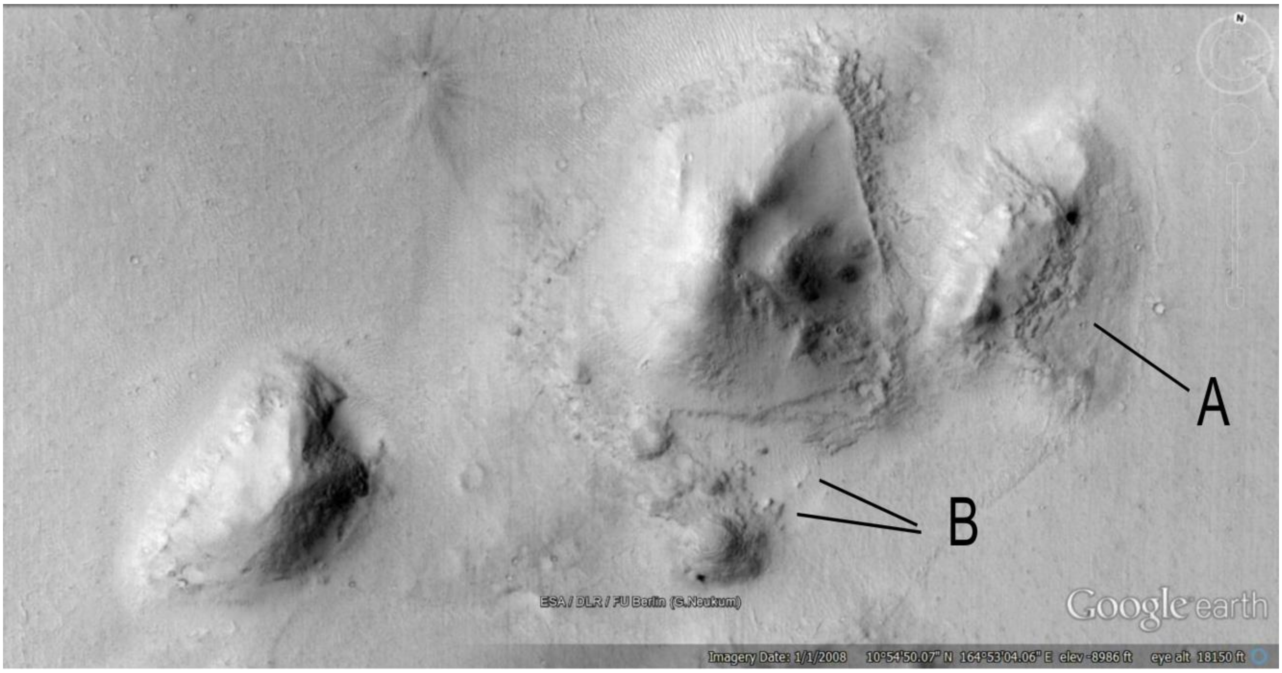

Figure 39. Collapsing walls.

In Figure 40 there seems to be soil packed in between the hills to make a more level surface. This might have been to make dwellings more stable. The layers are clearly visible on the right and some stones are protruding like they were part of the wall.

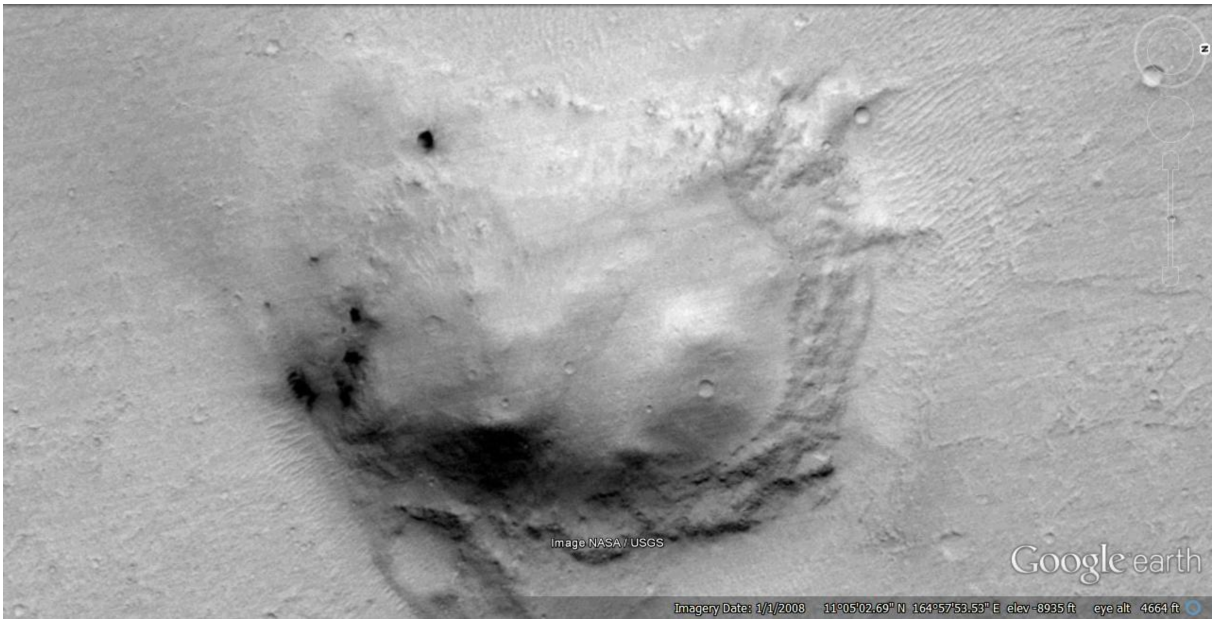

Figure 40. Soil held in by the wall.

The wall has eroded away at the bottom of Figure 41, soil appears to be spilling out or it was never there. The same geological processes should make this wall on all sides. The upper part of the wall seems to be in better condition, much of the erosion seems to have occurred more on the southern sides of these formations. It may be north of here the sea was much shallower and did not extend far. With a large bay to the south there may have been more waves, also a sea breeze from the temperature differences of the land and sea would have created more waves and eroding wind.

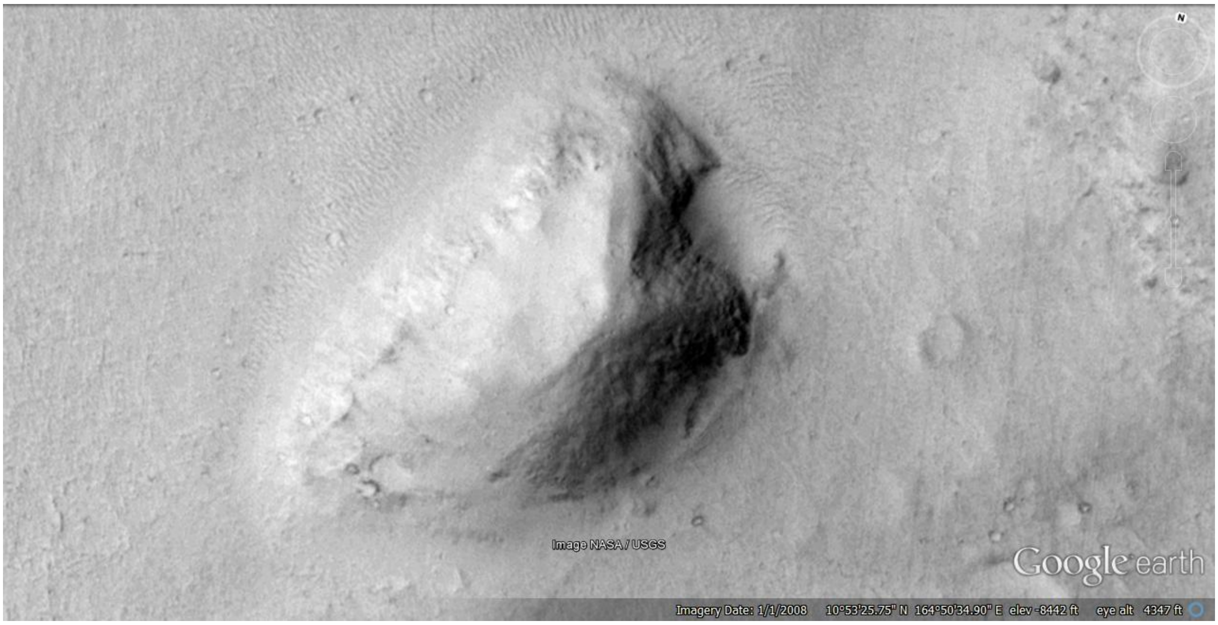

Figure 41. More erosion on the southern side.

The soil appears to be spilling out of the left side of Figure 42 where the wall has disappeared. On the bottom side the upper layer is very clear, then this has largely disappeared below it. Another example of this southern erosion.

Figure 42. The wall has broken up in the bottom middle of the formation.

This wall in Figure 43 has a wavier shape with layers on the left. This may have been another dyke wall protecting low lying areas.

Figure 43 Another dyke wall.

The wall on the right has practically disappeared in Figure 44, it shows how thick it may have been. Some jagged edges stick up at A as if made of concrete, it seems to have broken in angles perhaps showing stone blocks. On the left of the image large parts of the wall are missing or buried.

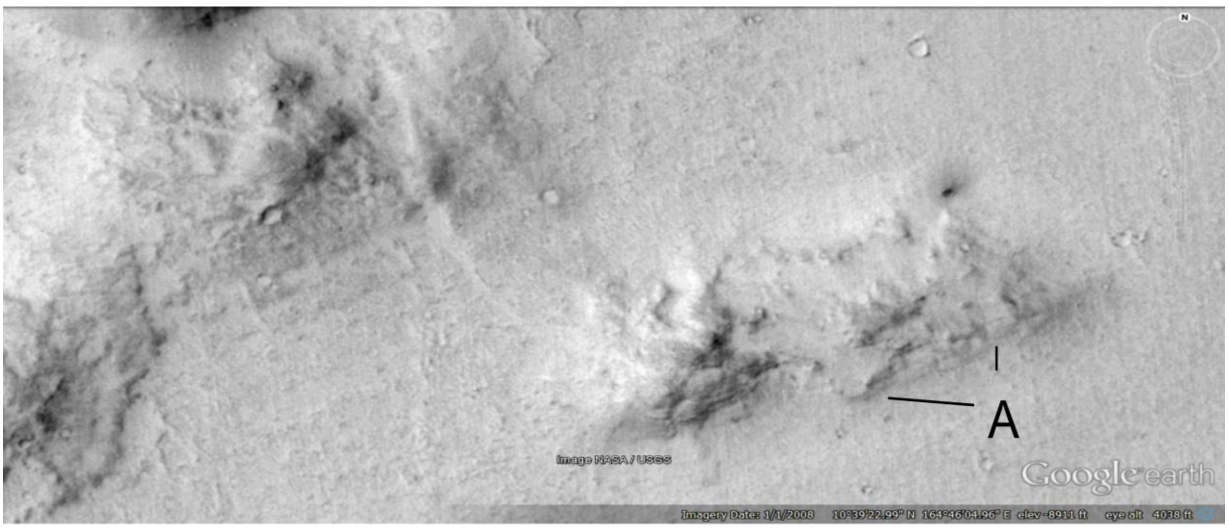

Figure 44. Jagged pieces of the broken wall.

A broken wall showing layers in Figure 45. The upper side at A appears to have broken in two as one piece moved down its slope to the right. At B the top of the layer seems to have stayed in place while the layers under it collapsed.

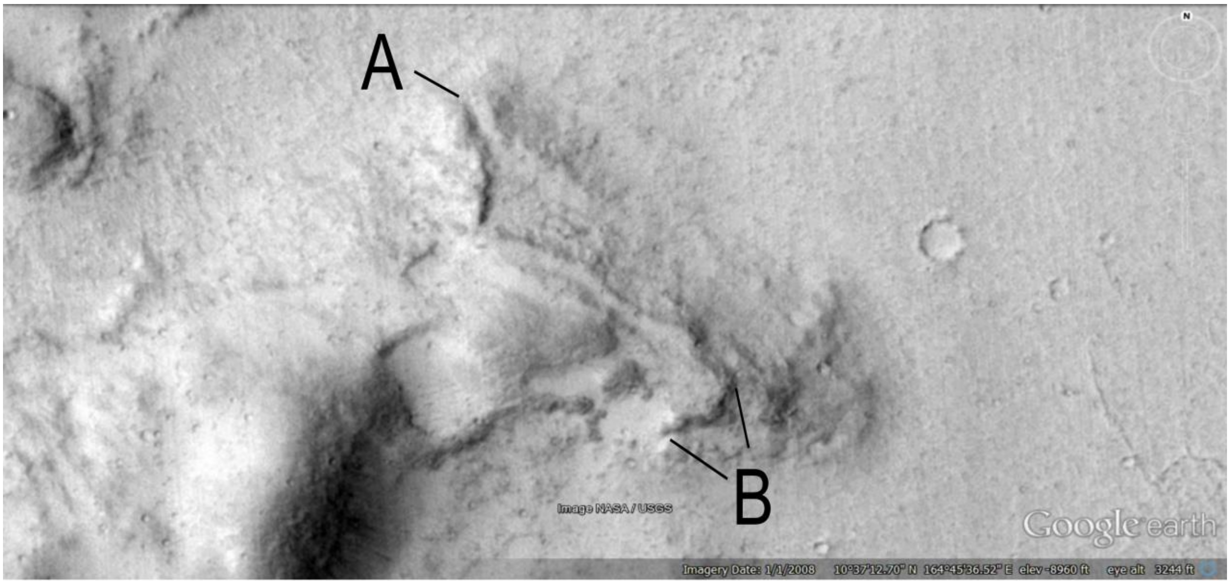

Figure 45. Subsidence of layers.

The wall in the middle at C is quite thick in Figure 46, it seems to be holding in soil meant to level up the ground between the mounds. The red lines are a HiRise image of this formation. This wall may have been shielded from this southern erosion, perhaps from waves. Wind erosion is less likely as it should have worn down the hills as well. A and B are much more eroded as if waves might have come in from the upper right but not hit directly at C. This kind of erosion can give clues to the ecosystem and weather of the time.

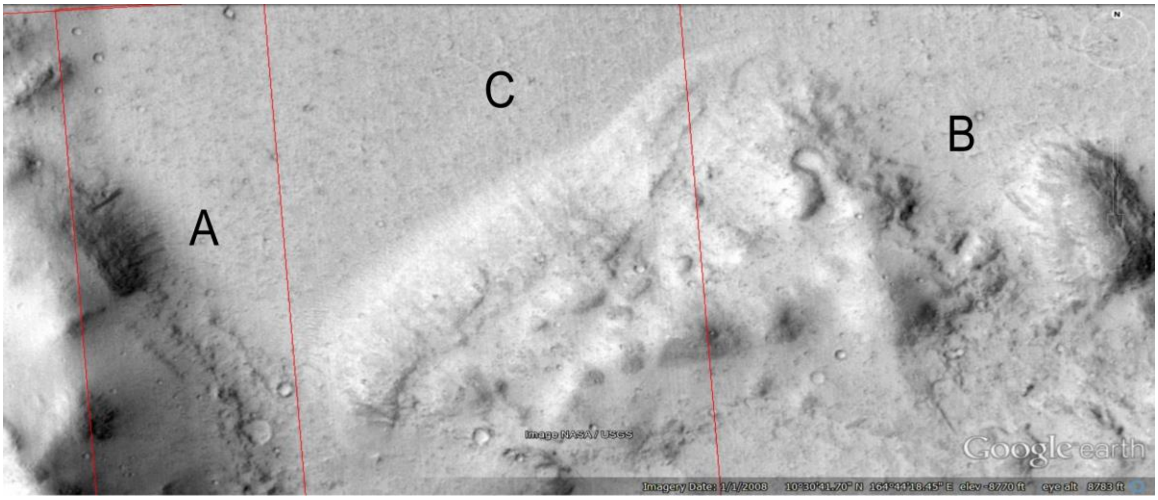

Figure 46. A better preserved wall on the northern side.

These next images show HiRise images with the same features south of here starting with Figure 46. There are some exposed layers on the left like on the Square Mesa.

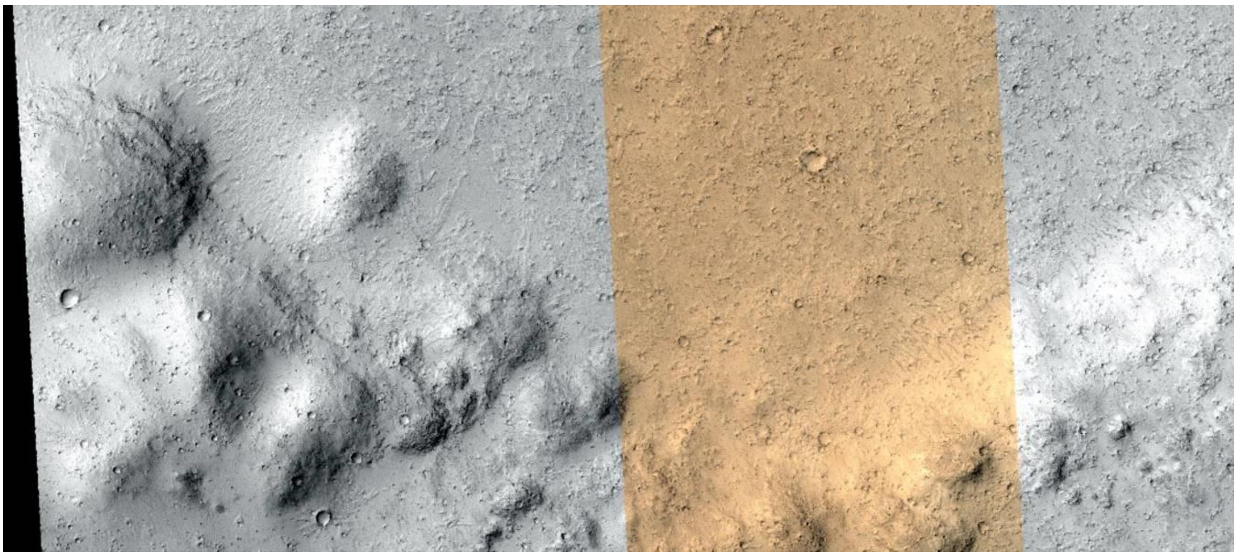

Figure 46. Exposed layers.

These walls in Figure 47 are also like the Square Mesa in its HiRise image. They are more rounded from the bottom up while other walls are straight. There are some vertical lines in the wall as if it was stressed and may crack in this way.

Figure 47. A HiRISE piece of the wall.

Figure 48 shows more layers like in the Square Mesa. The terrain is very flat between these steps like layers.

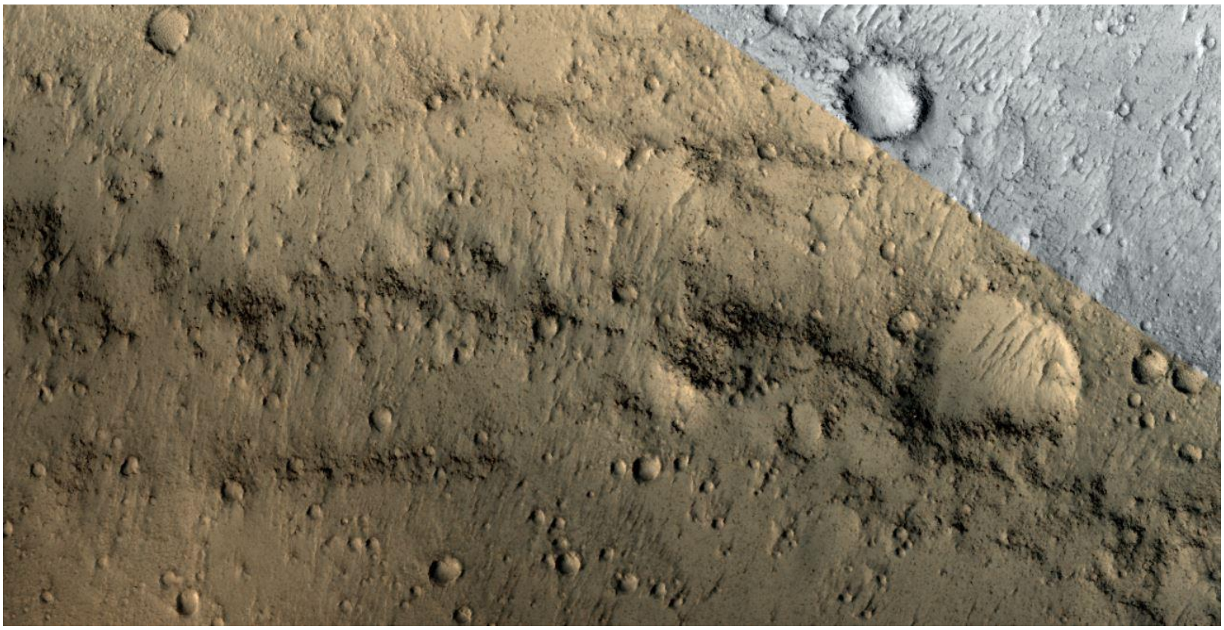

Figure 48. Step like layers in HiRise.

The soil seems to have spilled out inside of Figure 49 as the wall eroded away.

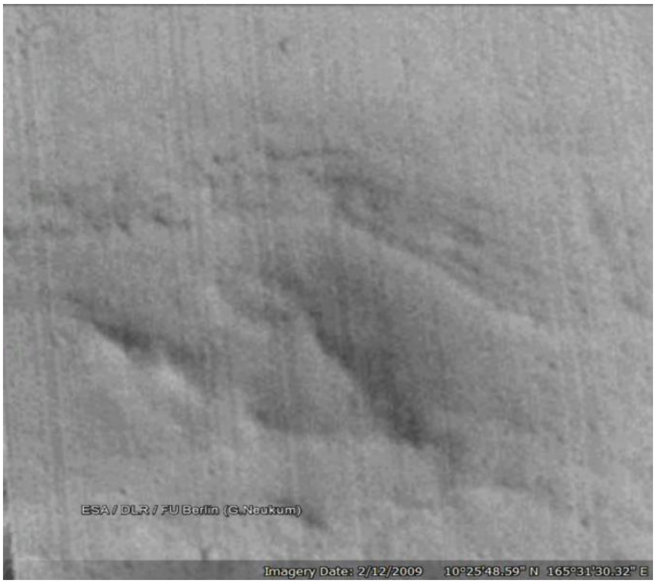

Figure 49. A depressed area inside the wall.

The wall surrounds the peninsula on the right in Figure 50. The layers form like steps particularly on its end at the right.

Figure 50. Layers around the peninsula.

A wall around a depressed area showing layering in Figure 51. The mottled areas on the left may be where the wall has broken up into its blocks, shown at A.

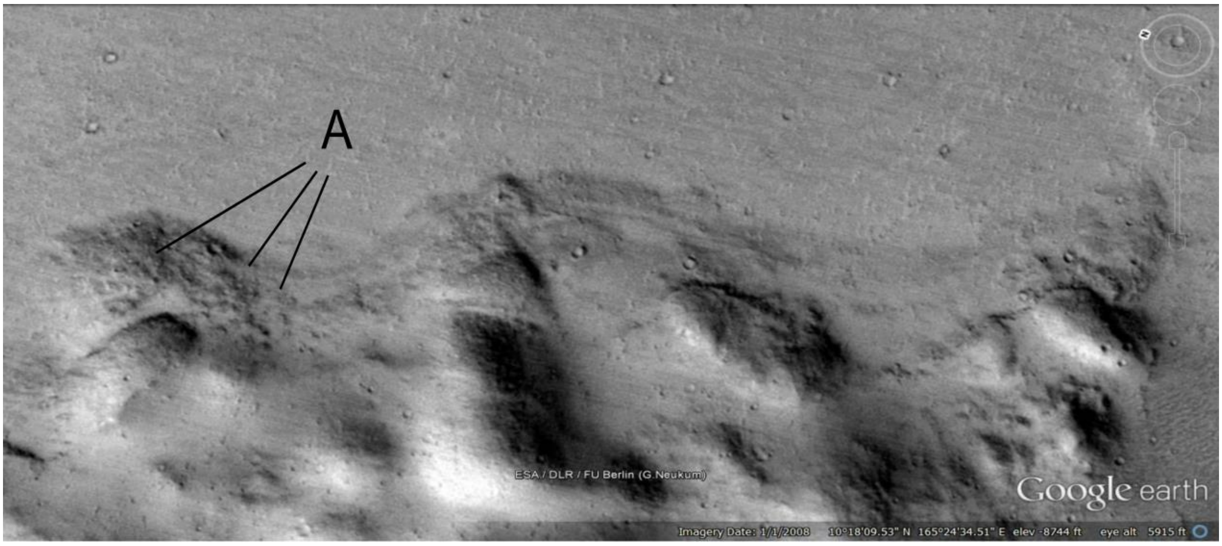

Figure 51. Stone blocks in the wall.

This wall in Figure 52 on the left seems to have had the interior soil washed away. It goes right around the peninsula. It is like the reverse of a beach; the sandy material is inside the wall not outside.

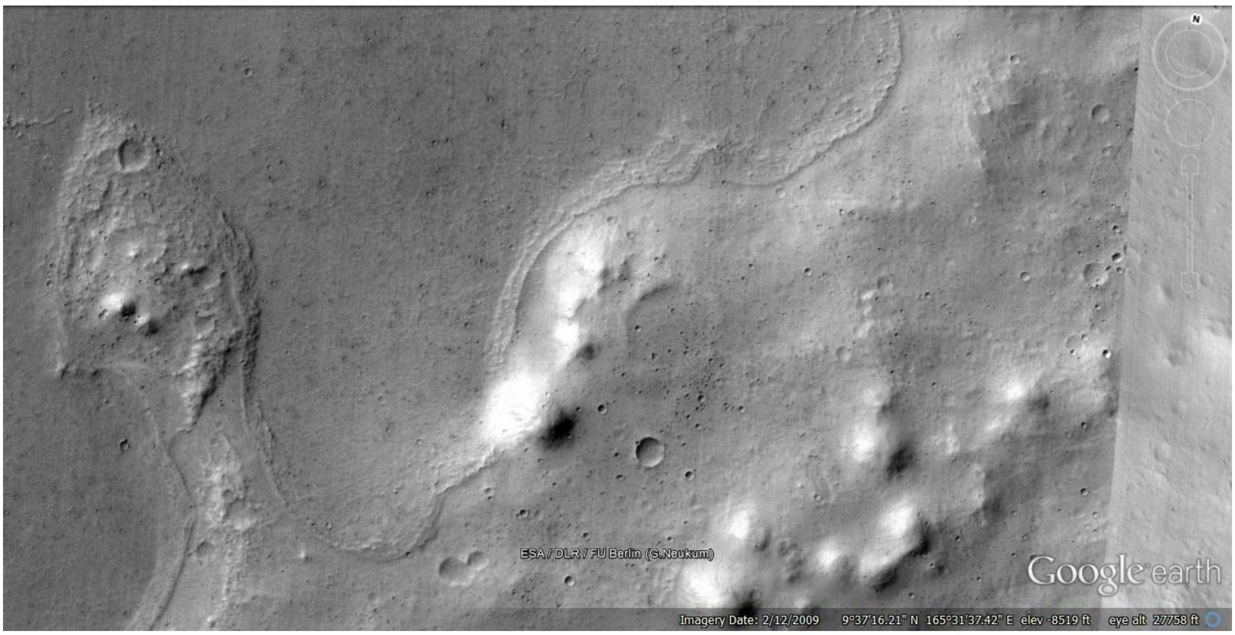

Figure 52. The wall goes around the peninsula.

Probably another wall in Figure 53 as the interior seems to have a lower elevation. This may have acted like a dyke protecting a depression.

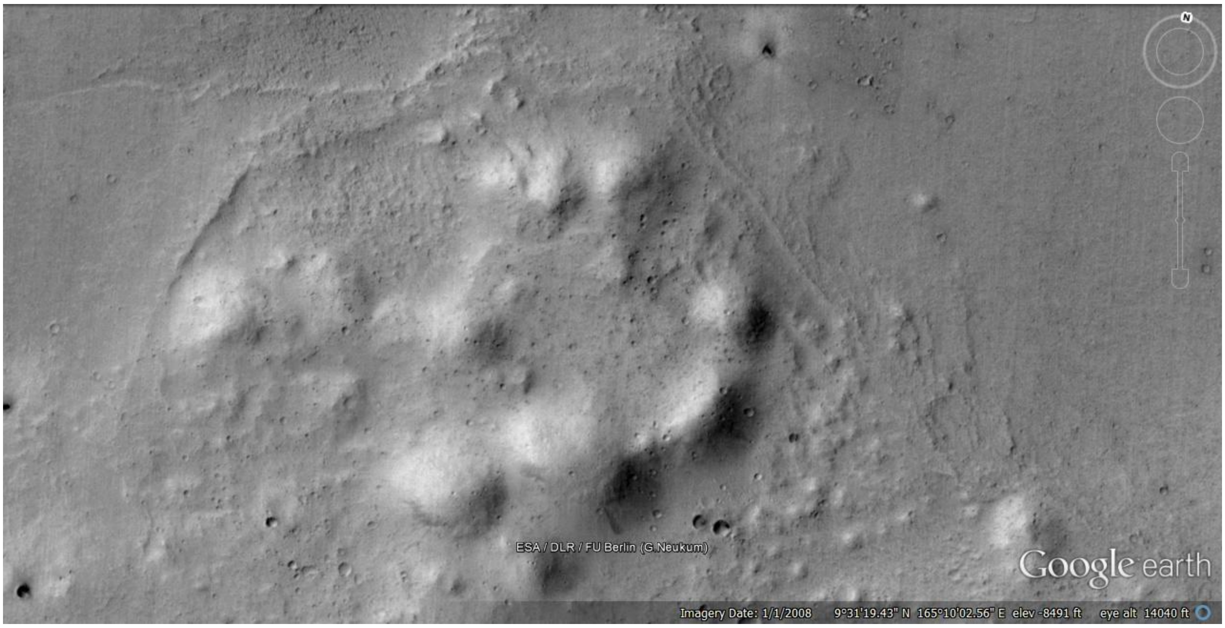

Figure 53. A dyke wall.

The wall in Figure 54 is a different shade to the other rocks and has the same beveled angle. This is in much better condition while others have nearly disappeared from erosion. This is on the northern side. Some parts of the wall at A have broken up into slabs still stuck to the slope.

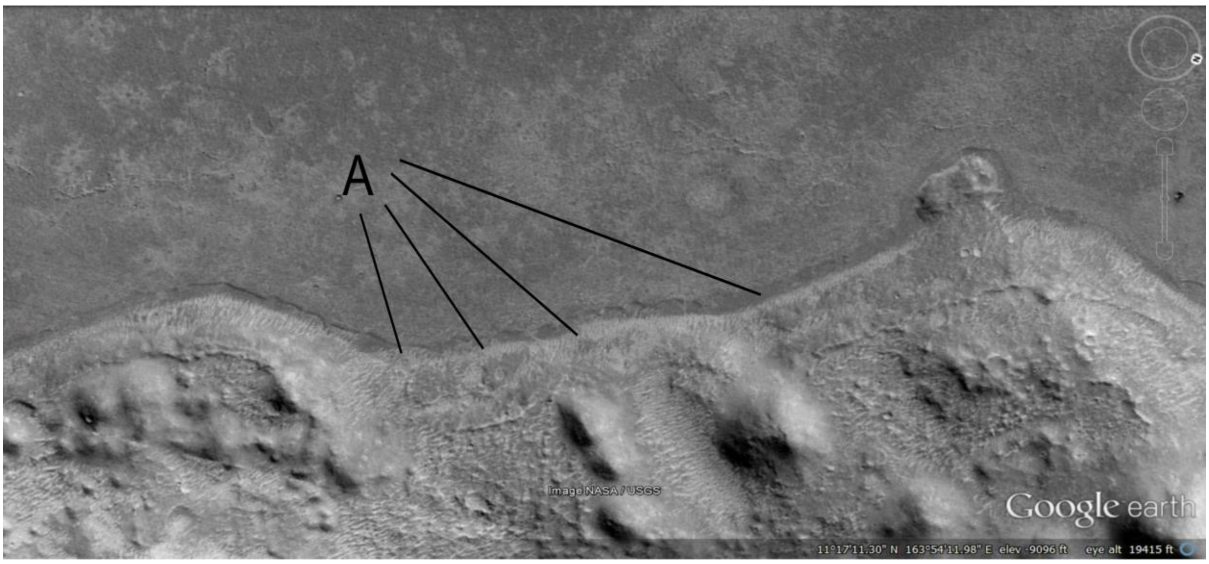

Figure 54. Slabs of rock in the wall.

The wall in Figure 55 seems to have broken up into segments with soil behind it. These rocks if natural should have fallen off the slope. The layers are also clearly visible.

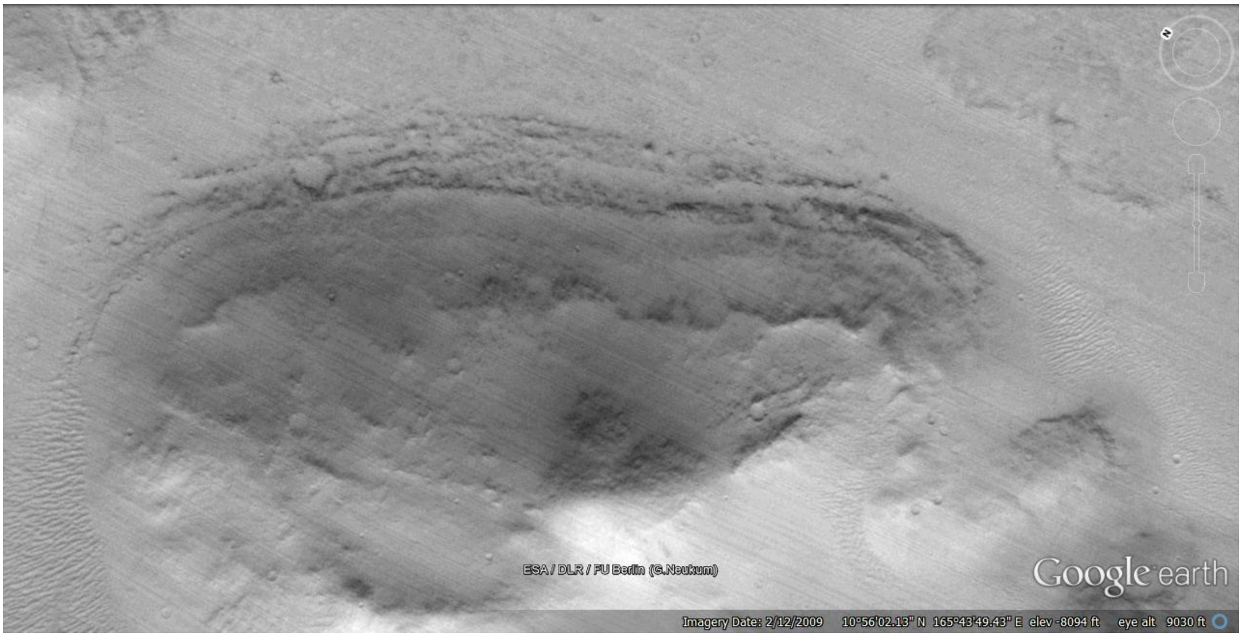

Figure 55. Layers in the eroded wall.

Multiple layers are visible in the central wall but not on the right wall in Figure 56. Erosion seems to be happening between the layers in the middle, perhaps soil is spilling out.

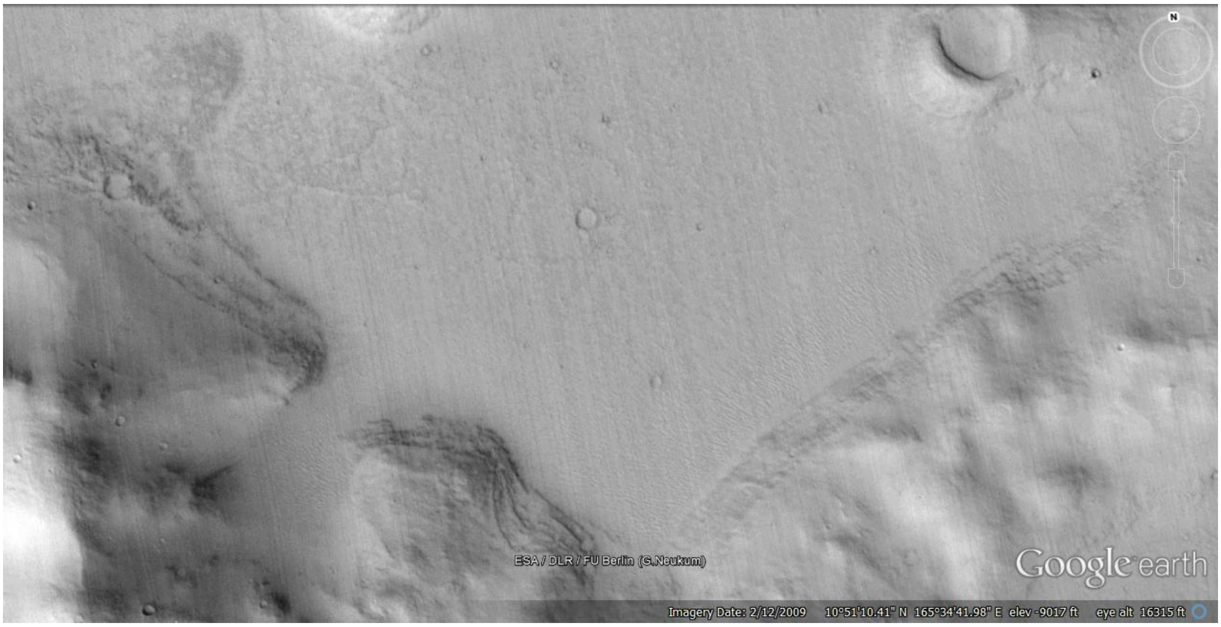

Figure 56. Erosion between the layers.

The wall seems to have broken around the upper side on the left of the crater in Figure 57, soil spilling out. The middle right of the island is nearly flat and surrounded by this wall.

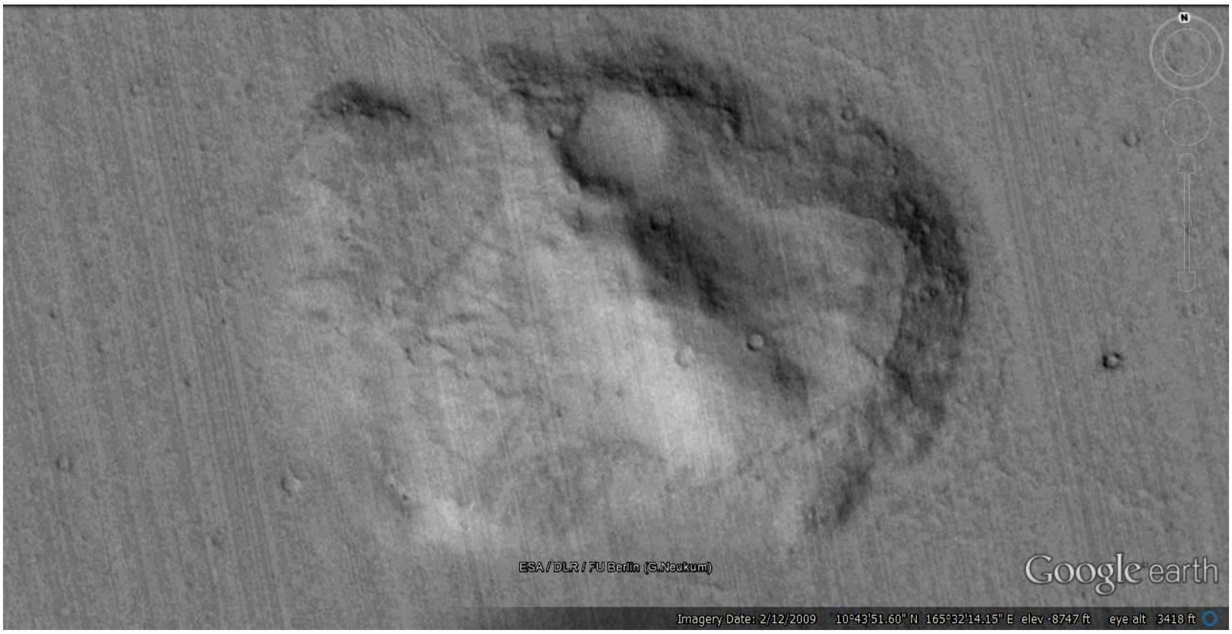

Figure 57. A spill through the wall.

A highly-preserved wall in Figure 58 on the upper side and more degraded on the bottom. Some pieces of the wall are missing at A.

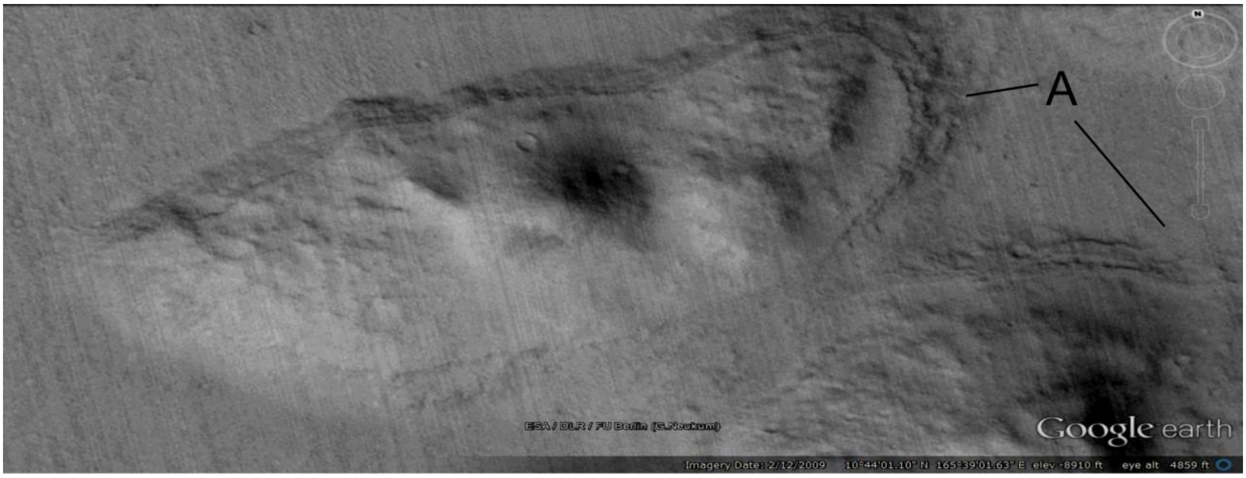

Figure 58. Missing pieces of the wall.

Another peninsula in Figure 59 with flattened soil between the hills making a level surface. On its end the layers are breaking up and one piece is missing.

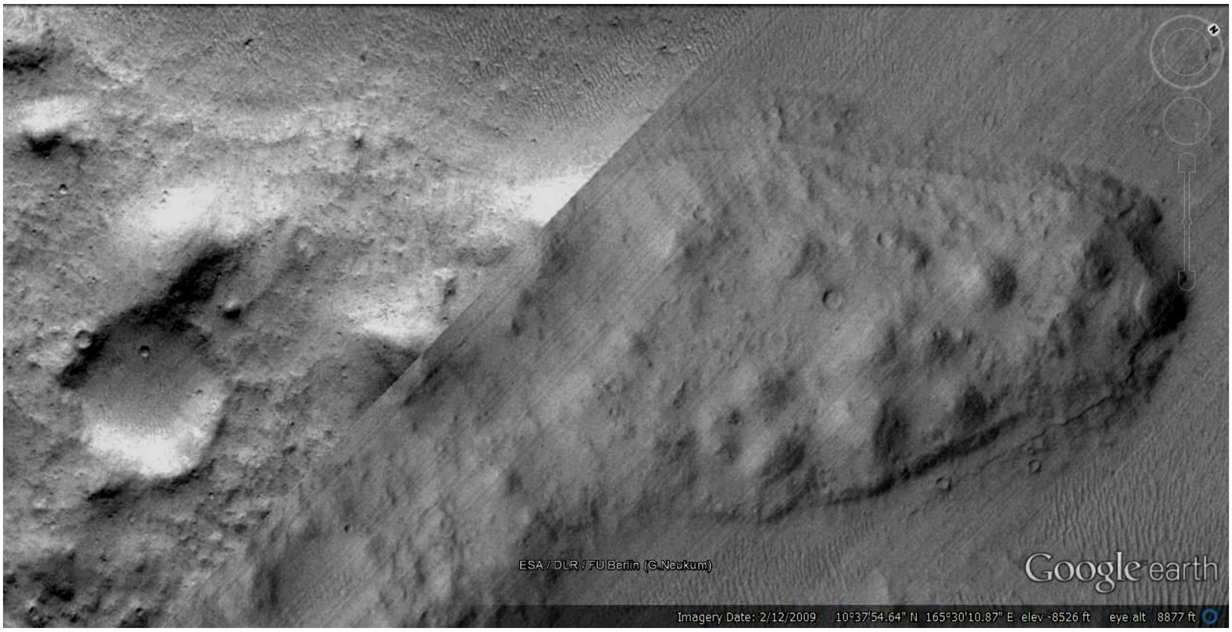

Figure 59. A broken wall on the end of the peninsula.

A squarish shape like the Square Mesa in Figure 60. It is approximately straight on its upper and lower sides.

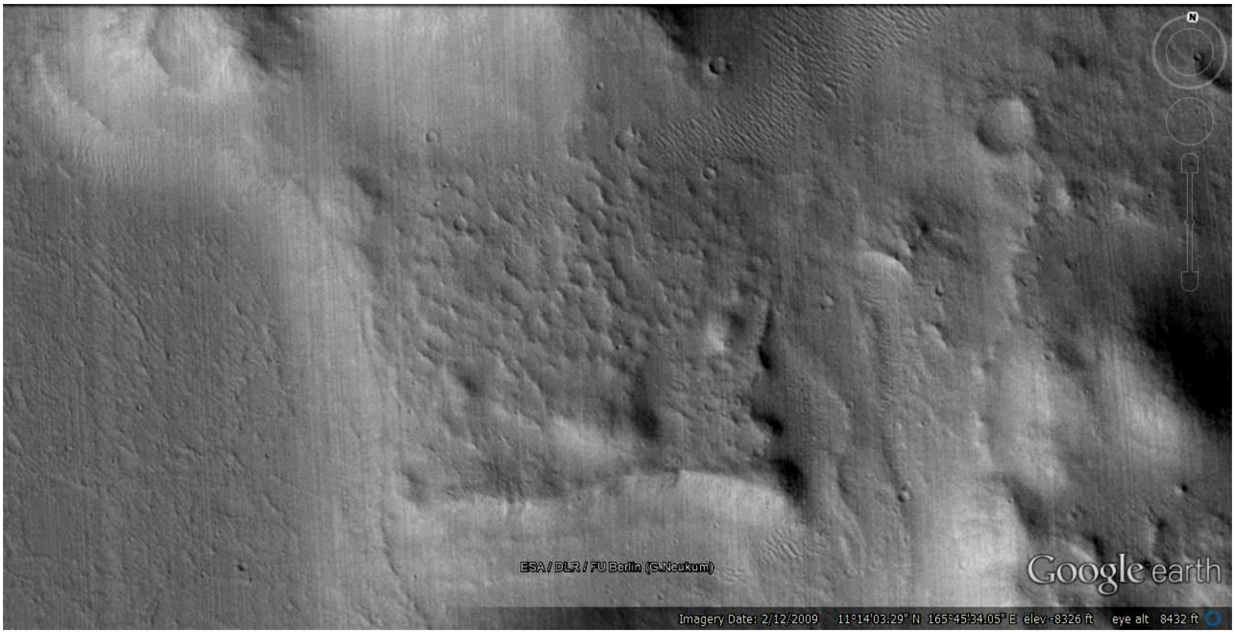

Figure 60. Another square mesa.

Another squarish shaped mesa in Figure 61. The walls have similar layers on the right to the main Square Mesa. The layers are more eroded on the right.

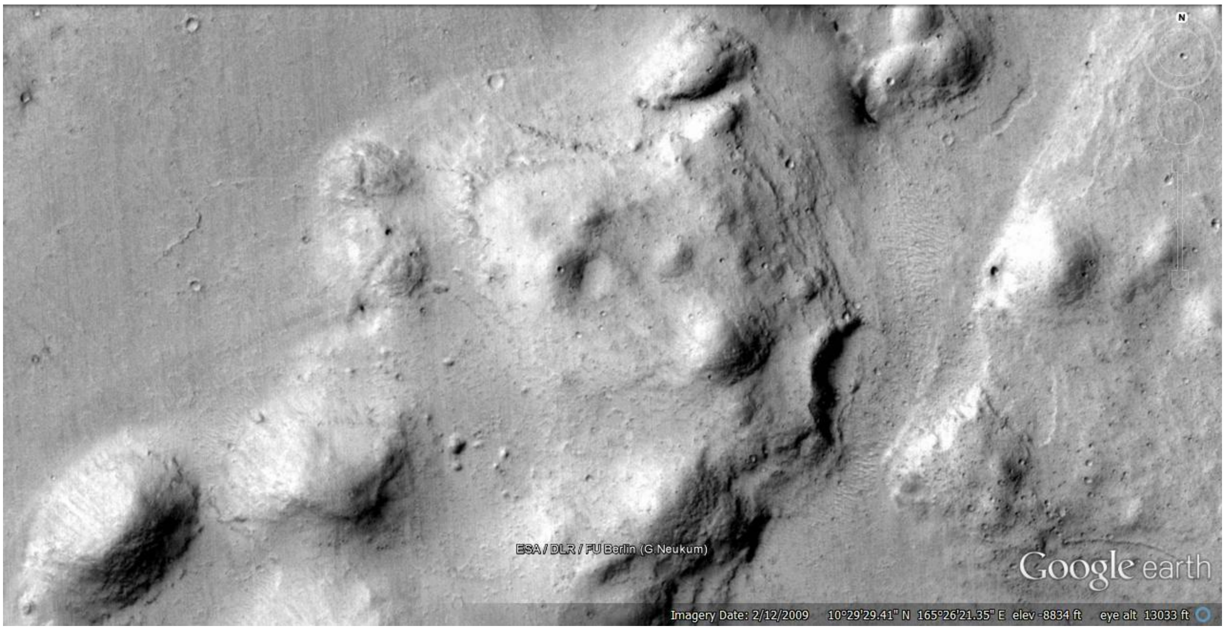

Figure 61. Similar to the Square Mesa.

A rectangular mesa more like the Cydonia face in shape in Figure 62. The red lines indicate it was reimaged by HiRise.

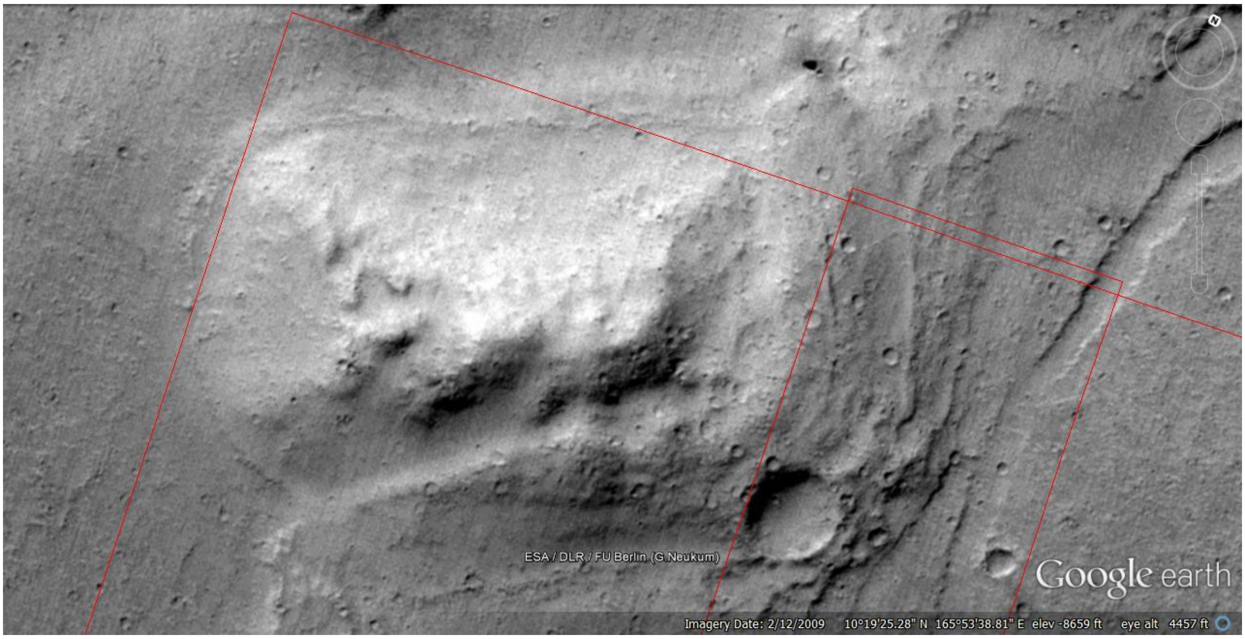

Figure 62. A rectangular mesa.

Here is the HiRise image of it in Figure 63. The layers are visible like in the main Square Mesa.

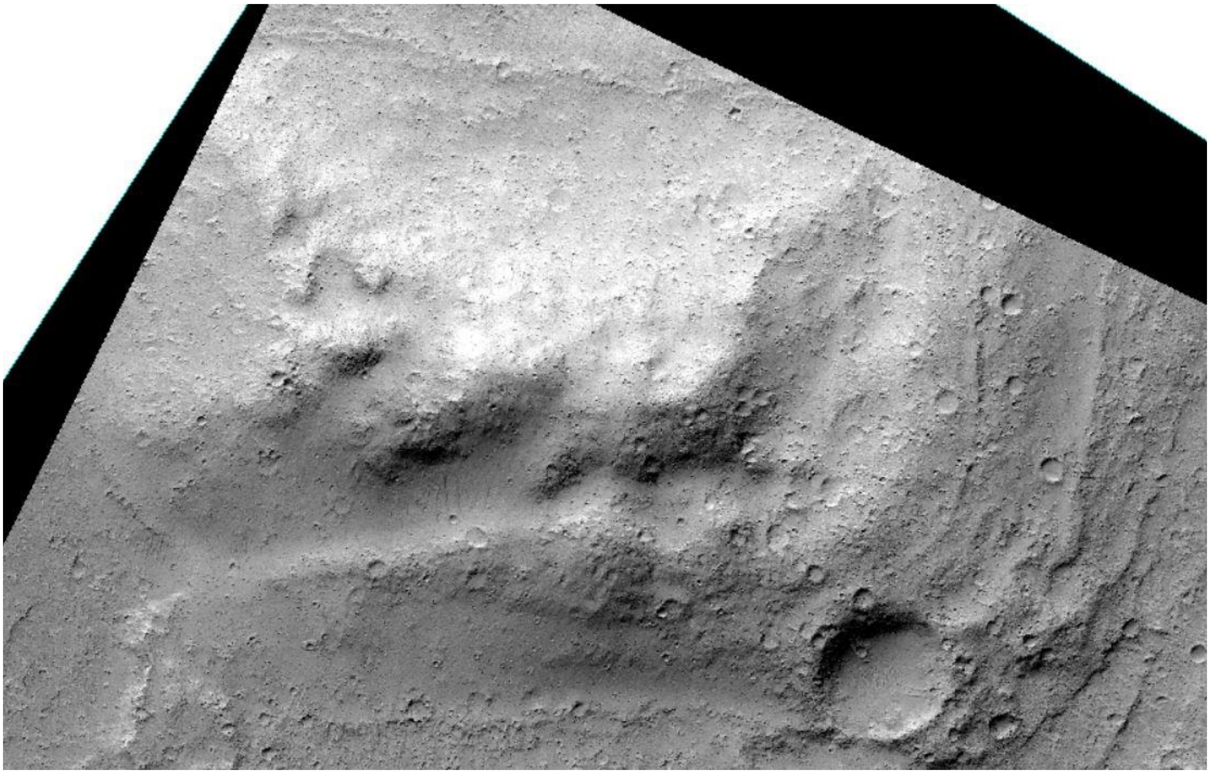

Figure 63. The HiRise version.

A squarish mesa on the left attached to a crater in Figure 64. There is again an impression of an angled wall holding in sandy soil.

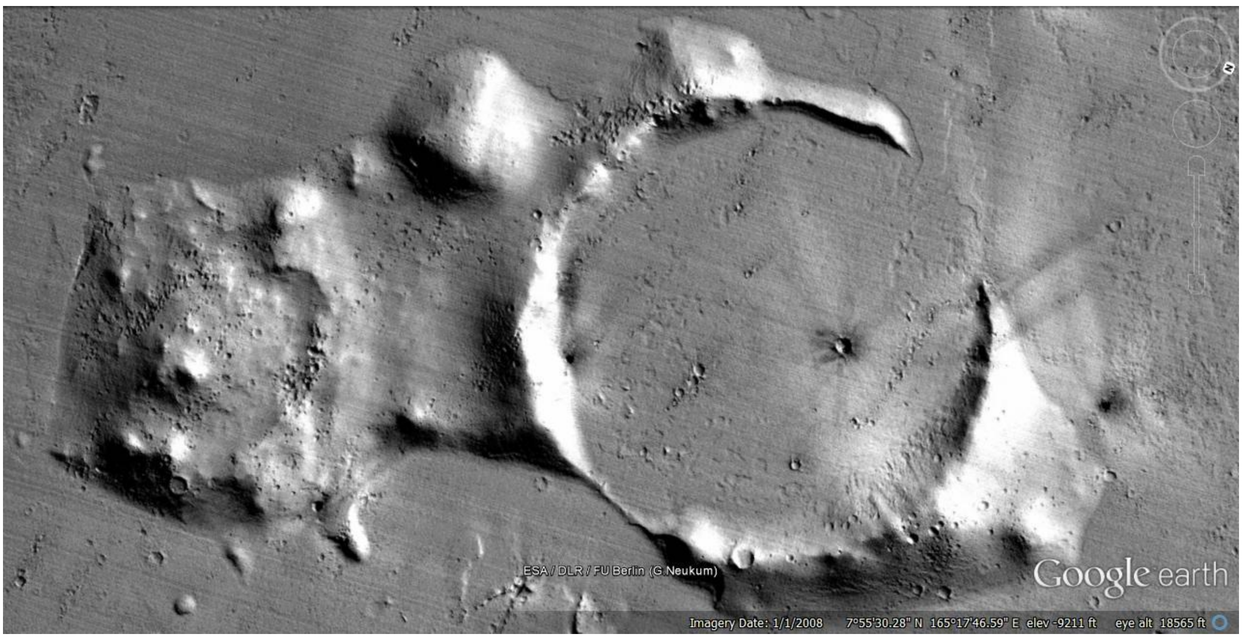

Figure 64. A square mesa attached to a crater.

A more trapezoidal mesa with the same walls and flat soil around the mounds in Figure 65.

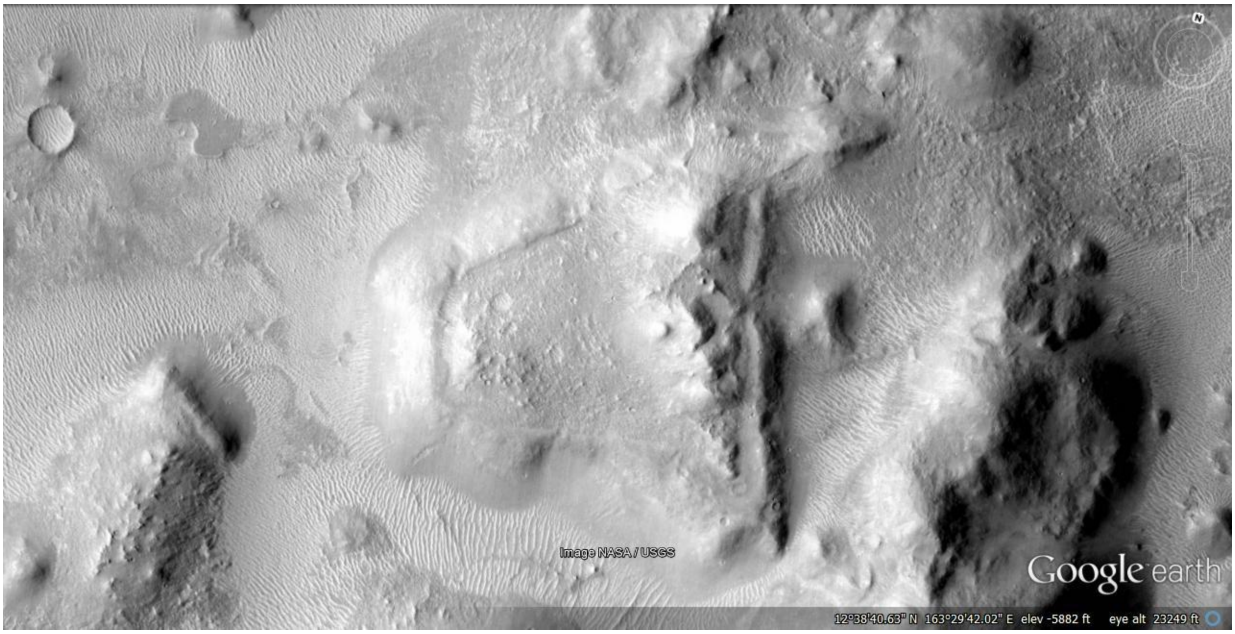

Figure 65. A trapezoidal mesa.

Another similar shape in Figure 66, the walls seem to be holding in a lot of soil around the central rock to give a flatter surface. The walls appear to be much thicker and stronger on the right.

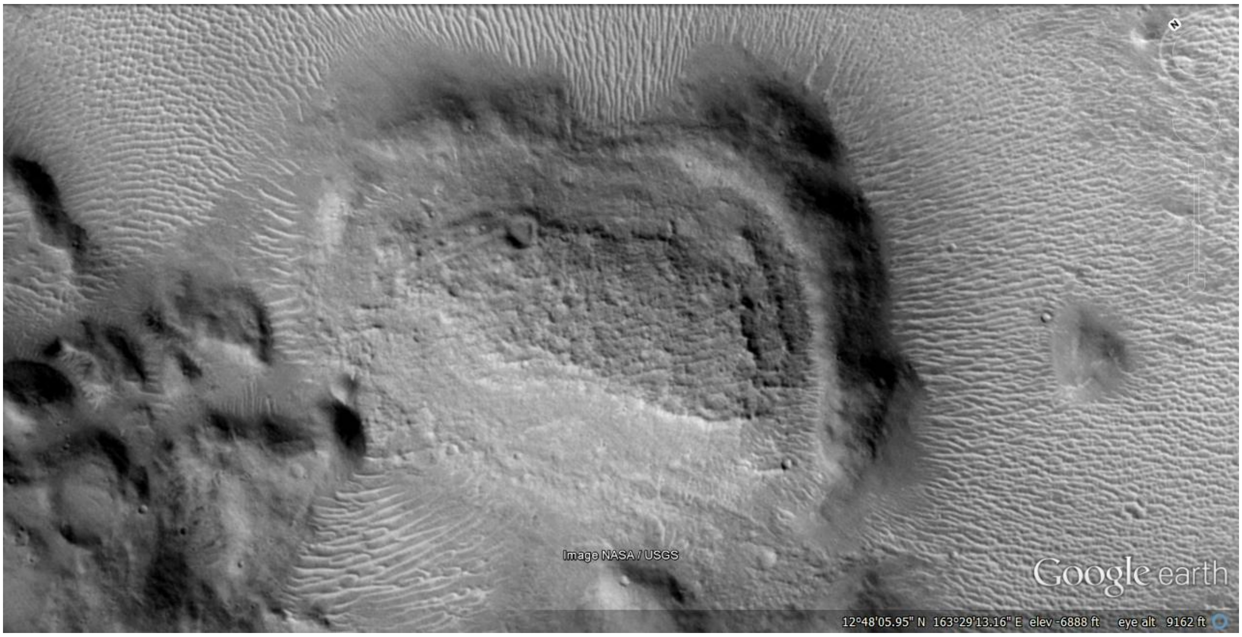

Figure 66. A more curved mesa.

This has a straight gap through the rock in Figure 67. This may have been used as a platform above the water.

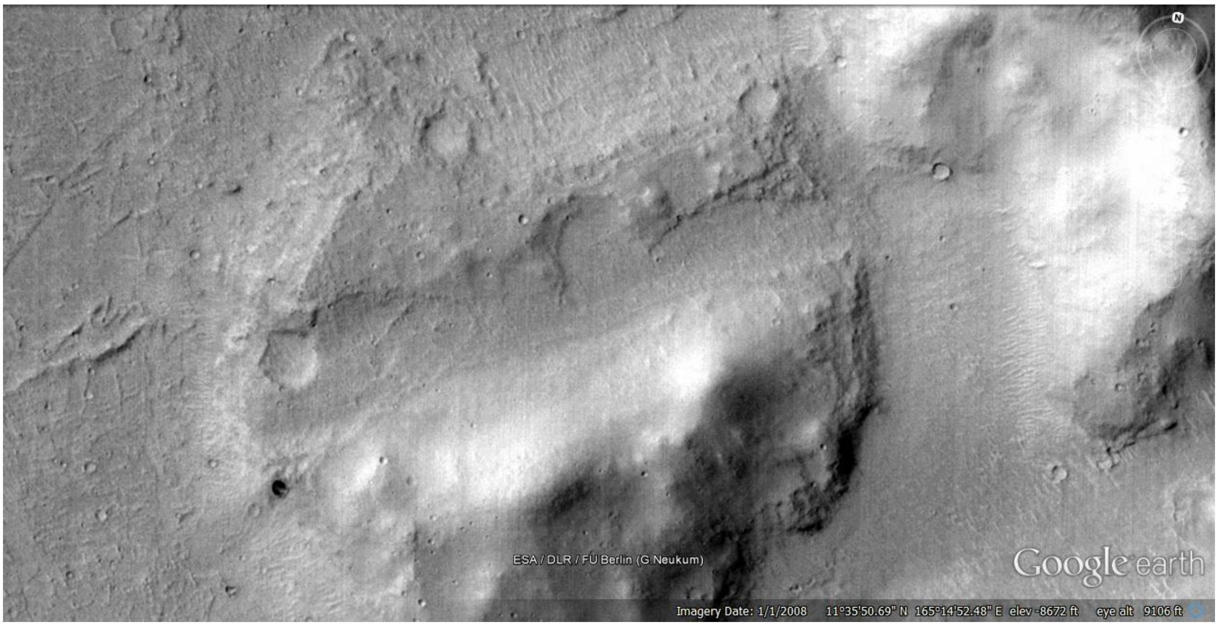

Figure 67. A straight platform.

Another straight gap in Figure 68. This may also have been a platform.

Figure 68. A straight flat area.

Figure 69 has a shape like the Cydonia Face. The walls appear to be very even and straight, on the right they are close to right angle where they join.

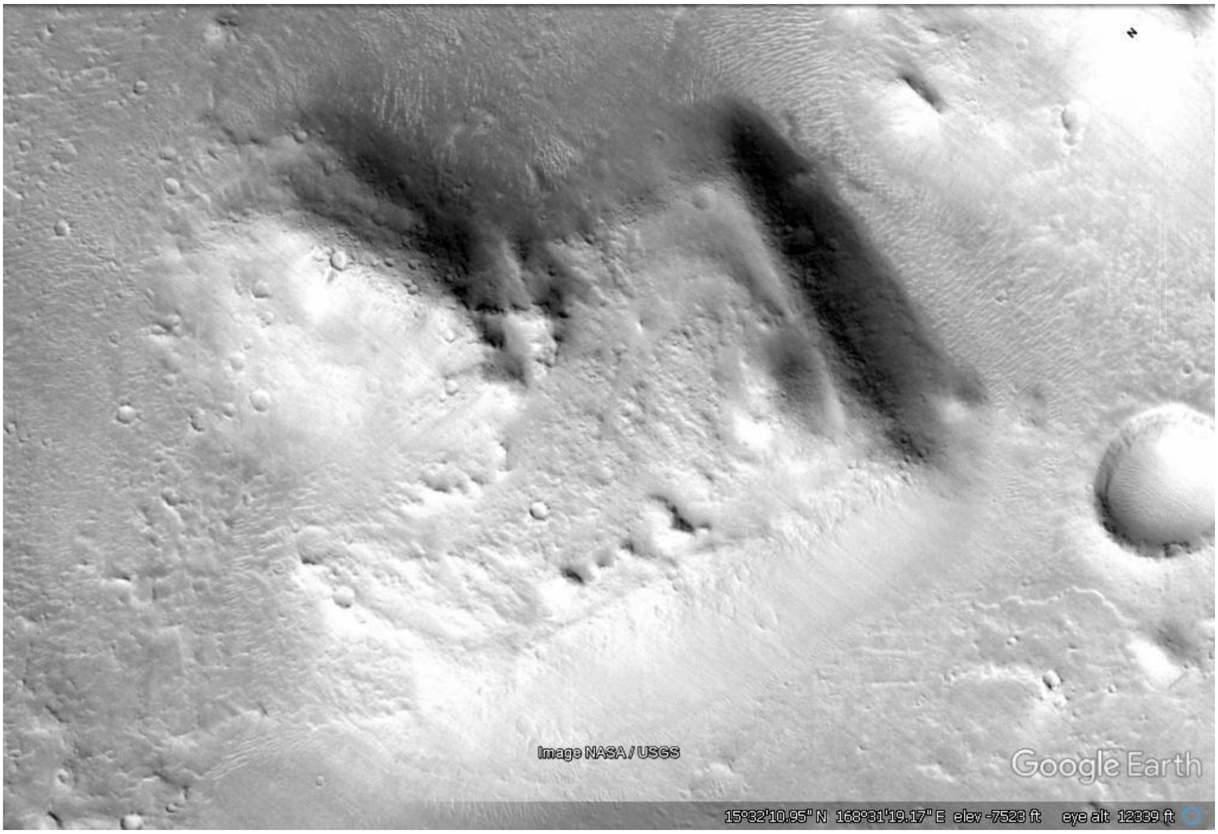

Figure 69. A face shaped mesa.

In Figure 70 there is a ridge which continues on from the formation, this turns at B to form the face like shape. C shows where the sand seems to have run out of the interior, eating away at the level surface. It indicates the interior is not made of rock but of sand. D shows how straight the wall is and the corner is close to a right angle. E shows a straight wall, it is much less eroded than the hill at H and may be concrete. F shows a corner that is like a modern building in shape, the wall terminates at G with another right angle.

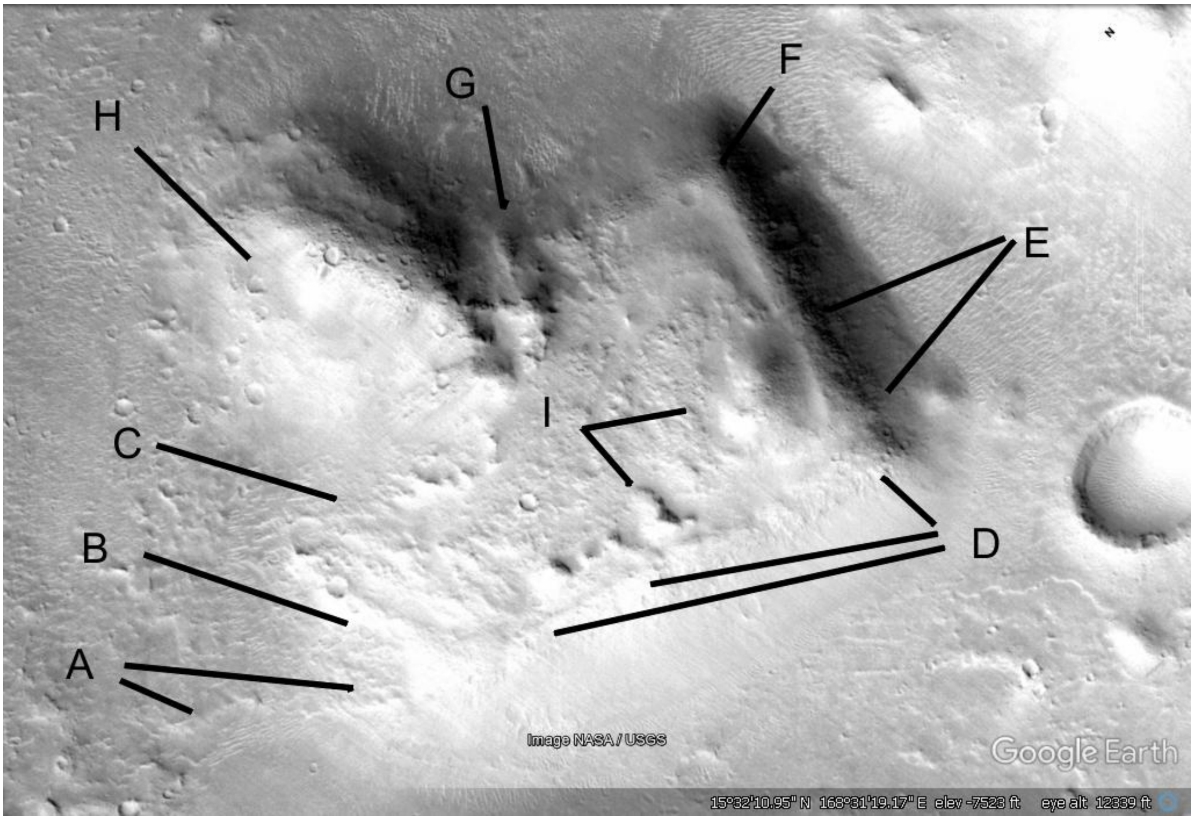

Figure 70. The face shaped mesa annotated.

Martian habitability

Nelson [11] discusses how finding water on Mars has raised hopes for finding past or even present life on Mars. Over 60 Martian meteorites have been found on Earth indicating an early wet Martian environment. Carr [27] suggests there could have been two oceans, a higher latitude one dating to 3.8Ga and a more recent lower one associated with Elysium and its outflow channels. Either of these could have been associated with the Argyre impact hypothesis. The OMEGA/Mars Express mission found evidence to support these two periods of paleoseas, one had phyllosilicates formed by interacting with water and the second formed sulfates in an acidic environment. The Mars Odyssey used a neutron spectrometer that found the top meter of Martian soil contained the equivalent of 14cm of water, including the polar ice this could have created a global average of 500 meters of ocean across the planet. This assumes that the water was there and has been lost, however the Argyre impact hypothesis can account for the flooding evidence using much less water. More recent estimates that may also have applied to this impact would cover Mars to a depth of 35 meters. This would be compatible with the Square Mesa and related formations in a shallow paleosea, it would also connect with the evidence of Kossacki et al. [15] concerning the depth of this paleosea.

NASA [28] announced in January 2014 that the Curiosity and Opportunity rovers were also searching for signs of ancient Mars life, Gale Crater is on the edge of Elysium near the Square Mesa formations and also close to the King's Valley, it has the still functioning Curiosity Rover. Meridiani Planum had the Opportunity Rover and is where the Meridiani Face is located. These ancient water environments may have led to the early emergence of life Grotzinger [9] [17]. The Mars Exploration Program Analysis Group noted "Conclusive proof that liquid water existed for long periods on the ancient Martian surface. This strongly supports the idea of life developing on Mars around the time of the Argyre impact, the main issue is whether this life could have evolved sentience if these paleoseas and a warmer climate lasted for long enough. They also suggested "If life evolved there, conceivably it may still survive".

Horneck [22] also discusses the amount of water on Mars, a range of 3.6 to 133m is indicated from the composition of the atmosphere with the D/H ratio, according to de Bergh [26]. Horneck also points out that life already existed on Earth 3.8Ga ago at the same time, the Argyre impact could then have created a habitable environment that was fed by panspermia as Earth meteors transferred its life to Mars. Meteors falling into a paleosea would have their life inside them more likely to survive. The Martian atmosphere has a low shielding of 5–16 g/cm^2, the lack of a magnetic field means a substantial portion of the cosmic radiation reaches the Martian surface. However, the Martian magnetic field should have still been operating at the time this paleosea existed, it has been suggested the Hellas impact caused it to slowly decrease over time. Also any evolving life could have avoided radiation by either living in the paleosea or only coming out at night. Many Earth creatures are also nocturnal and would not present problems for life to evolve.

De Vera [10] discusses how many lichens can live and photosynthesize under current Martian conditions, with low temperatures, aridity and high UV radiation. The warm and wet Mars after the Argyre impact would have been much more hospitable, also the UV radiation would have been reduced by clouds and the thicker atmosphere from volcanic outgassing. Using simulated Martian atmospheres, temperatures, humidity profiles and UV radiation spectra have shown photosynthetic activity of Xanthoria elegans. Lithopanspermia is the viable transport of microorganisms via meteorites, experiments have been performed to test the three steps of the lithopanspermia process. Viable transfer from Earth to Mars requires that microorganisms survive the ejection into space by the impact of an asteroid or comet on Earth. Secondly they must survive the journey through space, with timescales ranging between 1 and 20 million years. The third step is the entry into the Martian atmosphere. The second step has been tested by space experiments, the first step by meteorite impact simulation tests using explosive devices. The ejection of the organic material is assessed to be exposed to 5-50GPa, lichen has been shown to survive in this range. While there has been less success with reentry the falling of meteors into a paleosea might have allowed the lichen to survive, more testing is needed.

Schuerger [1] tested the biotoxicity of Martian soil, six Martian soil mixtures were created to simulate a range of potentially biotoxic geochemistries. They included basalt-only (non-toxic control), salt, acidic, alkaline, Aeolian, and perchlorate rich geochemistries. Six eubacteria were tested for tolerance to desiccation, the Bacillus subtilis HA101 and Enterococcus faecalis ATCC 29212 were found to be resistant. Tests with B. subtilis and E. faecalis showed that 1 mm of Mars analog soil fully attenuated the biocidal effects of a simulated Mars-normal equatorial UV flux. In the Argyre impact hypothesis the condition for life should have been much more hospitable, there would have been abundant water from the melting poles. Also the radiation would have been lower with the functioning magnetic field and cloud cover from weather patterns. If this life was evolving in the ocean then the conditions may have been as hospitable as on Earth. They conclude that Mars soils are not overtly biotoxic and suggest that the soil geochemistries on Mars will not preclude the habitability of the Martian surface even in the current environment.

Kuhn [7] discusses the Mars Science Lab Curiosity landing at Gale crater on August 6, 2012. This area, near the King's Valley and the Square Mesa formations was chosen because it offered a wide range of past aqueous and thus, potentially habitable environments. It had outflow channels, an alluvial fan, as well as finely bedded deposits containing strata with phyllosilicates and sulfates. The landing site had many features associated with deposition by water, the life-bearing potential of the analyzed sites was indicated by layers of sedimentary rocks and a gravel conglomerate. It's likely then these same features would be found around and perhaps in the King's Valley, a fluvial valley close to Gale Crater and containing possible artifacts. This is shown in Figure 71.

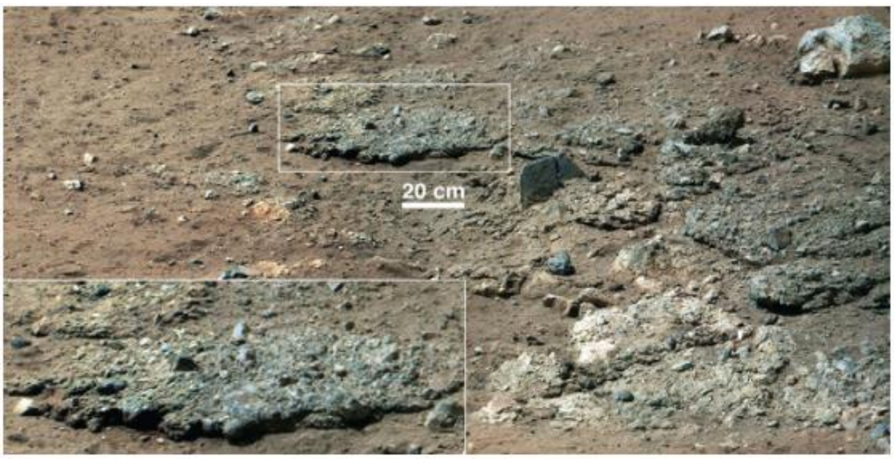

Figure 71. A conglomerate of sand and pebbles next to the Curiousity landing site.

The type of deposition according to Kuhn [7] is indicative of sediment deposition from a flowing stream of water slowing down rapidly, such as when leaving the confines of a channel. The rover had apparently landed on an alluvial fan, the flow velocity and depth of runoff from the crater wall was estimated at 3–90 cm deep and flowing at a velocity of 2–75 cm/s. The *Sheepbed* sediments showed strong evidence that they formed in a lacustrine, i.e., shoreline-type of environment that would offer habitability for microorganisms. Some features point toward a wet deposition of *Sheepbed,* the chemically uniform layer of mudstone is approximately 2 m thick. Accumulation of a fine lake sediment layer of similar thickness requires between 100s and 1000s of years. The *Sheepbed* sediments revealed that the area would have been habitable for chemolithotrophic microorganisms. The presence of hydrogen sulfides as an energy source and a pH in a near-neutral range, also essential elements for life such as carbon, nitrogen, and phosphorus were detected that would enable their use by microorganisms. The lake in which the *Sheepbed* sediments formed would have been habitable for the type of microorganisms expected to have evolved on Mars.

Conclusions

The Square Mesa and related formations are hypothesized to have been islands in a paleosea that lasted over 1Ga, the water would also have been heated by the rise of and long lived heat from Elysium Mons, Hecate Tholus, and Alba Tholus. Similar geology to that found by the Curiosity Rover in nearby Gale Crater may exist around these formations. The biotoxicity of Martian soil may have allowed for life to evolve in this area, lithopanspermia may have allowed for microorganisms such as lichen to be transported from Earth to Mars into this paleosea. Platy deposits indicate pack ice on this paleosea with fewer signs of ice nearer Elysium Mons and the Square Mesa formations. It is likely to have been more hospitable for life there. The depth of this paleosea would have been consistent with the height of these islands. The wall like shapes on these formations occur only on some islands but not on others close by in the same geological conditions and processes involved in their creation. Often these walls are on one side only of these islands though the same geological process would be expected to go all around them. The Square Mesa shows signs of bricks of the same size repeating, also layers of constant thickness. The theme of a sandy interior shored up by these walls is a proposed hypothesis for their creation. This area would have been one of the first to have a paleosea under the Argyre impact hypothesis, then with polar wander it would have remained on the equator heated by Elysium Mons. It appears then to be a prime location for artifacts to be found from a hypothetical evolved sentient species. Because these formations are so different from natural formations in the area it is proposed the null hypothesis is falsified and that some of these are artificial.

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The Ferns: Artefacts or natural formations?

Greg M. Orme[i], Brisbane, Australia.
Keywords: Mars, ferns, fronds, Fibonacci, channel, erosion, artefact.

Abstract

The ferns are a series of plant like formations discovered by the author on the 28th November 2014. The name was actually given by the HiRise team, it refers to a series of dark structures in Antonialdi Crater that resemble plants. The natural hypothesis is a channel network, that a series of rivers and their sediments were more resistant to erosion than the surrounding terrain. Over time the ground around these channels eroded away leaving the fern shapes above ground. The alternate hypothesis is they are artificially constructed, this paper attempts to show geological explanations do not work with these formations.

Introduction

The ferns are found on a great circle also occupied by the Nefertiti formation, Cydonia, and the King's Valley. This is explained further in my book[ii]. A part of the great circle is seen in Figure 1 as the bottom horizontal line. It has one of the fern images PSP_007095_2020 almost directly on it, the others are clustered around it. The other two lines in Figure 1 lead to more candidate artefact sites on different great circles. Some of these are examined in my book, however the closeness of the ferns to the more vertical lines implies they also line up with those candidate artefacts.

The best evidence for Martian artefacts so far happens to fall on the one great circle as the bottom line in Figure 1, this is like an equator or longitudinal line that bisects Mars. One theory as to why these anomalies occur on lines is random chance, this would be the null hypothesis. Another hypothesis is to mark latitudinal and longitudinal lines as part of an ancient navigation system, still another might be to make them more noticeable. The ferns are also significant because they are the fourth candidate artifact to be found on this great circle, they then represent a successful prediction. This a priori prediction is that future discoveries of candidate artefacts will fall on great circles more often than they should by chance, also that they would form a mathematically significant pattern.

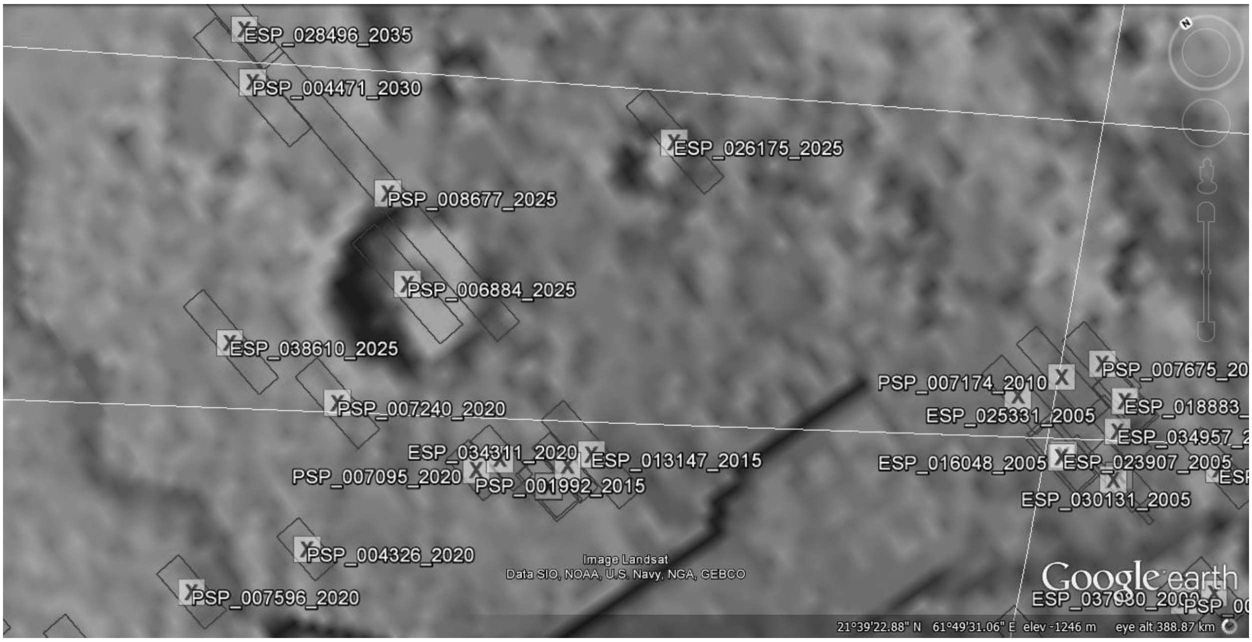

Figure 1. Position of the Fern formations on the Great Circle.

Location

The ferns are found in Antonialdi Crater in Syrtis Major Planum, approximately at 21N 60E. In Figure 2 the pins represent HiRise images of the area, the pins in the top right corner are where the ferns are found. Only part of the overall formation has been reimaged.

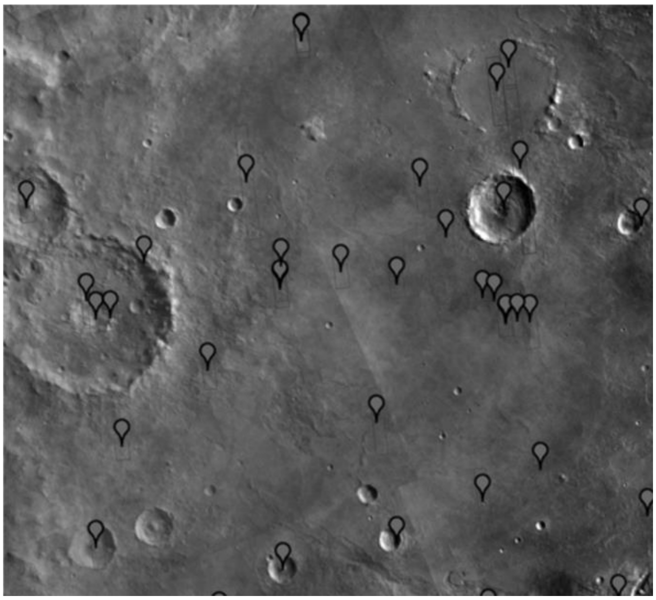
Figure 2. The area has only been partly imaged by HiRise.

CTX image

The ferns are also visible in the CTX image[iii] shown as Figure 3, this is a context image from HiRise while the pins in Figure 2 are images with higher definition. This context image gives an idea of the size of the formation. The ferns appear to be clustered together in one small part of the crater. This makes the natural hypothesis less likely as the same geological conditions should exist throughout this crater. For example the Martian spiders are a highly unusual natural formation, they are widely distributed on the South Pole. The terrain is similar throughout Antonialdi Crater and similar dark soil patches are seen all over it. But these are not in fern shapes, instead they appear to be randomly distributed. This implies a simple construction method, the ferns would have been formed by pushing this existing soil and rocks into the plant like shapes.

No ferns are found elsewhere on Mars so far despite similar geological and weather conditions elsewhere. The idea of forming recognizable shapes with dark soil occurs in other candidate artifacts, Nefertiti is a face that is formed from dark dunes among random dunes. The Meridiani Face is also formed from these darker dunes. Both can be seen in my book “Why we must go to Mars: The King’s Valley”[iv].

Figure 3. CTX image of the fern formations.

The original image

This area also appeared in the MOC image R1303336, the ferns section is shown in Figure 4. For example the elongated hill in the top right is in PSP_001952_2015 analyzed in this paper. It indicates the ferns are in one area clustered together. This presents problems for a geological explanation, the crater is very flat and water might be expected to create pools or lakes, however there are no actual pools like this in the ferns. When they rarely touch each other there is no increased flow to that point. But rivers flow down gradients and so as the lowest point there should be more signs of water where the fern leaves join. Rivers need a gradient to flow down, however these branches point in all directions.

Figure 4. Mars Orbital Camera image of the ferns.

HiRise explanations

The HiRise team[v] pointed out the resemblance to ferns[vi], they state they are made of rough rocky materials. However this is incompatible with a finely structured river network, a river cannot carry boulders along with it. This is because rocks are much heavier than water, any slow river like a delta can only contain fine silt and mud. These rocks are visible in the HiRise image, this should indicate that some are a meter in diameter or more. If flooding moved the large rocks then it should have created a flood plain seen elsewhere on Mars, not fine branches like this. If the rocks were moved by ice then this is also seen elsewhere on Mars, it forms large areas of scree and not fine branches. This is then falsified by gravity. There is also no sign of a water source for these ferns, however their large number should indicate a source as visible as they are.

The explanation by HiRise further states this is a channel network in inverted relief, they formed and then the less resistant materials around them were eroded away leaving the ferns. However there are no signs of former river banks containing them, even so how these rocks could move in water is not explained. Also the ferns are similar in rock color to other clumps in Antonialdi Crater, however those clumps are not in a channel system. So if these other clumps are close by then it implies they too are the resistant remains from erosion, they appear identical except for their random shapes. The HiRise team state a warmer wetter Mars is involved in the ferns formation, and also possible microbiological life. This is then consistent with the idea of Martian artifacts associated with life there.

Alternate hypotheses

NASA suggesting life may have occurred around this time is highly significant, the issue is then how advanced this life was. NASA's position is this life was very simple, however panspermia by meteor impacts might have brought life from Earth speeding up Martian evolution. Meteors falling into the Northern Ocean might then have protected more of this life from the impact, and provided Mars with life that evolved more quickly. It could have formed a primitive civilization that created these artefacts. Because Mars is much colder these hypothetical inhabitants would have died out as the Martian atmosphere froze. The other hypothesis is that aliens came to Mars at this time, they may have terraformed Mars in ways detailed in my book. The candidate artefacts such as the ferns would have either been formed by these aliens or by life seeded by them. In that hypothesis life on Earth might also have been seeded by them, we might then be a successful terraforming experiment much like those NASA is planning for other worlds.

The scientific method

Observations have been made of Martian formations, the next step then is to advance hypotheses that are consistent with these observations including the null hypothesis of their being random. There is no real evidence that aliens or indigenous Martians existed. Instead this paper tries to show the null hypothesis is incorrect. It does this in two ways. The first is that geological processes could not form the ferns, for example that they are not channel systems. The second is a statistical argument, that the fern branches are in a Fibonacci pattern used by Earth plants. This pattern occurs more often than chance should allow, this gives a high enough confidence level to disprove the null hypothesis.

Martian spiders

Another plant like shape found on Mars is the spiders[vii], however these are ravines while the ferns are above ground. Also the spiders are likely to be formed along polygonal cracks in the polar areas, the ferns are more varied like representations of plants would be. Where there are polygonal cracks the branches appear to have formed independently of them, cutting across them rather than following them. Spiders are also formed by CO2 outgassing on the South Pole, on the Martian equator this does not occur[viii] in a similar process.

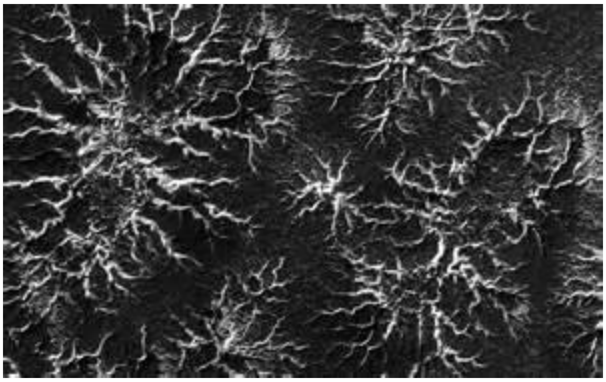
Figure 5. These are similar to Fibonacci branchings but are also random.

Circular arguments

The geological and null hypotheses are often regarded as the default or status quo on Mars, extraordinary evidence is needed to prove otherwise according to Carl Sagan. This then implies that a very high standard deviation should occur in the data to rule out chance, much more than with a more conventional hypothesis. However a geological argument also needs to stand on its own merits, for example there were many competing natural explanations for the Martian spiders. With a single explanation there is a false assumption of proof, there may be other natural processes involved with the ferns not considered yet. So they may not be channel systems but they may be formed by another natural process. It is important then not to give geological models a free pass where they have problems, they get no such treatment when artificiality is not a possibility.

Methods of proof

Next the HiRise images are analyzed in depth. The main process is falsification, to attempt to prove geological explanations are not possible here. This then only leaves artificiality. It is not very useful to just present evidence for artificiality, the ferns look like plants but many natural things on Mars appear artificial. Another method is reduction ad absurdum, for example it is highly unlikely every fern branch looks plant like if formed by geological processes. By random chance some might appear this way, sometimes a field of dunes might randomly form shapes that look artificial. A river system might occasionally look like plant roots but many do not. A large enough area with sharp rocks might sooner or later present one that looks like a symmetrical pyramid.

Fibonacci branching

On Earth plants form branches in specific patterns, the angles between them are similar and they branch every second time in a Fibonacci sequence[ix]. The river system below[x] looks similar to the ferns, however many river channels join up together while this only happens once in the ferns imaged so far. The branches appear Fibonacci like but are random, the ferns have every branching in the correct Fibonacci sequence. The angles between the river branches below are also random, however they are roughly equal in the ferns. A plant has a fractal shape that is more constant, smaller branches occur at a fixed ratio to larger branches. While rivers can be fractal the variations are much larger and more random. Also the ferns do not connect to a major river, often they are not connected to other branches at all so there is no way for water to have flowed to them.

Figure 6. Waterways have random branches only sometimes Fibonacci.

In Figure 7[xi] the Fibonacci sequence is shown, at the bottom the tree branches to the right, then following that branch it next bifurcates to the left. The result is a branching every second time in the sequence 1,2,3,5,8,… Following this sequence on the ferns seems to show a perfect pattern, each times this happens it is less likely to be occurring by chance. This allows for a statistical argument much like tossing a coin, each time the Fibonacci branching occurs could be heads and a deviation could be tails. Assessing this as an even chance of either occurring then the ferns can be evaluated on a normal curve.

The difference between plants and a natural river system is that plants always branch in a Fibonacci pattern, a river might randomly do this a fraction of the time like random coin tosses. As the fern branching is clearly visible it is possible to follow each branch to see whether the bifurcations follow this pattern. Another test is to compare the angles between the branches, plants of one species tend to use the same angle unless the wind bends them in some branches. If the angles appear to be similar then this also allows for a statistical test, there can be some error around this angle because of the difficulty of measuring thicker branches. Also a hypothetical builder may have constructed some branches to be bent in a more realistic way. Assuming conservatively that a three part Fibonacci set of branches each has a ½ chance to have the same angle or different this allows each branching to appear on a normal curve like coin tosses. The river in Figure 6 clearly has some randomness in its branching, but as will be seen the ferns do not.

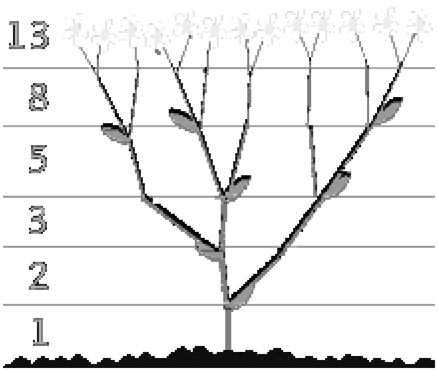

Figure 7. Fibonacci branching never has errors in plants unlike in rivers.

ESP_012725_2015

In Figure 8 a section of the ferns are shown. It appears to be different from the river network in Figure 6, the branches all have about the same angle. Following each branch the Fibonacci patterns can be seen. Some branches also do not connect to each other, this is impossible if they are formed by water as this water could not connect to them. Because there are many large rocks in the ferns this is a problem for the geological hypothesis as the rocks cannot disappear, they might be buried but the ground appears flat in the gaps according to the shading. In the bottom right at **A** there is a darker area like a main river, however the ferns don't connect to it unless this is buried. A natural river would have the strongest and deepest branches here and yet they are not seen, they are the least likely to be missing.

The craters at **C** show the branches are all about the same depth as there is no branch material under the crater, the branches are not deep V or U shaped ravines but just sit on the surface as if moved onto flat ground. If these are channel systems that were resistant to erosion then they should thin out in some areas as only the lower parts of the channel remain. Instead they are either there or missing, when thinner they have the same width. This might occur sometimes by random chance but there are too many examples of this.

In the bottom right at **B** there is a large ridge that cuts across the ferns, however water could not flow over a ridge to the other side as shown. If this did happen originally then there should be at least some deviation of the water around this ridge. Artificial construction however can ignore the elevation to maintain this organic pattern. The ground is uneven in many areas, however the ferns don't point to the lower areas as a water flow would. There appear to be no clear areas where these branches follow the terrain.

Figure 8. Each branching is a perfect Fibonacci pattern.

In Figure 9 two ferns connect at **A**, this is the only merging of two branches in the total formation but would be expected to happen more often in river networks. However there is no pooling of water there, the branches are no thicker where they join. It appears as if the right branch is thicker and overlays the one coming from the left, like plants with their leaves overlapping. There is some shading indicating the ferns are not flat on top, the centers are higher here. However channel systems should be thicker in the middle underneath not on top.

Water should leave a deposit that is flat because of gravity. The individual rocks can also be seen here, too large to be moved by a slow river. At **B** there is a crater covered by the fern branch, this is different from other craters that would have formed afterwards and damaged the fern structure. The fern material did not fill the crater like water would, it seems to have coated it evenly without affecting the fern shape. The crater walls appear to be higher than the ferns, they should have either gone around the crater or some of the crater wall should be protruding. This is consistent with a builder heaping rocks all over it. At **C** there seems to be a ridge going down the fern like a leaf rib, more is seen at **D** catching the light. This is a common feature of the ferns, the interior structure seems to be consistent with branches and leaf ribs. From **D** to **C** is an example of the Fibonacci branching with similar angles, one branch to the left then two to the right.

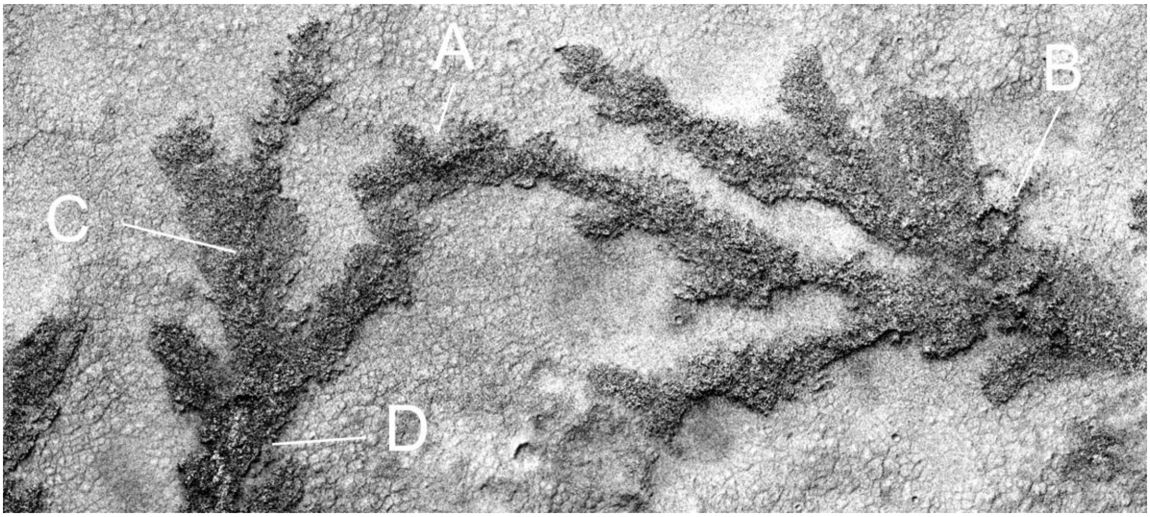

Figure 9. Rivers should not connect together downstream without pooling.

In Figure 10 **A**, **B**, and **C** follow ribs or branches that are raised higher than the rest of the fern leaves. The sun angle can be seen as coming from the top of the image from the craters shown. This is difficult to explain geologically, the river system is supposed to have formed slowly over time and then resisted erosion. However a river has to have a flat top from gravity, these tend to have a sharper peak in the center. There are too many examples of this to happen by random chance. One explanation could be the rocks were eroded more on the edges than the center, however the material appears to be identical throughout the branches. In many cases the branches have a sharp cliff like edge rather than a slope caused by erosion.

However someone constructing this could just heap up rocks higher in the middle of the branches. This is so common it is likely all the branches had this and erosion has leveled some of them. The angles between the branches remains about the same as before, Fibonacci branching is more difficult to count here because of erosion. At the end of the middle line from **A** one rib goes across another, this is unlikely to happen with a water flow without them affecting each other. A leaf also has Fibonacci branching in it on Earth, there is an impression of striations in the leaf that are parallel to each other. This indicates a common angle as with the branches.

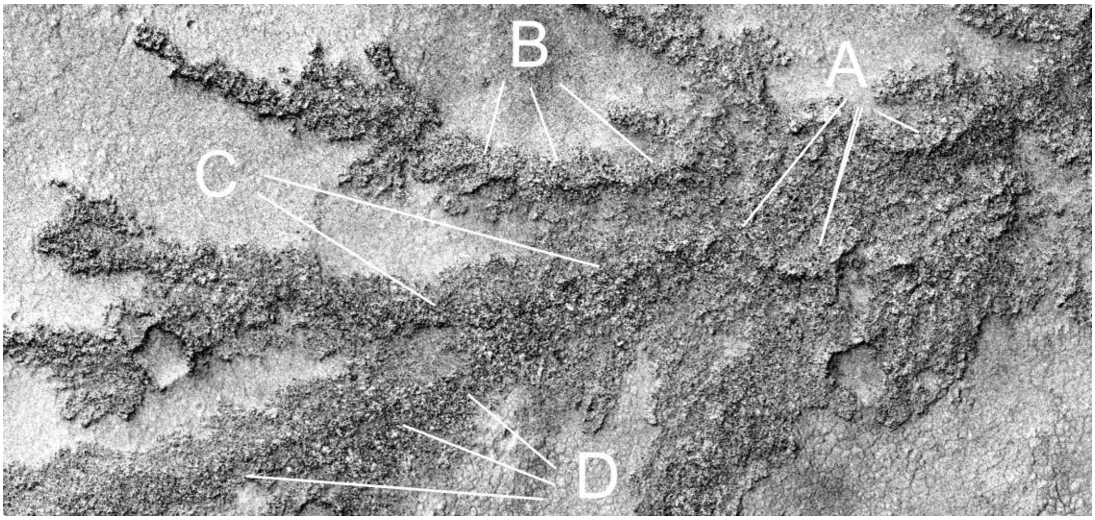

Figure 10. The leaves have raised ribs down their centers.

Figure 11 at **A** shows some of the rocks forming the fern shapes. **B** shows where this has been eroded away leaving just dark soil. Polygonal cracking is common in the area, however the fern leaves are much larger than these cracks. One theory of spider formation, proposed by the author, is that CO2 moves along these polygonal cracks forcing them open into the spider shape. This would occur from CO2 outgassing under an ice layer, with nowhere else to go the CO2 forces its way along the polygonal cracks. Those pointing more towards the source then are opened more, the cracks more at right angles to the CO2 source would be forced shut. However because the fern branches are much larger here the polygons are unlikely to control them, the rocks are larger than the cracks and so could not have originated from them.

In the full HiRise image there are approximtely 80 Fibonacci branchings and no exceptions to this. However some are too unclear to determine. Assuming each set is 3 branches then this gives about 240 angles in these branches. In estimating the odds of this occurring by chance odds of ½ are used, that it has an equal random chance of being a Fibonacci branching or not. In terms of the angles ½ is again used, that it has an equal chance of ½ of being similar in angles to the others. This then would give an odds against chance of $.5^{320}$ to 1 where the exponent is 80+240. The numbers will then accumulate through the paper.

Later a more complete analysis of each Fibonacci branch and angle will be done to make this more rigorous, however it can be used here as a guide. A channel network might tend to also have high odds against chance and similar angles, however this would be divided by the non Fibonacci branchings and different angles that are arguably absent here. Some do appear to be non Fibonacci branching here and different angles, however they are accompanied by vagueness in the image, crater damage, etc.

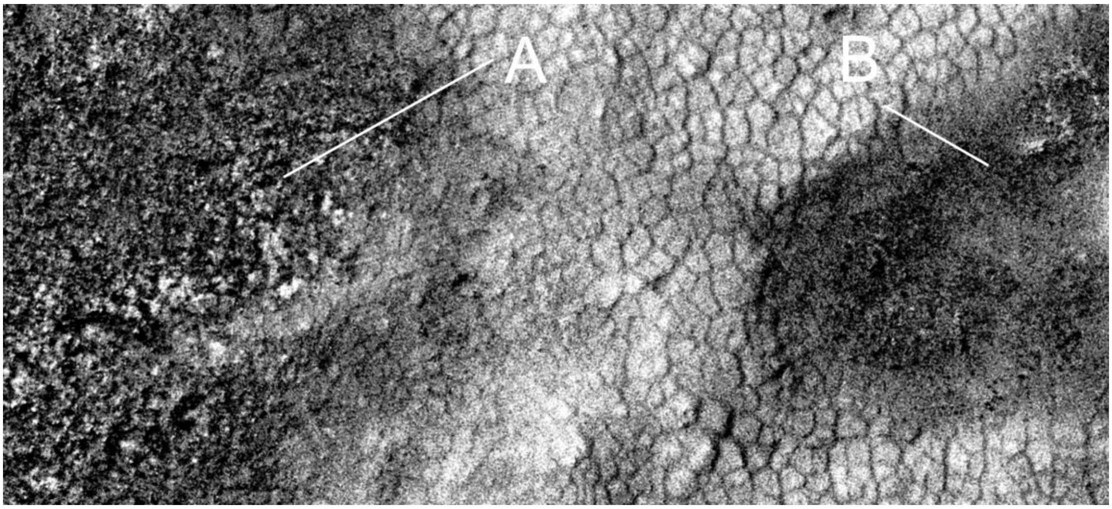

Figure 11. The leaves are not created or controlled by polygons.

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Figure 12 shows more ferns coming from a central trunk area. In the geological hypothesis then the ferns would be rivers coming from this central lake deposit. This explanation has problems because on the lower side at **A** the dark areas don't form fern shapes but are random. This is a recurring problem, the fern shapes seem to be arbitrarily positioned near random looking formations of the same soil type and color. This color is seen in other HiRise images, the image numbers can be used to examine them at the HiRise site. If they are formed the same way then both should be either random or fern like, not such an extreme difference between the two. However this was a problem also seen with the Martian spiders, they were near areas without polygons also free of spiders. This might indicate the polygons do have something to do with the fern formation. At **B** there are grooves running down the trunk, this is a feature of most trunk areas. They may provide a clue to a natural process, be unrelated faults, or represent capillaries seen in plants.

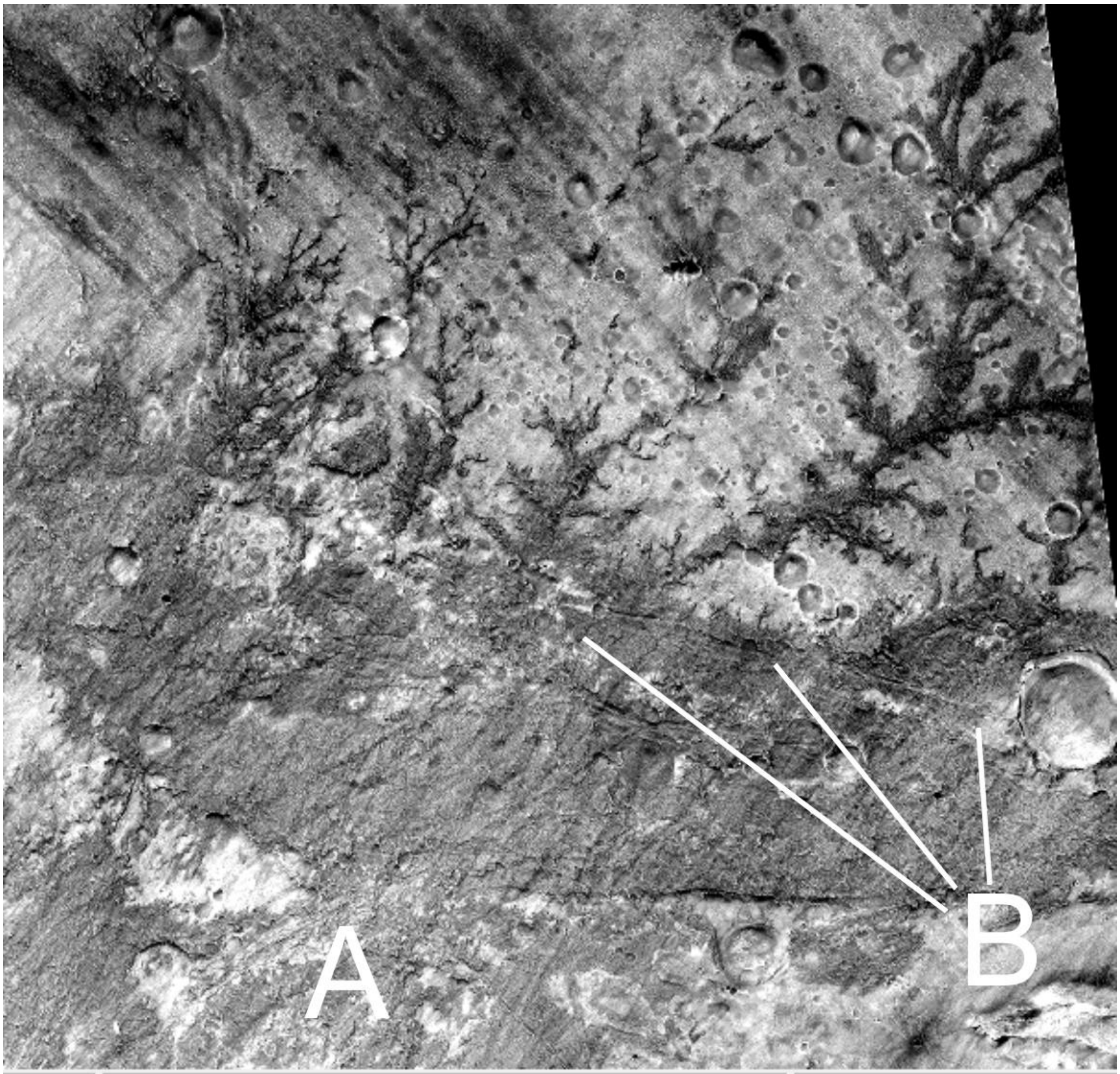

Figure 12. The branches may be from the trunk material moved by the builders into the Fibonacci pattern.

In Figure 13 the right hand line from **A** shows a perfect Fibonacci branch as does the middle line. The most vertical line from **A** traces how these branches go deeply into the dark soil. **B** shows a continuation of a branch along to **C**, a water flow should have been flat on top. Also these are covered in dark rocks and soil, if they were overlaying ridges then the lighter ridges should be showing through at some points. The dark soil is not thick, this is near the edge of it. **D** and **E** show more continuations of these branches, each seems to have the same angles as other fern branches.

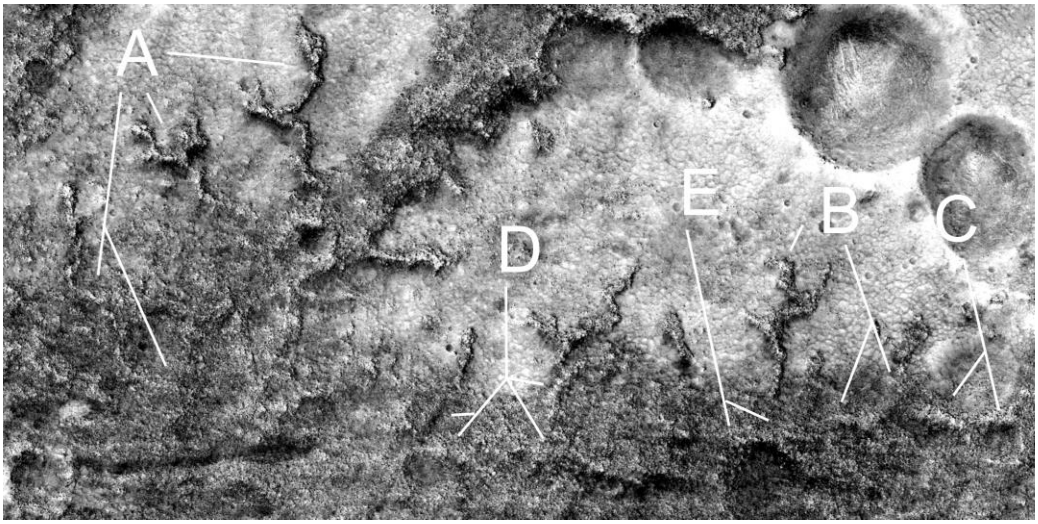

Figure 13. The fern branches are buried under the dark soil here.

In Figure 14 **A** shows how the polygonal cracks line up randomly against the sides of some branches. It may be the branch material influenced the cracking around them by a temperature difference. The ferns are darker and so would heat up more during the day than the lighter soil around them. However the polygons are unlikely to control the fern shapes because much larger ferns have the same proportions. This is different from the spider formations, they typically had branches the same size and following polygonal cracks.

The surface here shows some of the polygonal cracks have continued on under the ferns. This makes the channel hypothesis less likely because the ferns should be U or V shaped underneath. This then would interrupt the cracking so that each side of the ferns was independent. The left line from **B** shows a gap, the branch material has disappeared here. The next line clockwise shows another gap. This is difficult for the geological hypothesis to explain, first it should not be possible for large rocks to move along a narrow channel like this. Then gaps imply there was a section of flat ground the rocks jumped over without depositing there. However a builder might have been short of larger rocks in some areas, smaller ones might have fallen into the cracks or here been blown to above the gaps. The third line clockwise shows the polygon cracks here don’t line up with the branch edge and so are unlikely to control its shape, this is also seen on the fourth clockwise line. It appears as if the fern material is just sitting on top of the polygons, not going into it or attached. **C** shows how these branches also don’t line up with the polygons. The rocks appear small enough here for many to go into the polygonal cracks, this can degrade the branch shapes.

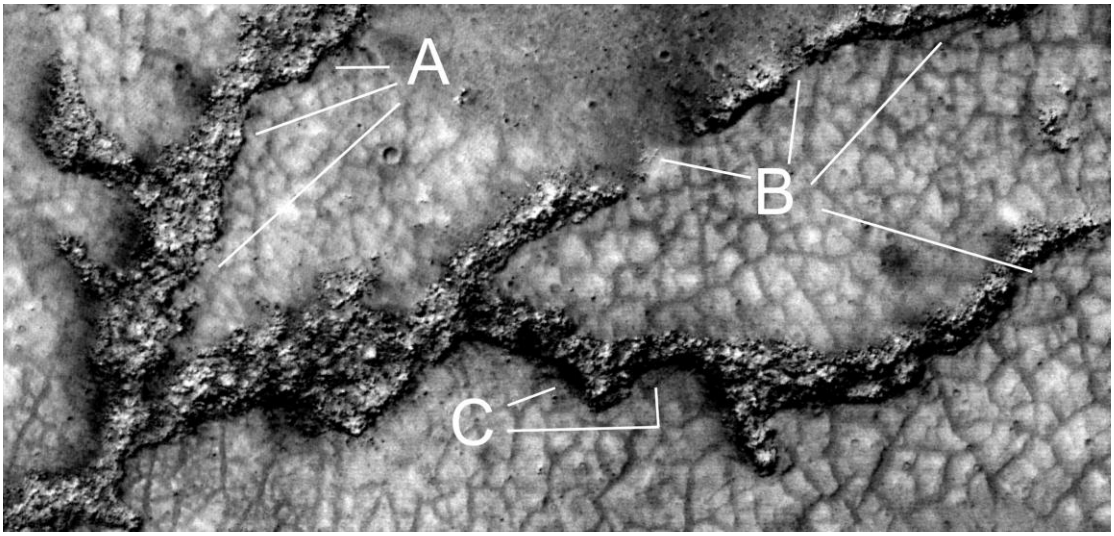

Figure 14. The branches do not line up on the polygons and so are not formed by them.

In Figure 15 the internal branches are very common, the polygons also seem to have degraded the ferns rather than be controlling their direction and shape. The right line from A points to a flat end of the branch, like it is cut off. It shows the cross section is roughly U shaped and high in the middle. The rest show so many ribs it is like tracing out the leaf ribs from an Earth plant. A geological explanation needs to explain these ribs as they are very common. The ribs also appear to be in Fibonacci patterns with the same angle, some of this is difficult to measure because of the limit of the image resolution and erosion. Being made of large rocks is also a problem for a water flow causing this.

This image has approximately 25 Fibonacci branchings and thus about 75 similar angles. This gives a running total of $.5^{105}$ to 1 for the branching and $.5^{315}$ to 1 for the angles.

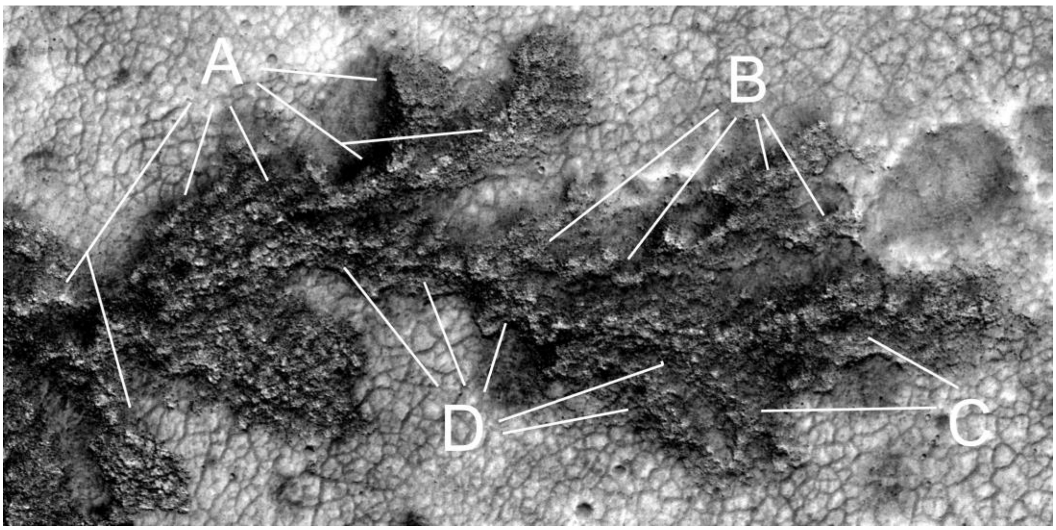

Figure 15. A river could not make ridges of material in Fibonacci patterns.

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The section below shows many lines running from left to right, they might be faults or design features of the plants. Capillaries are always found in plants running along the trunk, however these seem more random. The large mound and ridge in this image was seen in Figure 4, the MOC image then shows this section. It has an almost square symmetrical shape to its right.

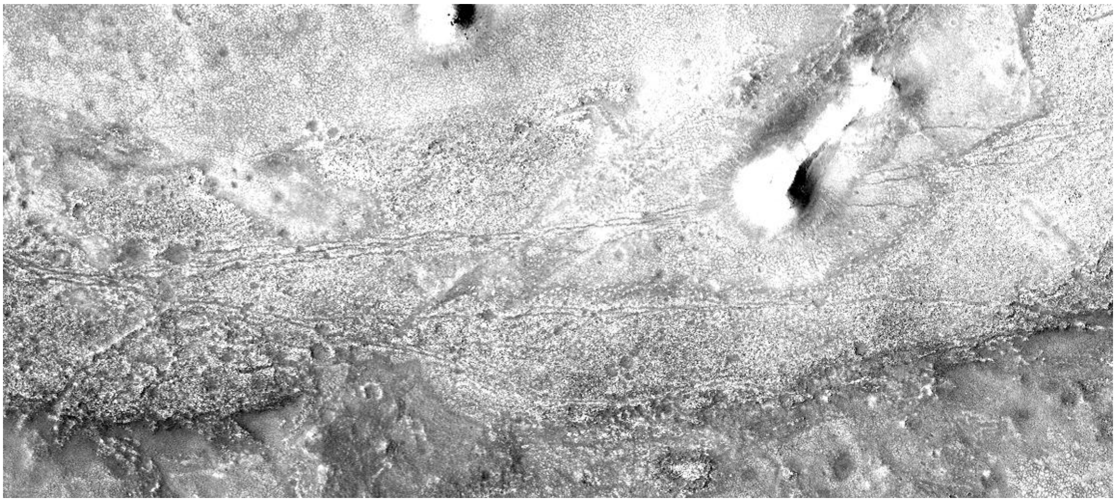

Figure 16. The grooves could be faults or might represent capillaries.

Figure 17 shows kelp fronds on Earth[xii], this has some similarities to the next fern image. There may be four different kinds of ferns here with their own leaf shapes and branch angles, these ferns may be acquatic. So far the ferns appear to be two dimensional rather than looking at an image of a three dimensional tree, that would change the angles of some branches pointing to or away from the observer.


Figure 17. Kelp fronds have rounded leaves like some of the ferns.

Figure 18 is similar to kelp fronds in the previous figure. Some fern leaves come from a narrow branch and then fan out into the full leaf. Others like this image seem to have thicker or no branches but instead have fronds connected to each other. There is then some variation which might indicate different kinds of plants. The angles between the branches may also be unique to each type though this is hard to judge. Earth plants also have this variation in angles, one kind of tree is usually distinguishable from others by this. The fronds also have less of a peak along the middle of the branches and leaves, however they have more of these lines like faults along them.

A shows some fronds which are degraded, the other branches are much larger but seem to come from this smaller source. Rivers typically work the opposite way, they get smaller further out as the tributaries narrow. **B** shows how these fronds are taller than the previous ferns and also have about the same height. **C** appears to show darker lines along them instead of ridges as before, perhaps like capillaries. The Fibonacci branching is continuing as before.

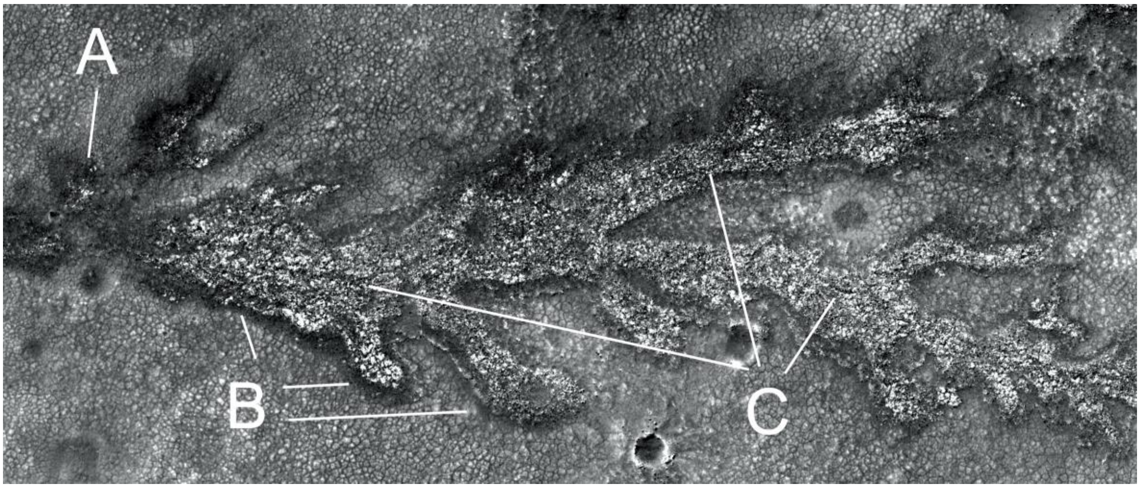

Figure 18. The fronds are thicker and flatter on the top.

In Figure 19 the fronds are missing at **A**, instead there is a shallow groove. This may indicate a shallow channel system, or that a builder laid these fronds in them. It might also mean the weight of the fronds has compressed the ground under them forming the hollows. If the leaves are erosion resistant then some areas should have eroded aroudn them faster than others. Some then should have remained partially buried while other areas formed gaps under the fronds and ferns. The uniformity is then a problem, the ground is uneven and yet the leaves still appear to have been overlaid on it. If the ground did erode away then how did the polygons form so uniformly around the leaves.

At **B** there is another gap, this may be caused by a crater or the branch may curve around it. These fronds are very long, they continue off the image to the right. Each has the Fibonacci branching but more like kelp. This is similar to the Martian spiders, they also had several distinct forms but are natural.

The HiRise image has approximately 33 Fibonacci branchings and hence 99 angles, this gives a running total of $.5^{138}$ and $.5^{412}$ to 1 against chance.

Figure 19. The fronds are highly eroded, the craters were formed later.

ESP_013147_2015

Figure 20 shows ferns that are more like the top of a tree or bush, the trunk ends and there are ferns above it and to the side. **A** shows the trunk, it appears to have grooves along it like the grain in wood. To the right of **A** there are some more fern leaves, one set with a branch coming off the main trunk. **B** shows fern leaves pointing out from this common source which is separate from the main trunk. It may also show a branch with leaves coming from the lighter ridge at the left, then crossing one coming from the trunk at **A**. This is more difficult to explain geologically, that one river could flow over another, if they occurred at different times then they appear on the same level of eroded ground. **C** shows areas that are either highly degraded or are random shapes unrelated to the ferns. This is a problem for a natural process because it forms distinct branches with similar leaves and angles on the left and then random shapes on the right. **D** shows one of these ridges going from the trunk and ending at some fern leaves. They appear to be ridges because of their shading compared to the craters.

This image is highly degraded but there appears to be 42 Fibonacci branchings, this gives a running total of $.5^{180}$ to 1 and $.5^{540}$ to 1.

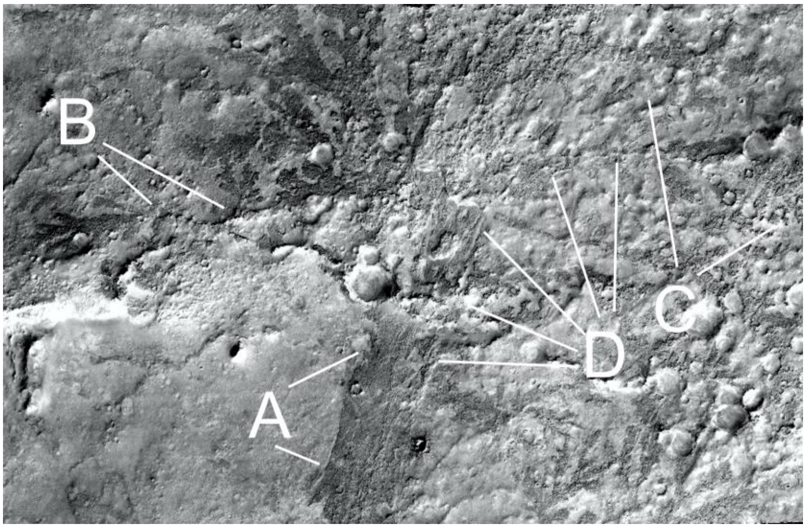

Figure 20. The uneven terrain has degraded the ferns more to the upper right.

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In Figure 21 there is a more distinct trunk, also the ferns are more like branches with small leaves. **A** shows the extent of the trunk, it is of more even size and does not have the longitudinal grooves like a wood grain seen earlier. **B** shows finer branches similar to Martian spiders, however the spiders are usually radially shaped from a central source. In some cases the spider legs can extend from a larger mass, however they are always very small and follow the polygon cracks. These ferns are always coming from larger branches and usually pointing towards a trunk like plants would be. In some cases the connection is missing completely. The cleaner terrain here could be from less soil being available to construct these branches. **C** shows how many of these do not connect to the trunk, this makes it harder to explain them as rivers because there is no channel hollowed out connecting them to the trunk. Only in Figure 19 so far as there been any sign of a hollow where branches are missing. All the ferns here have Fibonacci branching. With so many hundreds of branches so far there should have been obvious evidence of random angles and branching, however this is not seen. Some branchings might be argued about but a channel system should have abundant and clear exceptions to the Fibonacci branching.

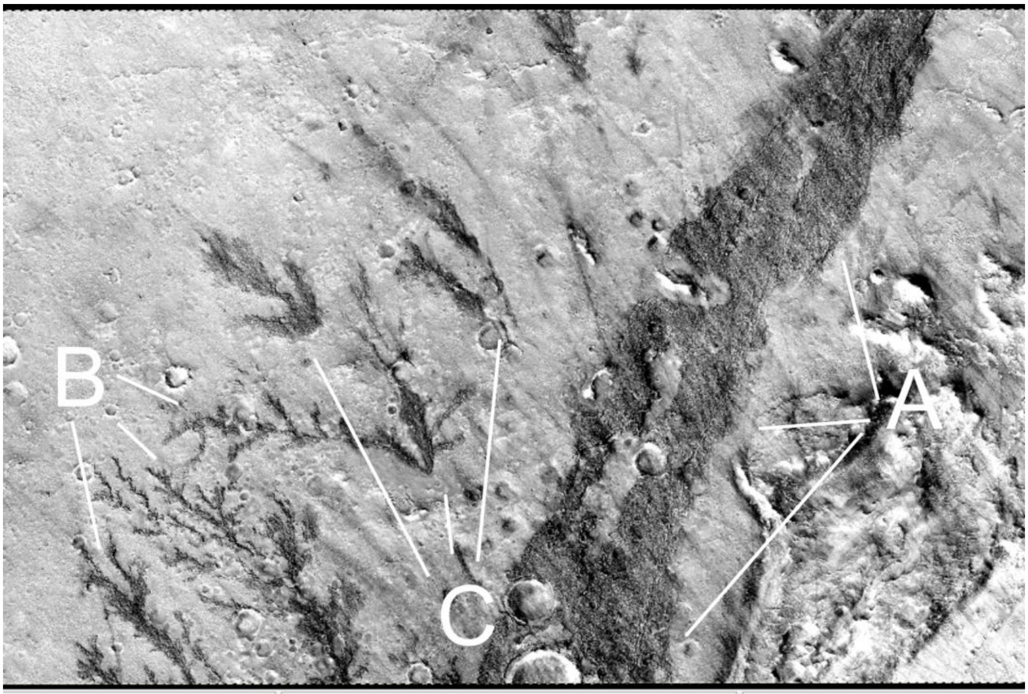

Figure 21. There is no channel from the trunk allowing gravel to travel through to the branches.

In Figure 22 there is a close up of a branch, it does not connect to the main trunk and is a long way from it. **A** shows there is no hollow or trail to the trunk. These ferns appear slightly lower than the ground around them, they might have sunk from their weight. **B** shows how this branch juts out from another at a sharp angle like some tree branches do. **C** is also like this, it appears to have striations along it like a wood grain.

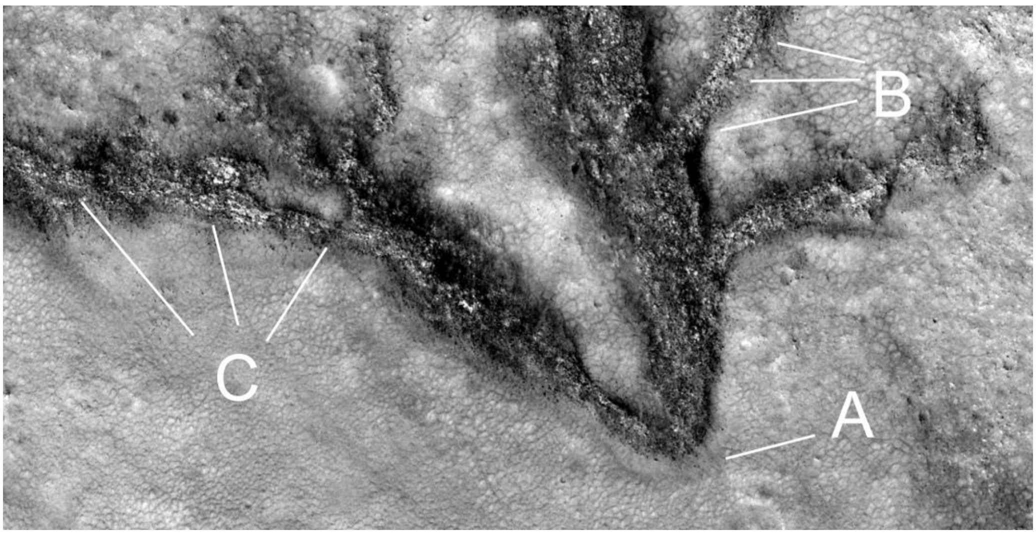

Figure 22. Some branches have striations like a wood grain.

The leaf structure in Figure 23 has many ribs clearly visible. **A** shows a crater, this seems to have occurred after the leaf was formed and shows how deep the dark material goes here. The texture is almost extreme in the number of gradients forming the ribs, it would seem impossible for water to create this. All the branches are Fibonacci and seem to have the same angle, many however are too unclear to check this.

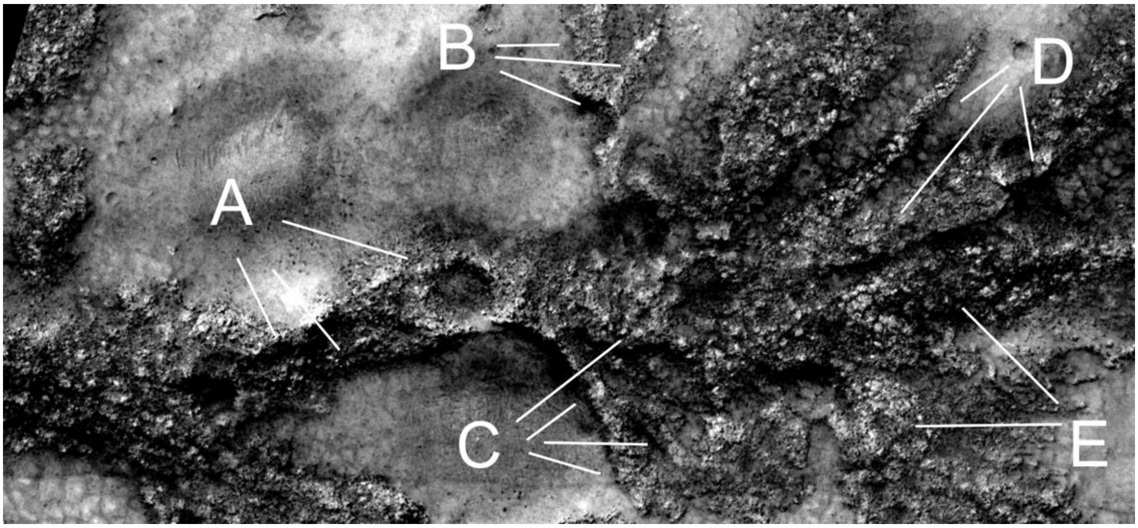

Figure 23. The ribs are sloping in different gradients counter to gravity forming water channels.

A in Figure 24 shows a section of the trunk, there is again the long striations like faults or perhaps a wood grain. This section appears more randomly shaped, it may be these striations are natural.

This image has approximately 30 Fibonacci branchings in it, this gives a running total of $.5^{210}$ to 1 and $.5^{630}$ to 1 for the angles.

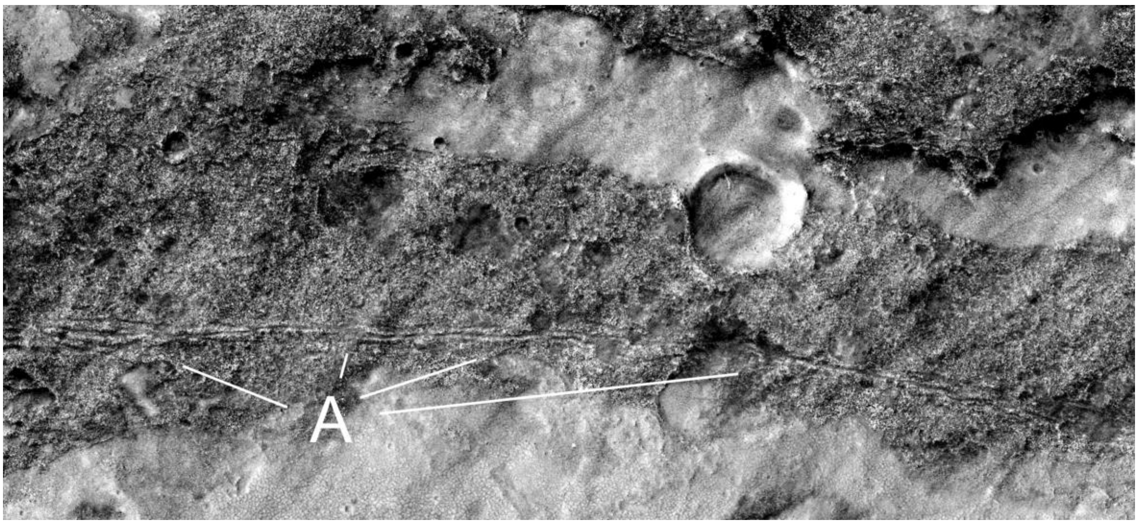

Figure 24. These striations may be natural faults or capillaries.

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Figure 25 has enormous numbers of ferns emanating from a large hill. They all seem very similar to each other, similar angles in the branches. They may be a fourth kind of plant, they are more like fronds as before but with more even width in the leaves. In with the ferns is a shape similar to the Cydonia face, this is significant because that is also on the same great circle as the ferns.

Figure 25. These ferns are a different type, they surround a similar shape to the Cydonia Face.

This is a close up of the face like formation. There are no clear facial features but the outline is similar. The Cydonia Face is shown on the right for a comparison. If artificial then extreme age would have caused this amount of erosion. In this image the branches are over a different type, there are at least 15 Fibonacci branchings and many more than 45 similar angles. This gives a total of $.5^{225}$ to 1 and $.5^{625}$ to 1.

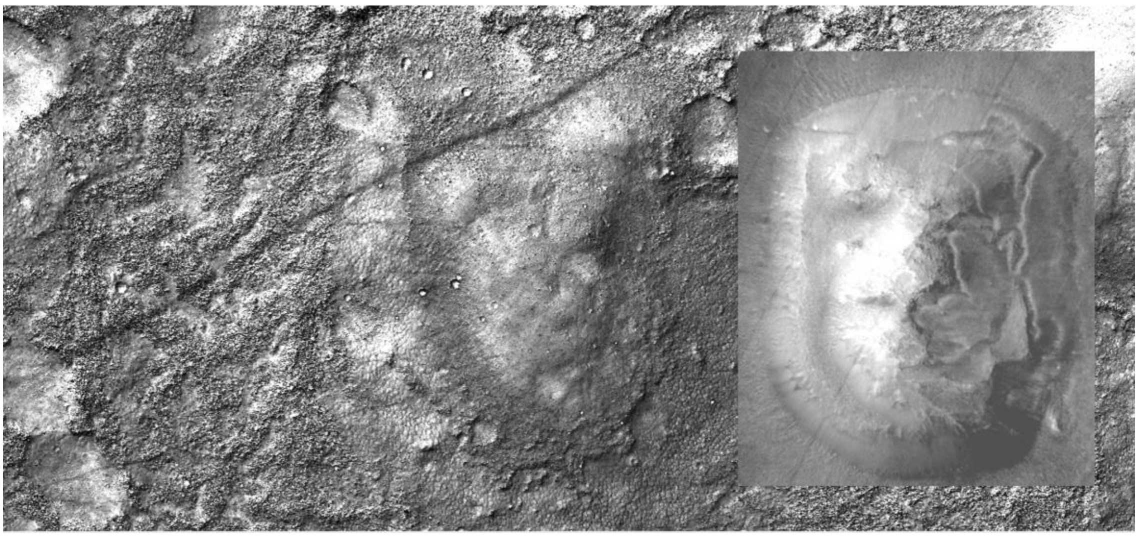

Figure 26. The Cydonia Face is on the same great circle as this formation.

Conclusions

This paper has tried to show as many features of these ferns as possible. The intent is to falsify the null hypothesis and the geological hypothesis. Martian spiders were also regarded as plant like but turned out to have a natural explanation. However the sheer amount of evidence here is hard to reconcile with a geological hypothesis. They are surrounded by formations that do appear to be random and consistent with geology, this small area however seems to defy all those explanations. The ferns seem to have four different types each consistent with known kinds of plants on Earth. This might indicate an intention to present a more varied flora. It also makes a natural explanation more difficult, it must explain how channel system can look like four distinct species.

Water based theories seem to fail because the ferns are not flat on top, they have intricate ribbing in leaves that would require something on top to mold these shapes. This could only be ice but there are no other examples of geology doing this. Even elsewhere in Antonialdi Crater there are patches of soil similar to the ferns but randomly shaped. It would seem a geological process that created the ferns would create them elsewhere on Mars or at least more widely in this area. Instead they seem to only be in one small patch.

The ferns are on the great circle along with the Nefertiti formation, the Cydonia Face, and the Crowned Face in the King's Valley. They would then appear to be a successful prediction of more unusual formations on this great circle, especially with a similar formation there to the Cydonia Face. The most likely theory of construction is simply to heap soil and rocks into these shapes, the more natural formations around the ferns would have been left untouched. The purpose of this is unknown as with the other candidate artifacts found so far.

They appear to have Fibonacci branching, the Martian spiders also had this to some degree because of being imprinted on polygons. There are polygons here as well but instead of the spider ravines falling on polygons these ferns are much larger. Also the branching is virtually perfect as Fibonacci sequences instead of approximate with the spiders. Each type of fern has a similar angle to its branching as with Earth plants, there seems to be four different angles in all. A statistical argument could be framed with this as explained, each Fibonacci branching having odds of ½ as it either happens or it does not. Then a similar argument can be used with similar angles, ½ is a conservative estimate as within say 15° it could be regarded as 1/6 between 0° and 90°. Each time these occur it is an independent event and so the odds multiply, the total is $.5^{850}$ to 1 or approximately 1.3×10^{256}.

A number like this is far outside random chance, an exponent of 9 would be considered virtual proof in a normal statistical analysis. Because there are so many branchings and angles the power to refute the null hypothesis is also very high. No statistician would say a data set this large and odds this high occurred by chance. This number might go up or down when each branching is examined carefully, however it shows there is a strong case to answer here. If the null hypothesis is refuted then a hypothesis based on nonrandom branching is needed. So there would have to be a geological process that virtually always creates Fibonacci branching, but this is not known to exist. Without a geological explanation the ferns represent strong evidence even proof of artificiality. This is because if nothing natural can create structures like this they must be artificial as the only other alternative. A builder would make virtually all the branchings Fibonacci with similar angles because they would be depicting plants that do this.

Martian Dams: Artefacts or natural formations?

Greg M. Orme[xiii], Brisbane, Australia, 4000.
Keywords: Mars, dams, Cydonia, King's Valley, artefacts.

Abstract

Unusual formations have been found in many Martian craters resembling dams. Some geological explanations have been offered, in this paper many of these dams are examined. With many candidate artifacts such as in Cydonia, the Nefertiti formation, and in the King's Valley found there may be an artificial explanation for these dams. Attempts are made here to falsify the natural explanation, to show they could not be formed by a geological process. Dams can occur naturally, a river for example might become silted up enough to block the water flow. Mud can also slump down in a crater to create a shape like a dam, then possibly catch water in it. However many of these dams have features hard to explain in this way.

Introduction

Since the Mars Orbital Camera has been imaging Mars dam like structures have been found in a small number of craters[xiv]. Many follow the temperate zone around the great circle candidate artifacts have been found on. This can be seen in a 2009 paper in Icarus by Dickson and Head[xv], they show brown dots on a map roughly between Cydonia and the King's Valley as water gullies. This suggests the great circle is an equator that coincided with water available for life in these ravines.

Since the discovery of possible Martian artifacts on Mars the search for an ancient supporting infrastructure has been important. If sentient life was capable of building these artifacts then it is likely they needed to acquire food and water in the meantime. The Martian dams represent a proposed component of this infrastructure, because there are hundreds of these dam structures they give an opportunity to falsify geological explanations. Only one needs to be artificial to prove this hypothesis.

The candidate artefacts are all extremely old, at least hundreds of millions if not billions of years old. It is likely then most would have long disappeared except for those made of rock and similar materials. This can explain the enigmatic nature of these possible artefacts, they need not be representative of this civilization but be all that could survive this long. Dams are another feature likely to survive, they would be designed for resistance to water erosion, being in craters would shield them from wind erosion as well. The strength required would also make them more resistant to earthquakes, meteors etc.

Reasons for constructing dams

Three of the most persuasive areas for artefacts all lie on a great circle, a possible former equator on Mars. This idea was originally suggested by Tom van Flandern, that the Cydonia face might be on an equator of a former pole position. It is known the poles wandered on Mars at some stage[xvi], when this great circle was an equator the candidate artifacts and dams could have been constructed.

This would then date the construction of these dam to long ago, before the poles moved to their current location. Recent announcements by NASA increasingly point to a warmer and wetter Mars in this distant past, this connects to the idea of possible inhabitants. Organic life needs water and so if they were able to construct monuments then they would also be able to construct dams to get what was likely to be scarce water. The most abundant source of this appears to have been water leaking out of an artesian basin into some craters, also some rivers. The Northern Lowlands probably had an ocean at this time according to Doctor Brandenburg[xvii] however evidence of artefacts would likely be buried or eroded.

Methods of proof

Many of these dams look artificial, however that is not necessary or sufficient in this case. Rather, this paper attempts to show geological processes could not account for them. This leaves artificial construction as the only other possibility. Accumulating evidence in favor of artificiality is not always useful, many things clearly natural look artificial such as faces in clouds. People also have a tendency to see patterns that aren't really there such as faces, this is called Pareidolia. Dams are a specific kind of construction, to work they need to hold water and to have lasted perhaps hundreds of millions of years. They are rare in nature so it should be possible to differentiate an artificial one from a natural process.

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This image, shown in Figure 1, is an ambiguous dam as a starting point, there are many craters with a dune similar to this. The interior of the crater is clearly on an incline because the water moved to the bottom right from the ravines at **A**. The dam shape here then would have collected water as long as it was not porous. Another problem in constructing dams is if the crater floor itself was permeable to water at **B**, this might have to be treated as well or the water would be lost. If a crater floor in the dam appeared to be rubble and fractured then this would detract from their possibility of being artificial dams.

The dam shape appears very flat along this area at **C** while most dunes are curved, also opposite the water ravines at **D** it is flat like it was molded. An artificiality hypothesis then might have this dune covered by a form of cement or concrete. Water might have collected here either as a natural or artificial dam, it is not enough to show water collected but that a natural dam of this kind could not form. If there was regular water here when Mars had an atmosphere then life might have existed in it. Some ravines are still leaking water and so a well-constructed dam might have had water in it for millions of years. The Northern Ocean and perhaps snow would have recharged the artesian basin to perhaps give a constant flow like an Earth spring.

If there was sentient life on Mars at the time it would make sense to adjust this supply of water to make it more useful as a dam. For example the floor at **B** might have been sealed and the dune covered with a sealant like a cement at **C**. This would be hard to see in images because the ravines would have covered this in muddy water and silt. This is then no different to on Earth where people might build a dam to capture water from a spring. Research on how to make cement and concrete on Mars has already been undertaken. According to Lin et al[xviii] CaO or calcium oxide is needed to make this and is likely to be found as evaporates near water deposits. With an ancient ocean, rivers, and water ravines then it is likely cement would be possible to make in these craters. Water is needed which would be available in abundance. Zeolite cement is likely to be naturally present according to Towell et al[xix]. With the materials to make concrete then it would present little difficulty to create these dams and candidate artifacts like the Crowned Face, NASA is already working on how to do this on Mars in the future.

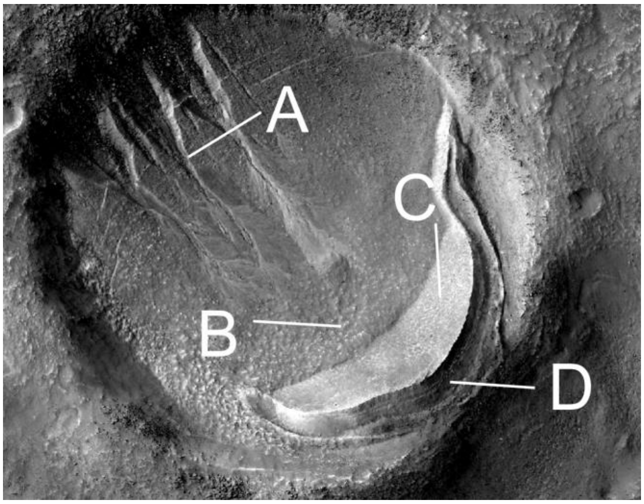

Figure 1. This has few signs of artificiality and may be natural.

The right corner of the dam shape is unusual, seen below in Figure 2. The interior of this has a groove at **B**, this might be formed on one side by the dune at **A** pushing upwards. However it is not clear what would push from the other side to create this groove. It may be two mud slumps, the distance between the two creates a hollow. However they join together into one edge and the mud slumps should not be able to do this. The relative pristine condition of this structure compared to the soil around it may indicate a Martian variation of cement. If so then this might be detectible spectroscopically, however it might be too covered in dust to do this from space. Overall then this dam is suggestive of artificiality but is not distinguishable from natural geological processes. To prove this hypothesis then features need to be found that could not be made naturally.

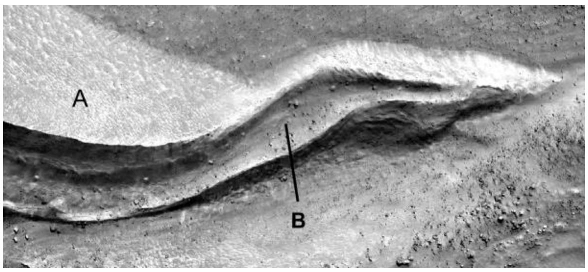

Figure 2. This groove is hard to form naturally.

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The dams in Figure 4 are harder to explain, instead of a possibly modified dune shape here there are flat platforms with water ravines above them. Water should have collected in these dams, there is a lip or wall around the edge at **A** and **B** which would have held this water in. At **C** there appears to be a depression. The structure is completely different from the previous dam. Whether natural or not this should have held water, the bottom of the reservoir area should not be porous because this appears to be rock or possibly concrete. The problem with a geological explanation is the flatness of the floor and what would have created this lip of the dam. This high up from the crater flor nothing could be in the crater itself to smooth out the shape of the lip and floor, it is not rough in texture like the rest of the crater. If this is a mud slump then it would have had to stop exactly on the cliff edge, in practice this is impossible.

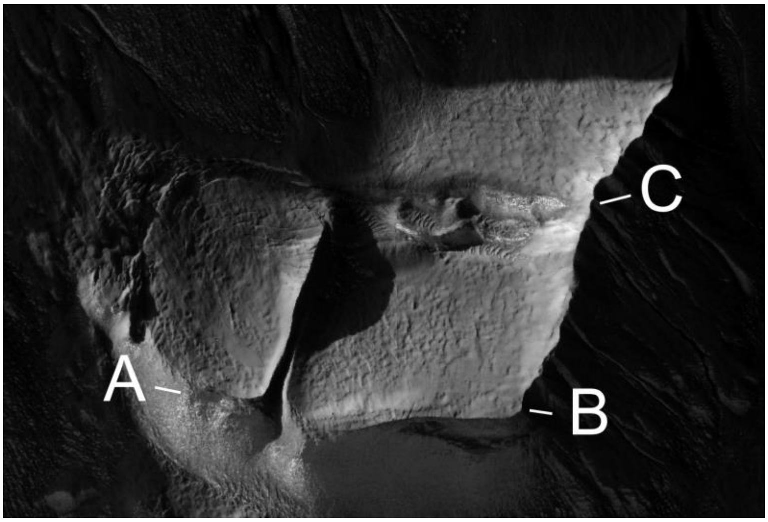

Figure 3. The walls could not form right on the cliff edge without toppling over from their weight.

A close up in Figure 4 below shows how thin the lip of the dam wall is at **A**, there may be horizontal layers in the wall related to its construction. Some whitish material is seen here in the dam wall, this seems to extend right into the wall itself despite it being so thin. **B** is a chasm between the dam walls, it separates the other thin walls at **C** and **D**. **E** has a very thin edge on top, this appears to be darker or may be curled over to give more of a shadow. **F** is a large dark mass that also extends into this wall. This creates a problem because the dam wall seems to have formed around the dark area. The wall here is probably less than a meter in thickness, however there are no breaks or cracks.

To the right of **F** there are more ravines going down from the dam wall, perhaps water that leaked from the dam. This can be seen in the LPSC paper by Kolb et al[xx], they point out that dendritic ravines at multiple levels in a crater are unusual. This is because two artesian basins separated by tens of meters might be expected to merge into one, a water table would have be separated by non-porous rock into two and leak into the same ravine. But if the dam is functional there is no difficulty, the water from ravines above is directed into these dams. Then some water over time leaks out the side of this dam at **F** creating a second set of ravines below it. This then would make a dam here much more likely, the water from two areas is connected.

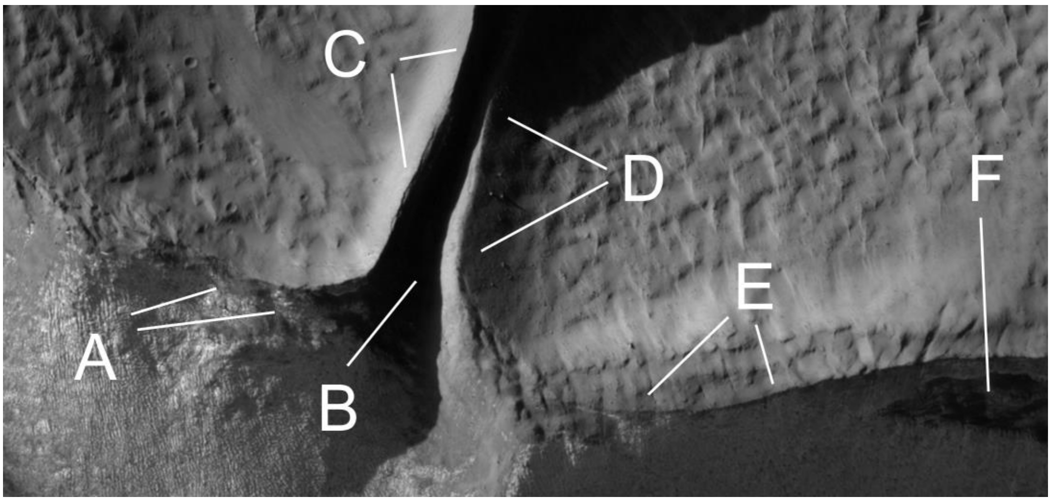

Figure 4. The walls have not fallen even when the crater is highly eroded.

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Figure 5 shows a third kind of dam structure. As can be seen there are water ravines which point downwards into the dams, this indicates the dams whether natural or artificial were functioning. **A** shows a highly curved dam shape, this is commonly used in Earth dams to confer strength. For example arches are used for strengthening in architecture, most dams on Earth use a curve which is stronger. The previous dam was a straight lip on the edge of a cliff, here there is some latitude on where the wall could have formed. Instead of the dam wall being on the edge of a cliff here it is against the rock of the crater floor.

B has an unusual shape where it curves in sinusoidally, this can also give strength to the wall from its curvature like an arch does. The sides of the dam continue on back up the slope, the same process that formed these dam walls seems to work both horizontally at right angles to gravity and also vertically. This is hard to explain if the shape is assumed to form by slumping of mud down the slope. With concrete however this should hold its shape at different angles.

There is also no sign of where the dam material came from, the crater walls are smooth above them with no gaps. These dam shapes are very large and not like an amorphous slumping of mud, there should then be areas above it where this rock broken off. This would also be problematic, that they would fall and land in such a neat arrangement, but the dam walls have to come from somewhere.

Also the dams have a very smooth texture while the crater walls are darker and much rougher, this is consistent with a cement or concrete resisting erosion in the thin atmosphere. A crater is formed from an enormous explosion in a meteor impact, these dams would have had to form after the impact and not be surviving rocks jutting out from the bedrock. If the dams were formed by slumping material then something would have to smooth it on both sides, the side facing the water might be smoothed by water erosion but the other side should not be. A different texture then should indicate the material is different.

In between the two lines from **C** this dam is squarer shaped like in the previous crater, the wall has no sinusoidal shape but is nearly straight. The sides also extend back up the slope, the forces that created it then had to function the same way vertically and horizontally all without cracking the thin walls. All these dams seem to have about the same height in the walls as well as thickness, consistent with being made that way. **D** shows a separate dam and a funnel that also curves back up the slope. On the left then there is a small dam and on the right it is like a funnel or groove that guides the water to the dam below it. Again this would function as a funnel whether the dam was artificial or natural, why the lip would form on the left dam but create a funnel on the right is hard to explain naturally.

E shows another pair of dams where the same wall curves to give two areas to hold water. The two walls meet at an angle but if slumping mud created them then it should not have left the depression below them. If the dams were formed with gravity then the material should have continued on to the crater floor, not stopped here. **F** shows the last dam, each seems to be at a different angle to the slope. Slumping of mud seems to be ruled out for this dam because the upper wall curves back to the right, at some stage then this mud would have been travelling back up the slope against gravity.

This creates a problem for the geological hypothesis because mud slumping should move directly down the hill, here it forms sinusoidal shapes, square walls, and seems to slump down the crater wall by moving at an angle to straight down. Each dam should hold water if the rock is not too porous, they would represent a logical kind of construction. Underneath each dam there is a cleared area like another depression, the dams then don’t seem to have stopped there by running into something else. The lower edge of these depressions could be from slumping material or it could have been cleared, the material for the dam is more likely to have come from the depressions under them rather than from above. The dams then appear to be perched over a much steeper incline, in each case they would have stopped just where gravity should have urged them onward.

Nowhere are there any signs of cracks or breaks in these walls, they would have had to elastically move down the slopes to form these walls yet not break. Also despite having water moving onto these walls for millennia this has not dissolved the walls, yet to have moved there they would have had to have been dissolved material as mud. They would seem then to have lost their ability to absorb water and form a mud, this would be explained by their being concrete.

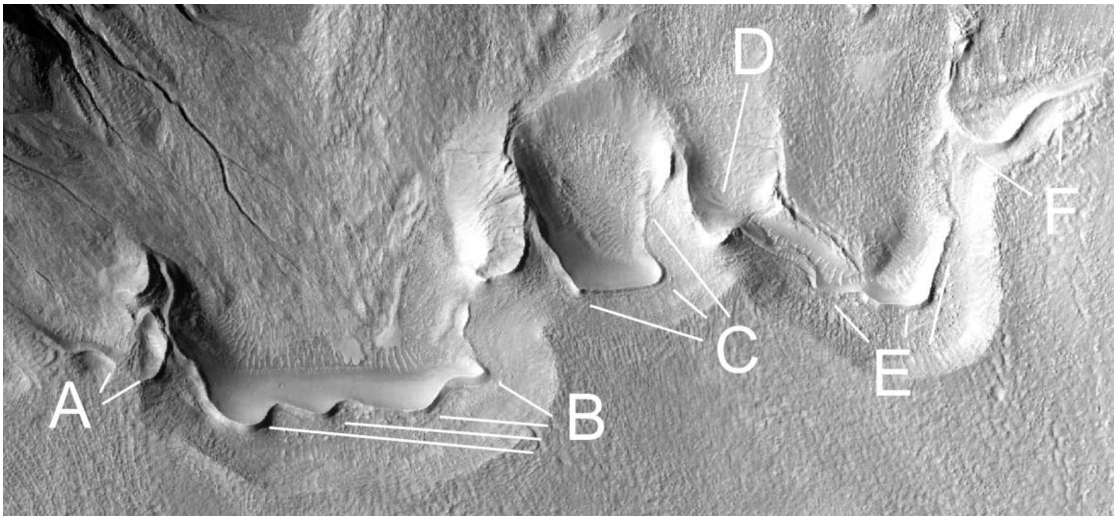

Figure 5. The walls appear very elastic in shape though mud is not elastic like this.

This image has a resolution of 25 centimeters a pixel, being able to see these fine edges of the walls implies they are a few meters thick or less. This then would be at the limit of how strong rock can be in this environment, subjected to quakes, impacts, etc. shaking the ground. The walls by contrast would appear to be tens of meters in height, a wall like this would have stresses in it capable of making it collapse or topple over. But even though these are on a slope and perched over the edge of a depression there is no sign of damage.

In Figure 6 **A** shows the edge casts a shadow as if thicker around the top, hard to explain geologically. The two right lines from **A** show an apparent layer in this wall running parallel to the top, this may be where layers are constructed internally with a concrete skin over them. **B** is looking close to directly up the wall, it shows it is perhaps a meter wide compared to its height. How it could bend like this without breaking is also unusual, a mud should not form tens of meters high and a meter wide without collapsing before it dried. **B** then shows the wall curving in an S shape, slumping material should be moving directly down the slope. **C** shows a slightly concave area or perhaps it is a darker material. It also appears to be a series of arches which could increase its strength. **D** shows yet another curve with no signs of breaks. Mud and rock is not known to have this kind of elasticity. A wall like this on Earth might be assumed by most people to be artificial.

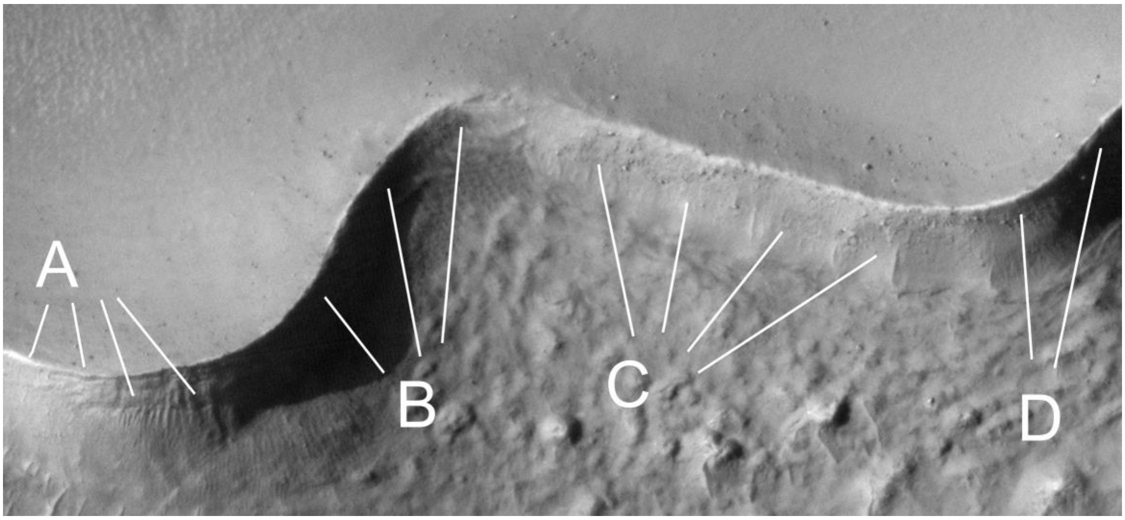

Figure 6. The wall undulates though gravity should be equal on the slope.

The dam in Figure 7 has a different shape to the one in Figure 6, the left side is a sharp angled turn while the right is more arcuate. **A** shows from the left line how narrow the top of the wall is. The middle line shows how sharply the dam wall bends without breaking, this is supposed to be either rock or mud but is highly elastic like concrete. The third line on the right from **A** shows a dark band like layers in the wall perhaps from erosion. **B** shows a continuation of more layers, the dunes have formed along the wall giving an impression of struts. **C** on the left line shows the lowest part of the wall, it seems surrounded on the outside by sand but this is apparently not material from the wall itself eroding. Then the next two lines from **C** show how the wall again curves smoothly without breaking. It appears to be thicker at the base internally which is how modern dams are constructed.

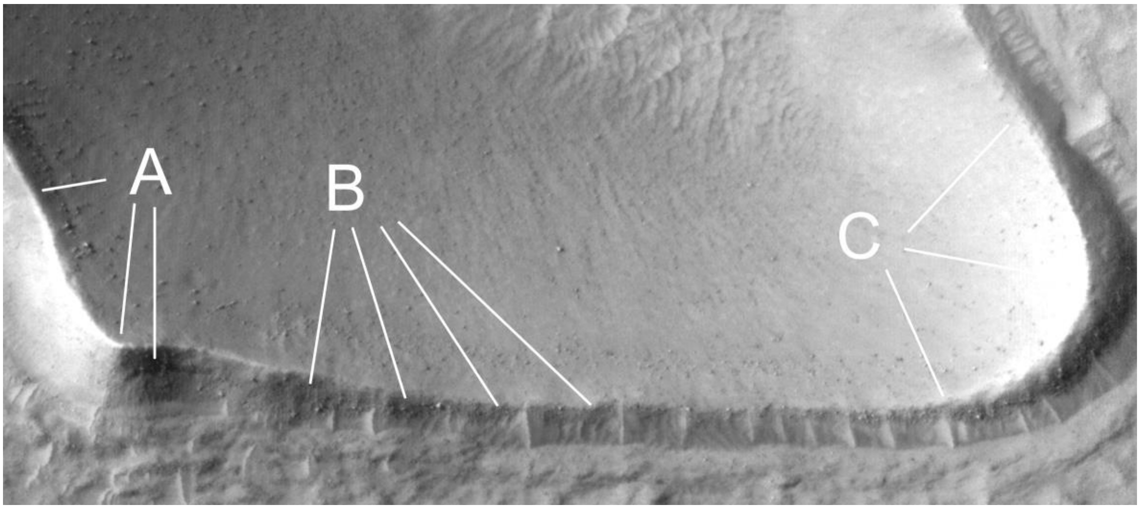

Figure 7. Mud should have broken at A, the downward side is nearly vertical.

The dam in the image below[xxi] is in Ontario, it has a similar S shape where the curves give strength to the dam wall.

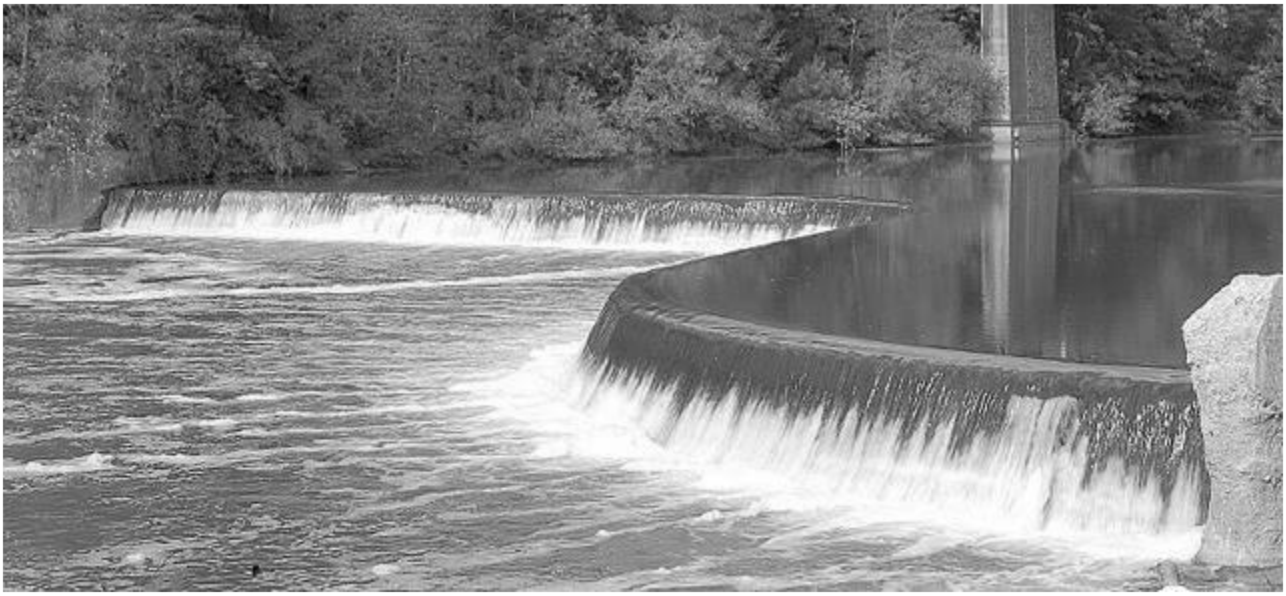

Figure 8. Curves in dams are made to increase their strength like with arches.

In Figure 9 the left line from **A** shows some marks or damage on the wall. The other two lines from **A** show a ridge or depression running parallel to the top of the wall. Some craters do have layers in them, however the dam should not have formed from the crater bedrock as an explosion like a nuclear bomb created this crater. Protruding rocks like these dams then would have been vaporized. **B** shows a similar band casting a shadow, it seems there is some layering going all the way around in these walls. **C** shows where the inside of the wall is much thicker towards the base, this may be because of silt or the wall may be thicker here. The dunes don't reach into this area, one possible construction technique then might be soil from below is pushed into shape and then covered in concrete. The wall might be built in layers using some other material to make it more elastic, like rebar is used on Earth. Concrete is often mixed with gravel to make it less brittle.

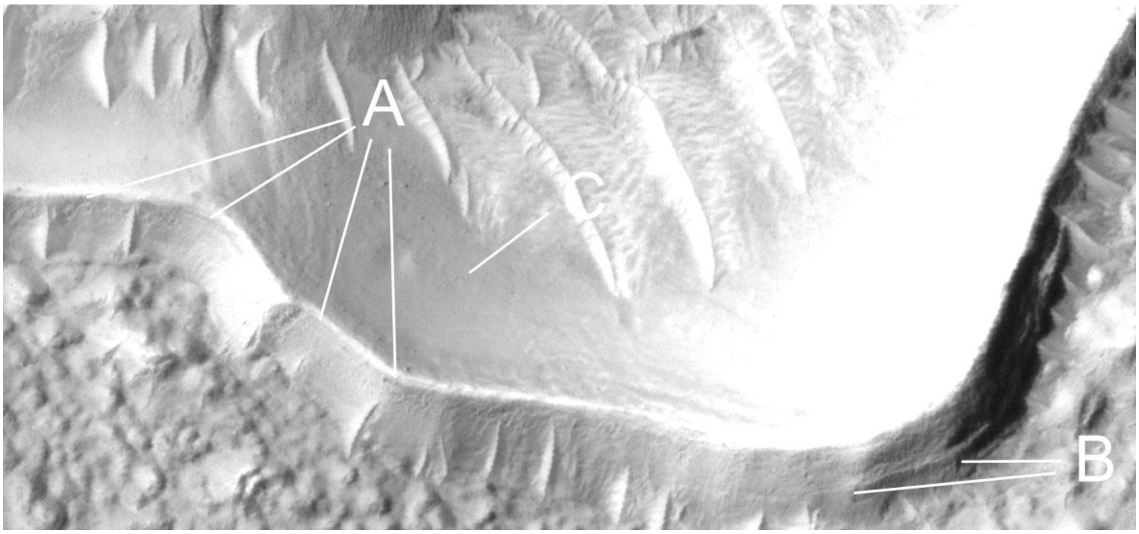

Figure 9. The wall appears to be a different material to the dunes and the rocks below it.

It is common on Earth for walls or dams to follow the terrain rather than being straight. The Great Wall of China[xxii] below is an example. Another material used in the dam construction might be bricks, perhaps interlocked in a tongue and groove shape. Mars has plenty of clay, bricks might have been made by heating this clay and might last like the Great Wall below. This also shows how bricks made from clay and mortar can be built with simple technology. Tamped or compressed earth was also used, this might give strength inside the dam walls by simply tamping it down in layers.

Figure 10. Long walls on Earth have a similar shape on uneven terrain.

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The dam in Figure 11 may be natural, this however should still have filled with water at the time. **A** shows where there is an unusual edge to the soil, perhaps silt has fallen down here. Similar edges to this are seen in many natural formations. Natural dams like this may have formed by a meteor impact in an existing crater half way up its rim. However it would have been possible to shore up the sides to hold more water, **B** shows here water would have accumulated. Natural dams then might have inspired the inhabitants to imitate them.

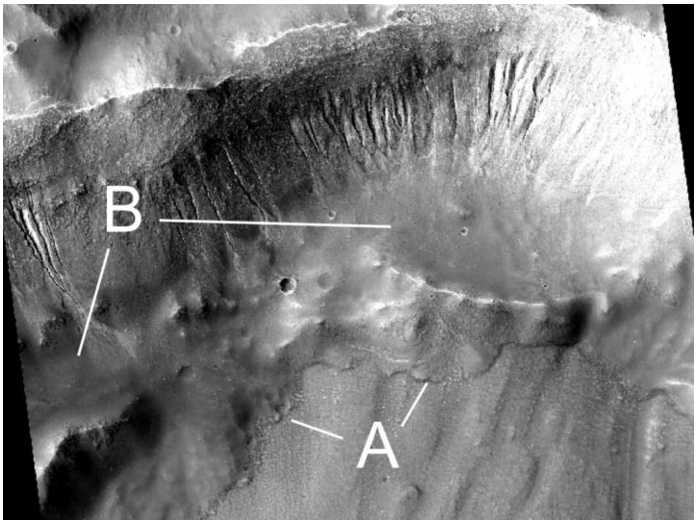

Figure 11. Natural dams from craters may have been imitated.

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Figure 12 shows a small dam, however it is a continuation of a rougher and more natural rock in the crater. On the left line coming from **A** the rock is much like in the rest of the image, however at the second line from **A** anticlockwise it turns into this smoother dam wall material. In the middle the dam is highly curved and thin but does not break. It then appear to be highly elastic like many other dam walls. It can be seen that it is the same material as what it is joined to, however this other rock has completely different characteristics. **B** shows how a second lip or wall, seen on many other dams, also merges into a smoother and thinner dam wall without breaking. On the right it ends in a vertical groove at **C**, this smooth face also connects onto much rougher rock. Below the dam as is common elsewhere the rock is smoother as well, like it has been scooped out perhaps to build the dam. The more natural rock then appears to have a random texture but suddenly forms this dam, it would seem impossible to explain geologically. If this dam is formed by the rock material slumping it should not have smoothed itself out on both sides in the process.

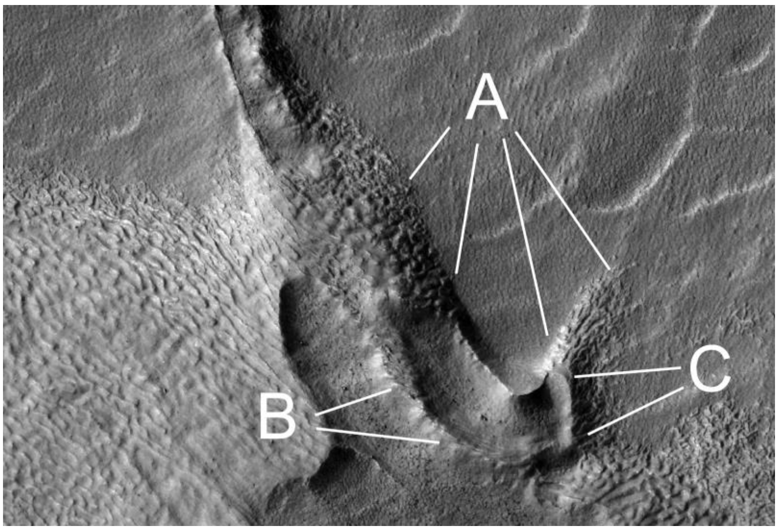

Figure 12. The smooth walls should have eroded all over like the ground to the left.

A close up of the dam shows more features. **A** shows where the dam begins, the wall suddenly thins into the typical narrow top edge. **B** shows a small break in the wall or where the two edges would have met at an angle. Any kind of damage is very rare in these walls. **C** shows the edge curls around in an artificial looking arc, it avoids connecting onto the natural looking rock. **D** shows material similar to above the dam, but very different to that on both sides. There seems to be polygonal cracking which merges into the crack free dam walls. **E** shows another smooth arc shape that merges directly into the natural rock. Like some of the others, this dam may have filled up with silt from the water ravines. If artificial they may have needed to be cleaned out regularly.

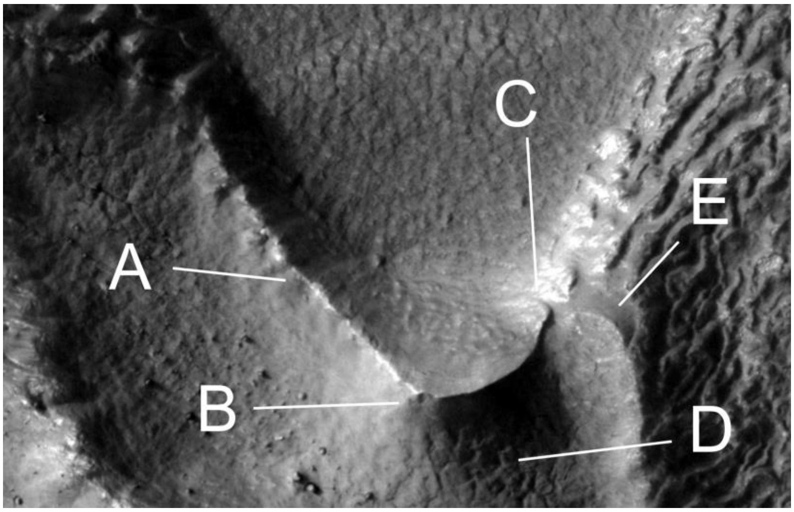

Figure 13. Some wall parts remain smooth with polygonal cracking all around them.

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In figure 14 below the ravines are much higher, the water would have had further to fall. On the left at **A** there is no dam, but with nearly identical terrain on the right at **B** a dam is found. There is no missing soil further up the slope to form a neat dam shape on one side and nothing at all on the other. There may however be the remains of another dam at **A** buried in the mud, there is a faint outline. In Figure 15 the lines from **A** show a symmetrical shape joining up to the left dam wall. The upper line from **B** seems to show and angled start to the wall, there also seems to be a double groove along the wall top or else it is more eroded. The lines from **C** show damage in the wall at each point, the top two show a small piece missing in the usually narrow top. **D** shows how the base is angled to be thicker like with most Earth dams. **E** shows a very straight piece of the wall top.

Figures 14.

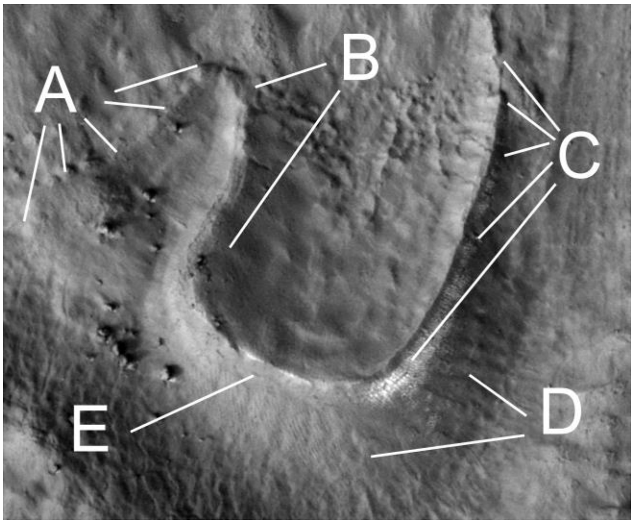

Figure 15. A mud slump breaks a dam wall.

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Figure 16 has multiple dam shapes similar to Figure 12. The rock below is highly random in shape but then suddenly becomes smooth in the dam walls, this is a recurring feature in all settings and is consistent with concrete being used. In some cases the dam walls are separate from this rock and in others they merge into it. **A** shows a series of three dams with two overflow ridges. The first line from **A** on the left goes to a small dam, the second line from the left shows the bottom dam. The third line shows an angled ridge which should move water to the fourth line and the second dam. Even if natural it should act this way, water from the first dam would overflow to the second and then to the third.

Any inhabitants would think themselves fortunate to find a natural dam doing this. **B** shows four separate dams with smooth faces in this rough rock. **C** points to two cases where the dam walls are close then merge together leaving a hollow, another dams are adjacent to these. **D** shows water ravines above the dams, **E** shows a standalone dam. The left line from **E** shows a ridge similar to the others, this would catch water like the side of a funnel. The right line from **E** shows a ridge going downwards from the **E** dam, this also has a depression or cleared area under it.

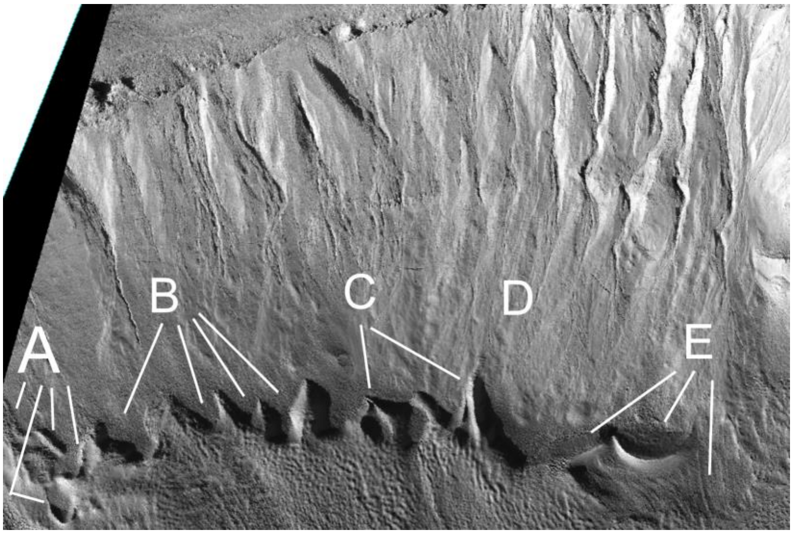

Figure 16. These parts point up the crater against gravity, they should have slumped to around the same level.

The close up below in Figure 17 shows the operation of the leftmost series of dams. The first line from **A** on the left shows a small curved ridge, this would catch some water running down the slope and direct it to the right. The ridge at **B** would catch this water and move it further to the right, this would happen whether the dam was natural or artificial. There is another ridge directly above **B**, this would catch a stronger runoff from **A**. Both water flows would then end up in **C**, when this overflows the gap shown would allow the water to go further down rather than overflow. This would direct it to **D**, it would bounce off the opposite wall which directs it towards the middle of the dam. A scenario like this being natural strains credulity, imagine watching this operate.

The four lines coming from **E** show four dam walls, the line points to the base of each. These walls are very straight even though the rest of the rock is highly random in shape. Even the dams to the left are curved in their shape, the straightness of these dam walls should not occur if they have been worn into the rock from erosion. The same kind of water flowing down a slope should not then form such different shapes. **F** shows another pair of straight dam walls, they are separated by a straight base line that should not be worn in this shape from water erosion.

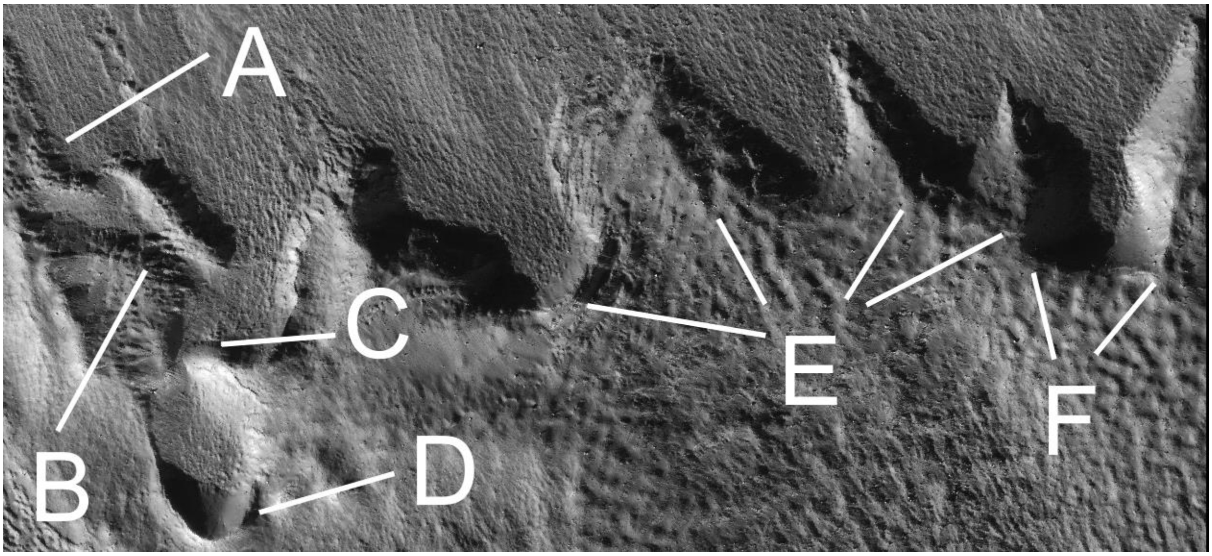

Figure 17. The ridges direct the water to break its descent.

In Figure 18 the left line from **A** shows how the rough rock suddenly becomes smoother in connecting to a dam. The right line shows how two dam walls come very close together. This is difficult to form geologically, if the dams were caused by slumping mud then they should not form straight edges as in Figure 17. If they are eroded this way from rock then they should not suddenly change from rough to smooth textures. Also then how this hollow between the two dam walls would form is also problematic. They are close together, perhaps less than ten meters apart. Something would have to get between them to erode the hollow area but they do not face upwards into the path of any water, it should have eroded away the top wall if it could erode this hollow underneath. The top wall also merges into rough rock as does the left wall, but no explanation as to how. But this would be relatively simple for someone to construct, smoothing walls with a kind of cement. The hollows then would be used to supply material for the walls.

The left line from **B** shows again how the rough rock becomes a smooth curving dam wall. The middle line shows two small defects in the wall perhaps meteor impacts. This appears to have broken off the top of the dam wall here. The right line from **B** shows how the dam again comes close to another wall but still leaves a gap, then this opens up under it. **C** shows how the top of this dam wall has eroded almost down to the crater bedrock. There appears to be striations in this rock at right angles to its length, they might be bricks made from clay inside the wall and covered in concrete.

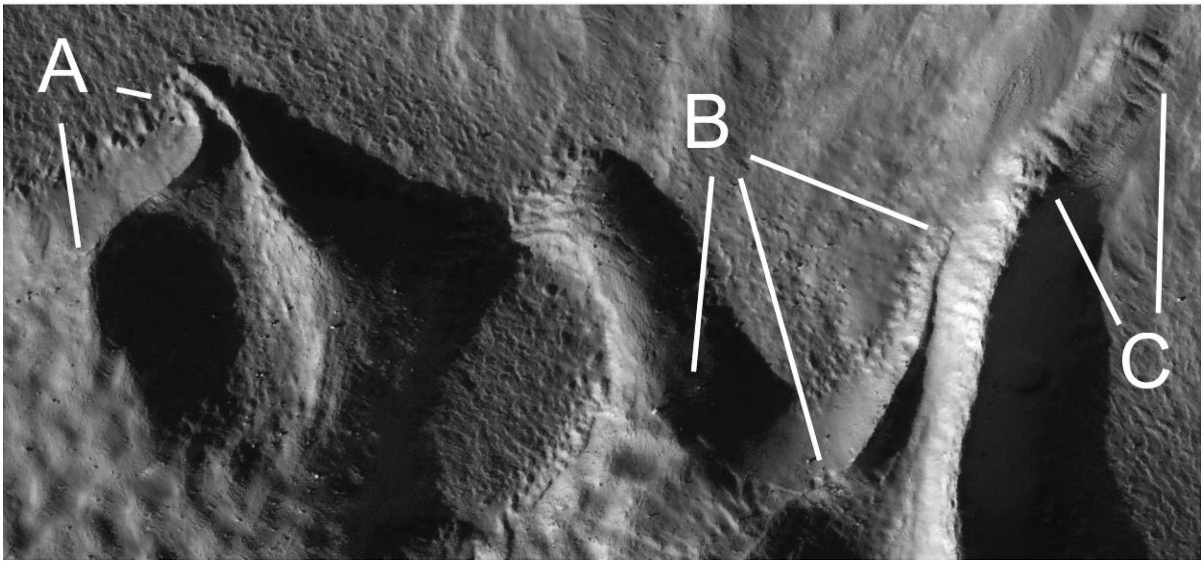

Figure 18. The walls form the same at right angles to gravity, mud cannot slump like this.

The dam in Figure 19 is free standing, as with the ones shown earlier there is no sign above them of where this dam material came from. **A** shows a distinct edge to this wall, **B** shows a distinct band as is there is a layer going through the wall parallel to the top. These exterior walls usually appear to be flat rather than curved, here the shading from the sun indicates a flat gradient. This is similar to how Earth dams are made, the water pressure increases linearly and so this shape is optimal. This should not occur with a mud flow, it would tend to slump in a curved shape, however so far there are no mud flows remotely resembling these dams.

C shows actual mud and what it looks like when it falls down the slope, this has filled up much of the dam but has not formed a smooth surface like these dams have. It also has cracks in it but the dam walls have no cracks. If the dam material came down this slope then it should look something like this mud. **D** shows some damage in this wall, the left line from **D** appears to show a piece has cracked off like a layer near the top. The right line from **D** may show another piece that has come off. **E** shows some degradation on the wall top. It however should never have been smooth and regular if formed from erosion. This jagged top to the wall then only makes it appear more natural but it looks more like it has eroded to look like this from a previously smooth and narrow top to the wall. This should not then have begun as a natural wall eroding like this. The striations are at right angles to the wall surface and so may be a series of bricks exposed. The spacing between them appears to be highly regular but this is at the limit of the resolution to measure.

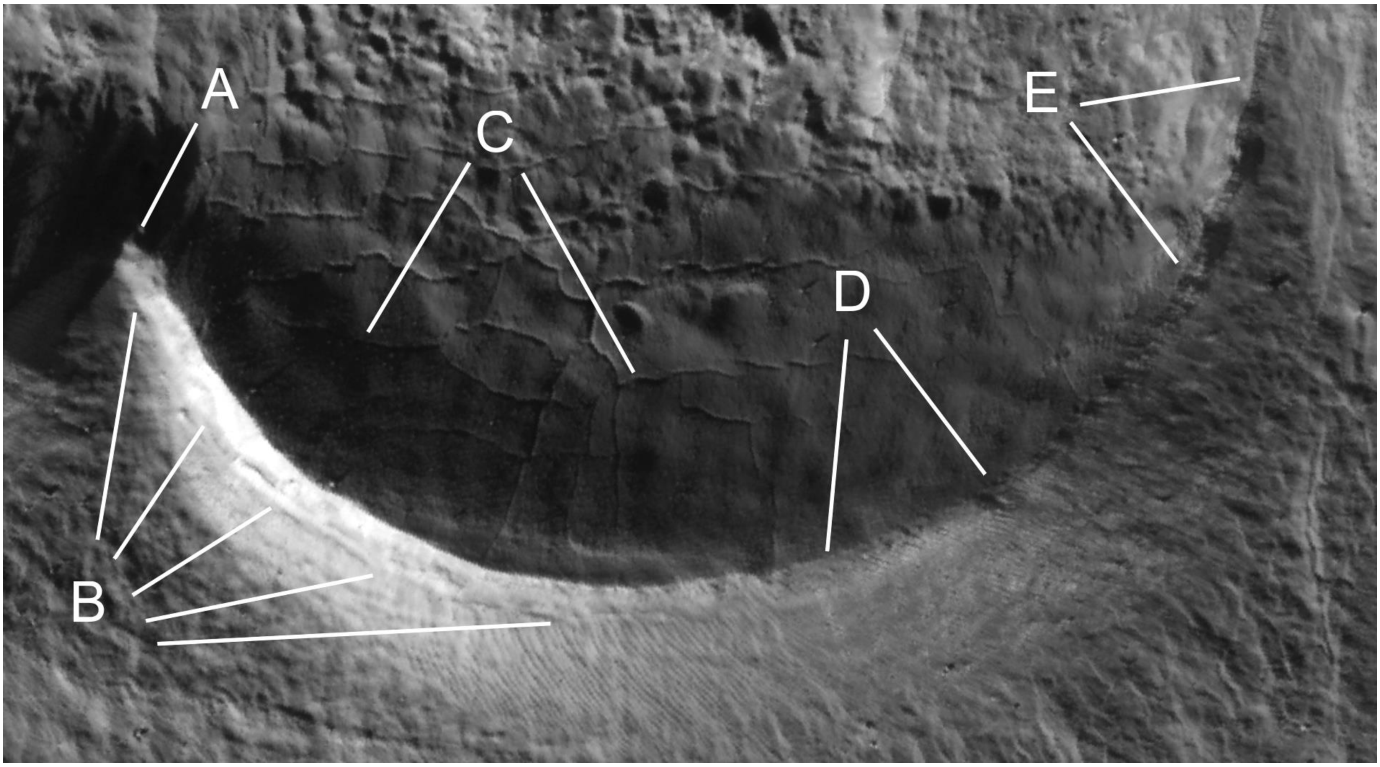

Figure 19. Mud that slumped into the dam is nothing like the wall material.

Figure 20 is a close up of another part of the crater. Here it appears mud has slumped down from water ravines above this area. The light is coming from the bottom of the image, this casts a shadow so the right line coming from **A** shows a dam. The left line shows some mud that has come down from the ravines. This process is one explanation for how these dams are formed, it slumps down the crater and the bottom part creates the dam walls. However this mud seems to only fill the dams in an amorphous way not create new walls. **B** shows from the right line the dam hollow, this is separate from the slumping mud which seems to have filled and dam and buried it.

The left line from **B** shows this mud, it seems to be a completely different shape from the dams seen so far. It is also a completely different texture to the dam walls, however this is the smoothest mud flow so far. Mud flows seem to have small wave like shapes in them, however the dam walls do not have these. **C** shows another dam with the slumping mud partially filling it, again there is no dam wall formed by the mud. **D** shows another small dam with no mud in it. A comparison between this mud flow and the dam shapes so far shows no similarities. But if the dams are not mud then they must be either something else geology can produce, or they are artificial.

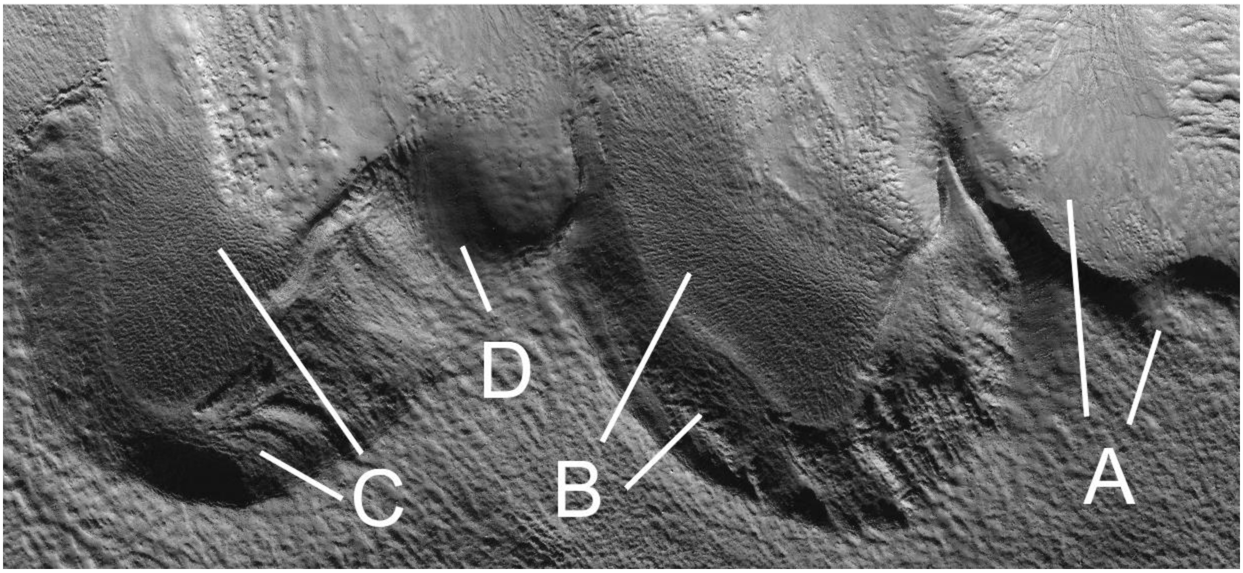

Figure 20. Mud fills the dams with a different shape, it cannot form both.

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Figure 21 shows a more ambiguous pair of dams. The bottom line from **A** shows the smooth dam wall and an arcuate shape as with many previous examples. The next line up shows the dam is apparently filled with mud that has come down the slope. The smaller third line from the bottom shows apparent damage of this dam wall. The top line from **A** shows cracks and faults in this mud and rock. One interpretation is this dam is artificial and filled with mud, this has cracked over time perhaps from temperature variations and quakes. Even with this extreme erosion the main dam walls look dissimilar to the surrounding rock.

The bottom line from **B** shows the same smooth arcuate dam wall. The next line up shows apparent dunes obscuring part of the top of the wall. The next line shows the dam is again full of mud, the flow shows it coming from the ravines above. Space does not permit showing this but the full image shows extensive water ravines over these dams. The top line from **B** shows a connection from a small ridge to the dunes that goes down to the dam wall, it's likely this is a mud flow. The natural and artificial explanations can then be viewed side by side, the mud here can be regarded as forming these dams. However in other examples there has been no mud, no slumping, no cracks in the mud, and nowhere for the dam material to come from. And yet the same dam features are still there.

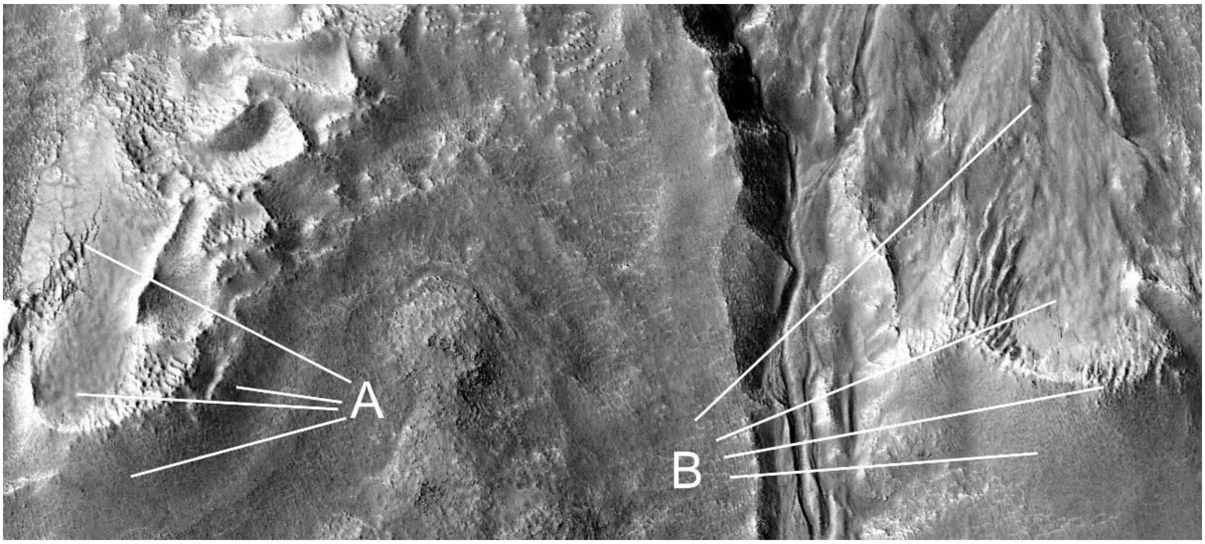

Figure 21. More mud slumps with cracks fail to damage the dams with their weight, so they are different materials.

ESP_036839_1420

Figure 22 has an enormous number of possibly artificial formations. Each letter has lines coming from it, the first line referred to has a **1** next to it. Then the lines will proceed anticlockwise from the **1** to be analyzed. The first line from **A** with a **1** shows a small eroded dam. The next line anticlockwise shows a possible gating point, to the left the water would fall through a groove to this dam. More to the right the water would fall through another groove to another eroded dam below it directly below the **D**. the third line anticlockwise from **A** shows another eroded dam. The fourth line shows two dams, one under the other. The top dam would receive water directly from the slope, the bottom dam would have water directed to it shown by the **1** line from **B**. The last line from **A** is vertical and shows how smooth the dam wall is compared to the rough rock of the crater, typical of these dams. The next line counterclockwise from **B** shows either another dam or a funnel system directing water to the dam below it. The third line from **B** is horizontal and shows another small dam.

The **1** line from **C** shows a small dam, the second line anticlockwise shows another dam. The third line appears to show a ridge where water would be diverted to the left into the dam shown by the **1** line from **C**. Some might also go into the dam below it. The next three lines from **C** appear to show fracturing of the rock, none of these seem to be a natural process forming dams. They may also be ridges to divert water that have eroded away or broken off. The **1** line from **D** shows another dam. The next line anticlockwise shows the smooth dam wall. The next two lines shows grooves where water would be diverted downwards by ridges into this dam. All of this water flow so far should have happened whether natural or artificial. However to see water collected like this naturally would beggar the imagination.

The **1** line from **E** shows a groove which would funnel water to the dam below it. The next line shows some slumping of the rock or mud, however this doesn't form a dam shape. This is significant because there should be signs of natural processes forming dam shapes if this is possible. The third, fourth and fifth lines anticlockwise from **E** show where two walls have come close together, the walls are the same type as dam walls. So to form naturally they would have to come together like this without breaking or filling in the gap between them. The vertical line from **E** shows another ridge which should divert the water to the left to the funnel shape directly under its end and to the dam below it. The last line anticlockwise from **E** shows the smooth sides of this wall.

The **1** line from **F** shows an eroded dam. The next line anticlockwise shows another eroded dam with a funnel like shape above it. The third line shows a groove and arcuate ridge which should let some water drop down to this dam, and other water is moved to the right. The fourth line from **F** shows a remarkable long ridge which would direct water to this dam, on its left it becomes arcuate and directs water to another dam. The sixth line from **F** is nearly vertical and shows another dam with smooth sides, the last line shows a groove which would funnel water to the dam below it.

The **1** line from **G** shows a groove where water would be funneled to the dam below, this would also be directed by the curved wall to the left of it. Here it is simpler to go clockwise, the middle line shows a small dam and the next line a funnel which could direct water all the way down through these funnels breaking its fall to the dam at **F**. This would be necessary as if the water moves too quickly it would spill out.

It should be apparent by now serious questions arise as to how this could form by coincidence. The engineering here would rival the Ancient Romans in its complexity. If artificial these ridges would have been covered by concrete and have been much smoother. The **1** line from **H** shows another dam with smoothly curving walls, there are some cracks in the dam floor where it bends to a steeper decline. The next line anticlockwise from **H** shows the smooth curve extending up to the vertical wall. The third line shows another small dam. The fourth line shows how this smooth narrow wall leans over onto the rough rock below but is separate from it.

The fourth line nearest vertical shows where two dam walls join up leaving a hollow. The long **1** line from **I** shows a deep dam, there may be runoff ravines eroded into the wall below it as water escaped, perhaps from the long fall. The next two lines from **I** show another two highly eroded dams. The **1** line from **J** shows another long dam with a squarish bottom to it. The next line anticlockwise shows how this wall should funnel the water down perhaps breaking its fall. The last two lines from **J** are near vertical and show grooves which may have been formed to direct the water to this dam. **K** shows three more dams. The **1** line from **L** shows a very deep dam. The next line shows how this smooth material is draped around a large rock, hard to form naturally as it shields this rock and acts to divert water smoothly around it to the last line from **L** as another dam.

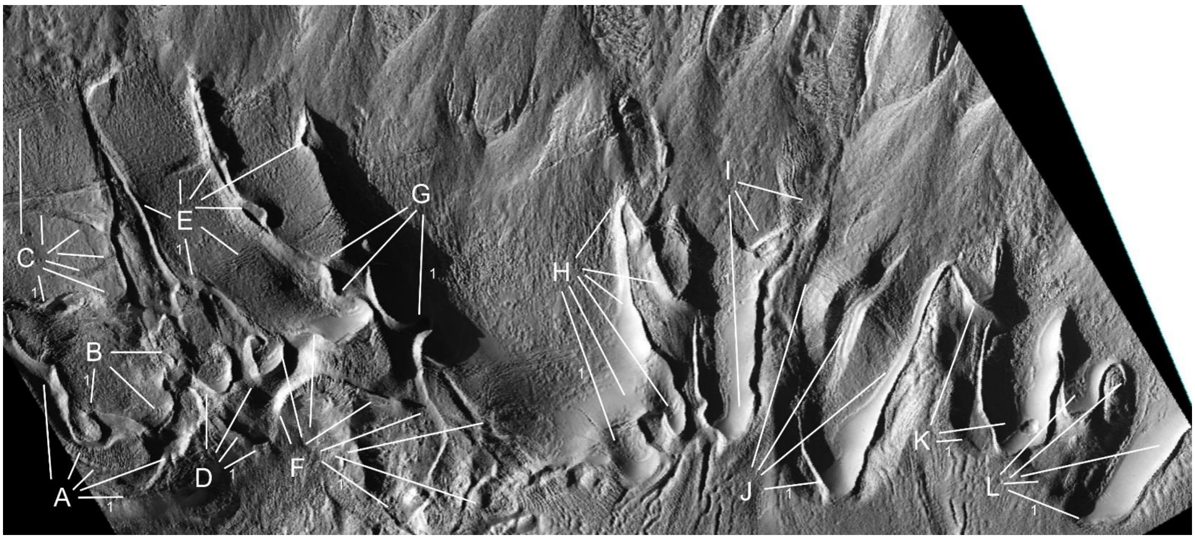

Figure 22. Almost nothing here can occur naturally, the walls are very smooth and elastic compared to the crater material.

there are far too many dam features here to analyze in close ups, some selected areas will be examined. In Figure 23 below there are three areas where the dam walls are broken, this can give some clue as to their nature. **A** appears to show two layers, an inner one is still standing and the outer wall has peeled off. **B** appears to show a near break in the wall, there is a concave band or missing skin going along the wall top connected to this damage. This can indicate an inner and outer layer for strength, plus horizontal layers in the walls. **C** is another example of how this outer wall has broken away from the bedrock, this may show how the walls were attached to a cliff face. It may also have two layers here.

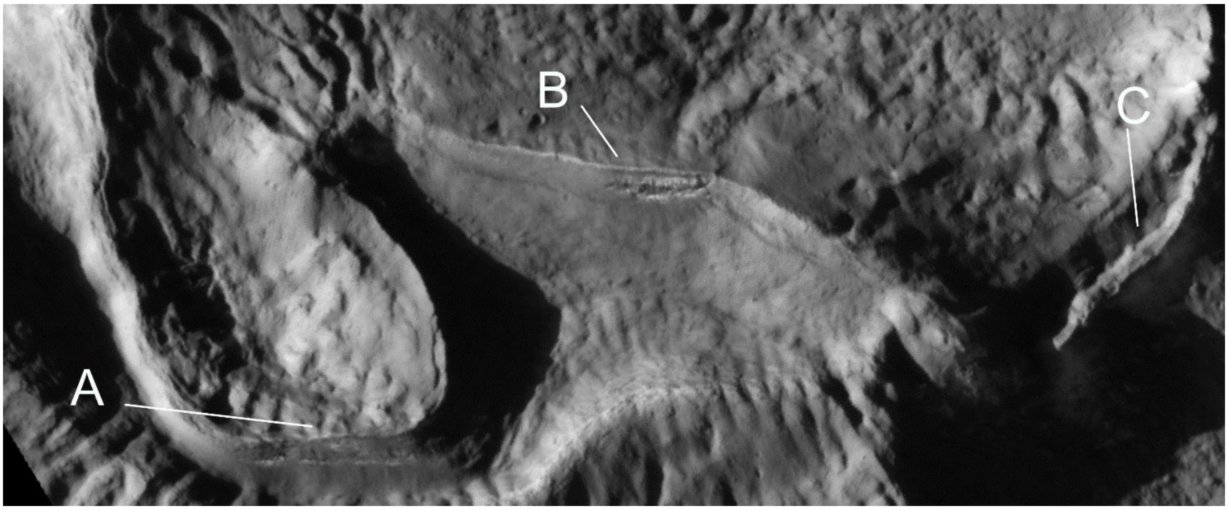

Figure 23. Breaks in the walls show layers impossible to form in slumping mud.

In Figure 24 **A** shows three funnels directing water to dams, the middle one is choked up with silt. The left line from **B** shows there the dam wall has broken off, the damage indicates extreme age or perhaps more water flowed here for longer than the other dams. The dam wall then becomes smooth but the two lines from **B** to the right show breaking of layers under the floor. This indicates what this material could be made of. A floor of concrete might have been placed over the bedrock, over time this is beginning to flake off at the lower end. There may also be multiple thin layers on top of each other.

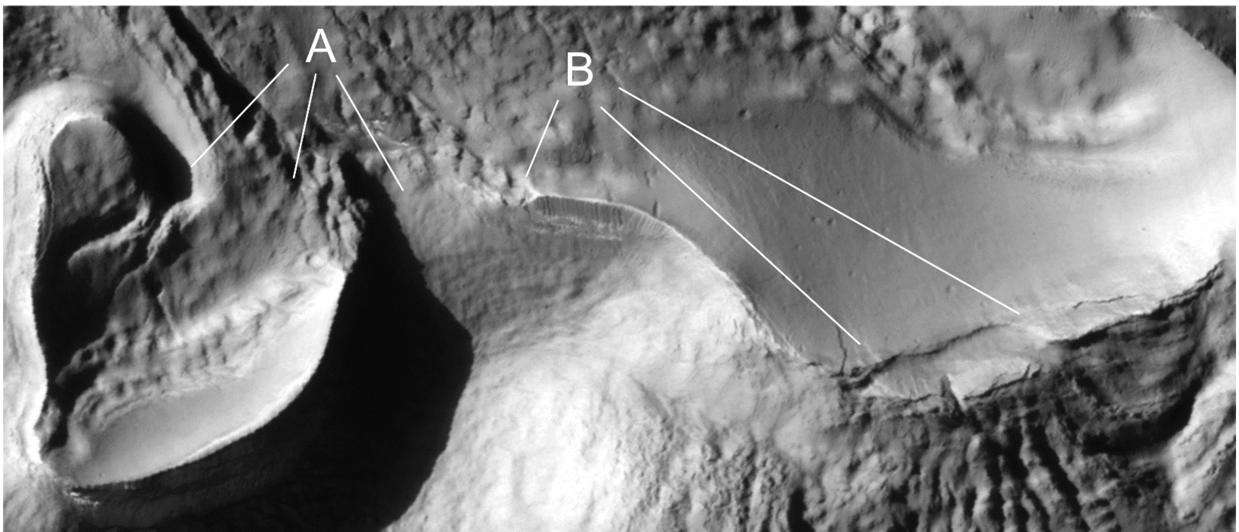

Figure 24. Layers cracking as the ground underneath is eroded away.

Figure 25 shows a ridge which would divert water, shown at **F**. **A** shows a more unusual wall, this one appears to be very straight with a fat top and a rectangular section on its end. This might be the inner wall after the outer skin has eroded away. The letter **A** is in a hollow but this is hard to explain naturally, how the rock would be hollowed out under this ridge. **B** also points to a hollow, the ridge forms one piece diverting water to the left and right. **B** also shows where a wall might have been, there is some damage here like previous images where a wall had broken off.

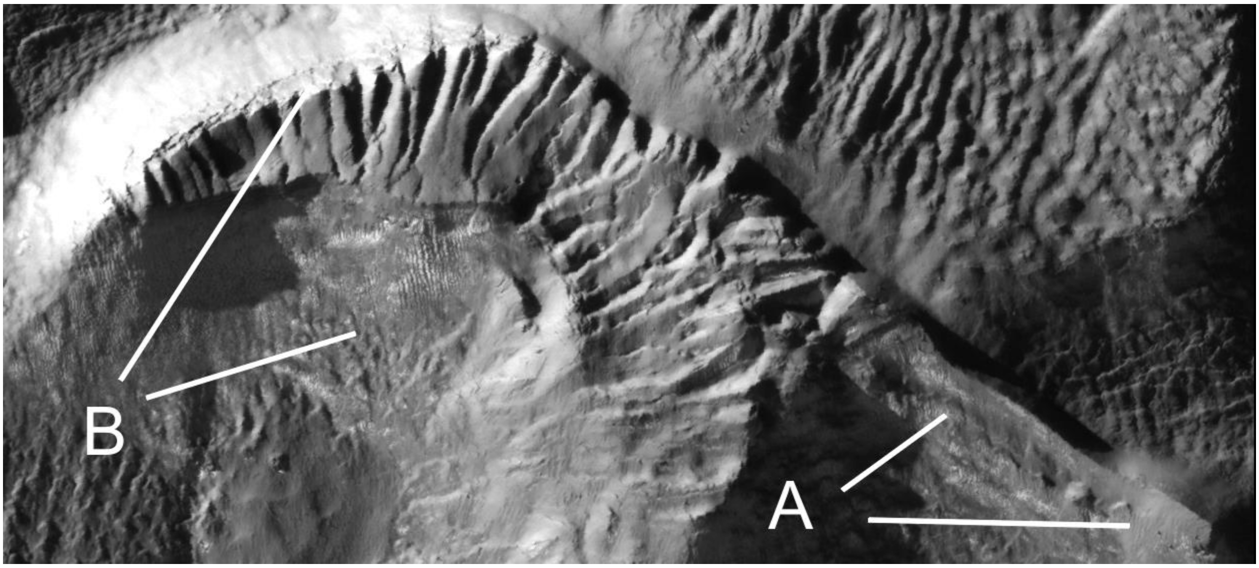

Figure 25. A is highly unnatural with no erosion, it connects to the whole shape but is a different material.

Figure 26 below shows a large hole at **A**, this is hard to explain naturally as the dam floor is formed all around it. If the hole was there when the floor was formed then it should have created turbulence around it and shaped the erosion under it with the water flow. However the floor sharp is pristine on all sides of the hole. Instead it may have been coated with the same material as the floor. The left line from **B** shows a dark streak running along the wall, perhaps related to a layer in it.

The next three lines show damage to the dam wall and floor, there appears to be multiple layers that broke off. **C** shows how this wall material curves smoothly around this large rough rock without touching it, for mud to create this by slumping should be impossible. It is the same shape and texture vertically on the sides, also it curves around under it to some degree with the right line from **C**.

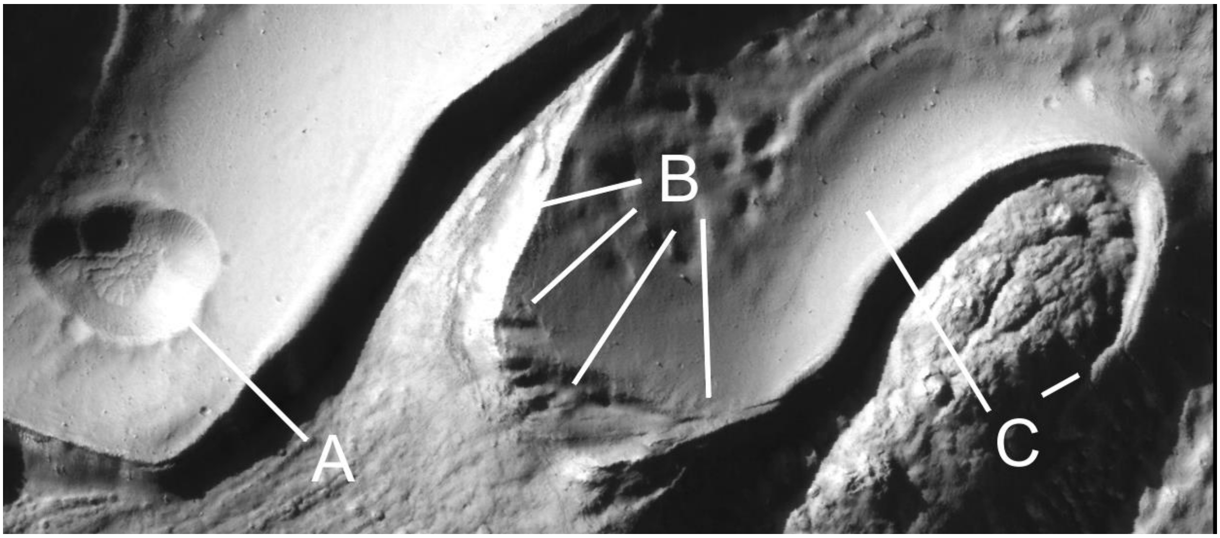

Figure 26. The wall curves around and under C against gravity, it also doesn't fill the hole at A.

The use of contoured dam structures to hold water is well known on Earth, for example the rice paddies[xxiii] in Figure 27. They may have been used on Mars to hold water, grow crops similar to rice, raise fish, etc. It also shows how the Chinese were able to hold water in these paddies without using concrete.

Figure 27. Similar contoured dams are used on Earth.

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Figure 28 shows dams in a highly degraded state, as the walls break it gives more clues as to their nature. **A** shows many areas where the ground has cracked and slumped, however this has not broken any of the dam walls. They would seem to be very strong and resilient to stress, more than the natural rock of the crater. **B** shows the same kind of cleaned up area under the dam walls, this makes them more comparable to previous images. They are unlikely then to be something else that happens to look like these dams. **C** shows a dam wall that has eroded away to virtually nothing. The next dam at **D** as also lost most of its wall. **E** shows a dam that connects to two ridges in an unusual way. **F** shows a very long dam that has the wall missing at one point.

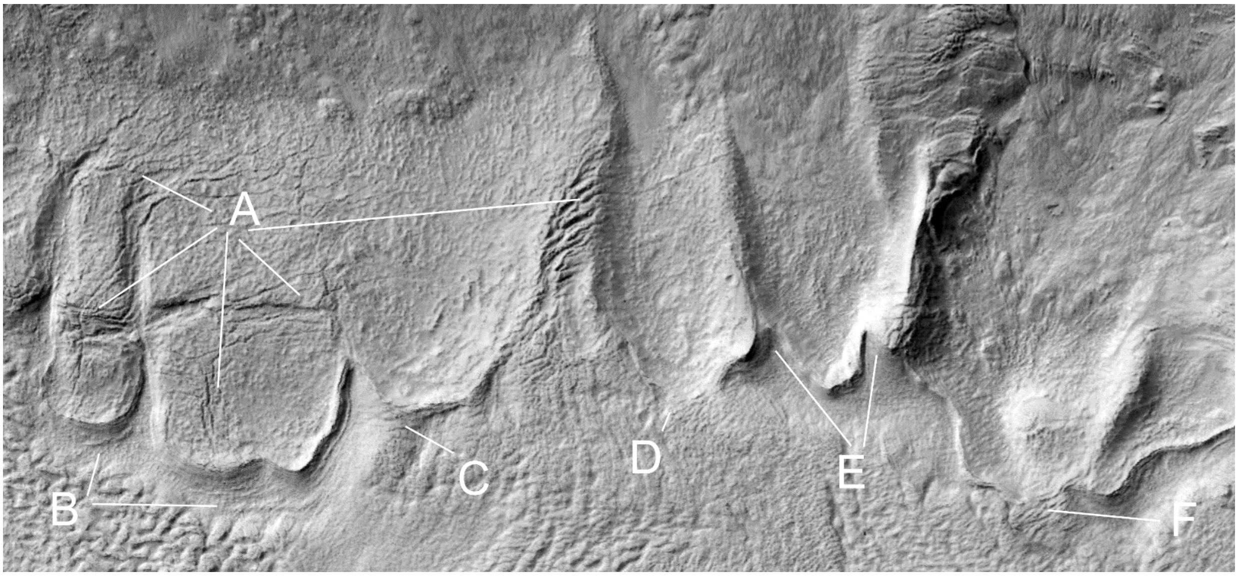

Figure 28. Slumping mud forms cracks but not in the walls, they act differently to this stress so are not the same material.

The walls below in Figure 29 are severely degraded, **A** shows how the material is made of layers but the rock above is not. This makes it unlikely they were made by the same process, also slumping mud does not form layers. **B** shows many layers in the wall, there may have been a smooth coating that has eroded away here. **C** shows a bulging area of rock and a hollow, this may indicate a missing external layer. The top layer here is much darker, perhaps a different material to the rock above it. The left line from **D** shows the wall in much better condition but perhaps still missing some of the external coating. The right line from **D** shows a missing piece from a layer, perhaps this was an external skin of material missing elsewhere. The left line from **E** shows the top of the wall in good condition and then it degrades to the right.

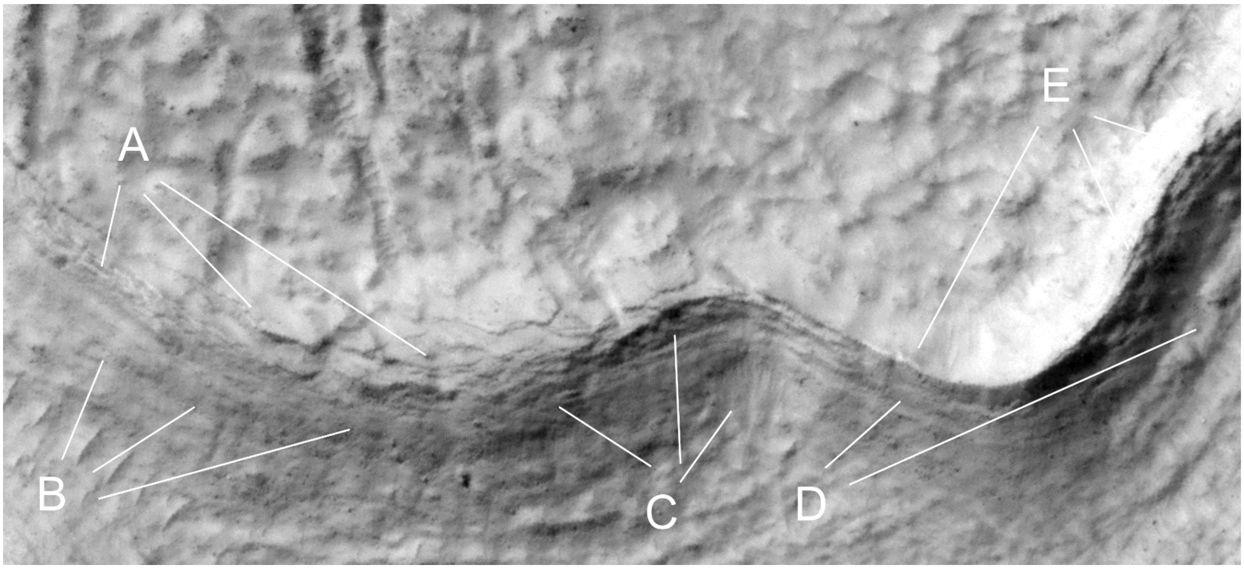

FIGURE 29. The walls are layered, but could not have survived the crater impact.

In Figure 30 **A** shows the wall has disappeared, the dam might also be full of silt. **B** shows layers that seem to break up in pieces and perhaps a weaker material between them erodes more easily. **C** shows more deep holes in the wall. **D** shows a dark layer in the wall and on the right perhaps the remains of the exterior wall.

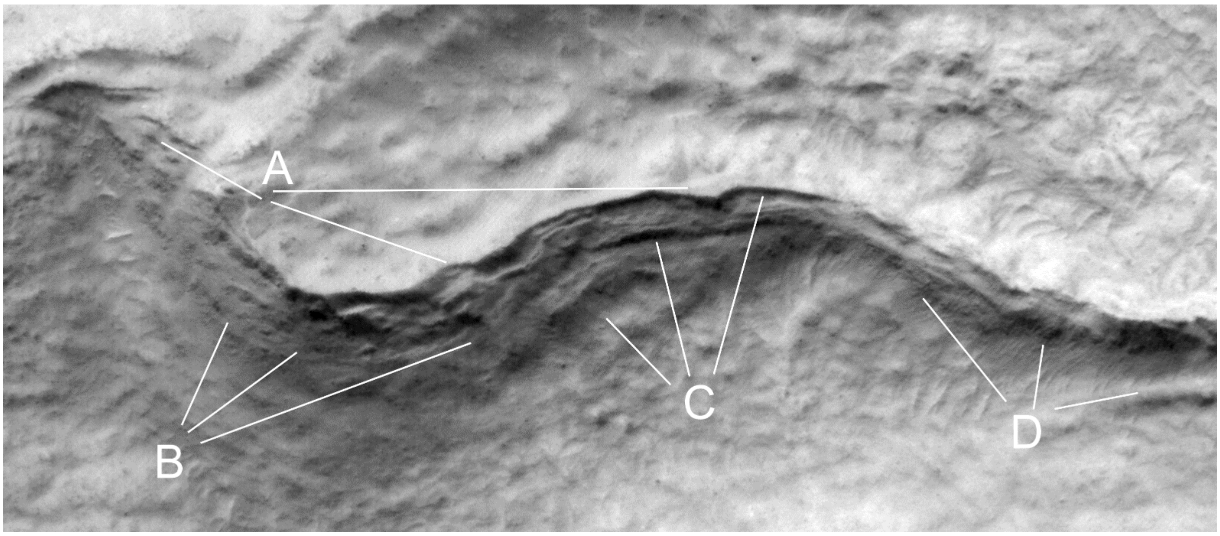

FIGURE 30. The wall still holds despite the weight of mud and dust above it.

Conclusions

The Martian dams are highly unusual, they range from the probably natural to seemingly impossible structures. This is not unusual on Earth, for example the pyramids probably imitated similar shaped hills in Egypt and some buried sites can resemble natural terrain. One major problem with the natural hypothesis is the lack of any missing material in the crater walls above them, instead the hollows occur under the dams. If they were formed by slumping materials then there should be a recognizable area where the mud came from. To suggest otherwise is to say the mass of the dams came out of thin air.

Another problem is their longevity, often the ground can be highly eroded yet the dam walls remain pristine. They can also be very convenient, water ravines form and usually water will wear a path down a slope. Here however the dams seem to do the opposite, they catch the water in intricate arrays that seem to slow the water and break it into smaller catchments to avoid spillage. When there are signs of erosion the dams still degrade slowly as pieces of layers break off. They seem then to act like concrete would assuming it could last over hundreds of millions of years. However basalt contains a natural Zeolite cement that also survives this length of time, it is unlikely then radiation would destroy concrete on Mars.

These dams are not a feature on every crater wall with ravines, many look as they should be with no dams or obstructions of the water to the crater floor. Often this disparity occurs in the same crater, there can be multiple dams on one side and the other with the same geology has no dams at all. When they do erode they show extensive layering, the floor can be seen in some cases as a layer like concrete. The walls sometimes have horizontal layers and several vertical layers, they sometimes contain blocks that look like bricks. This is problematic if they form from mud slumping down the crater[xxiv], this is because the layers are parallel to each other not mixed up from a randomizing flow.

Where there is clear slumping of mud and faulting the dams seem to be very different from the result, often they are found side by side with the dams unaffected even when buried. This indicates the dam material is impervious to water even over millennia, it would appear to rule out any process of their forming with water. The dams cannot be remnants of bedrock protruding from the crater wall and resistant to erosion, the explosion created by a crater vaporizes all rock or throws it out as ejecta. These dams have delicate shapes which could not survive an impact, the tops of the dam walls appear to be less than a meter wide and sometimes are tens of meters tall.

The wonder then is they can stand by themselves, to survive an impact like a nuclear bomb is out of the question. These layers cannot be those exposed in a crater impact because they curve around in the dam walls following their shape. If they were exposing contoured layers in bedrock then the layers would not remain parallel to the dam wall tops[xxv], the dams can curve around into U shapes which layers could not do. NASA recently shows how these layered outcrops would appear from the rover[xxvi], they do not form shapes resembling these dam walls.

With the candidate artifacts they seem to cluster around the same great circle, many are between Cydonia and the King's Valley. Others are found at lower latitudes on the other side of Mars consistent with how the great circle lies at an angle to the current equator. If not artificial they represent a convenient read made dam structure useful to the inhabitants. If Mars was terraformed the artesian basin might refill and many of these dams start operating again for colonists. It would not be difficult for the hypothetical inhabitants to build them as long as a concrete like material could be made, it would be a logical step to improve the water supplies like this just as people do here on Earth.

For skeptics the dams should be less problematic than humanoid faces, it might be expected any kind of sentient carbon based life would need to collect water. It is also likely dams like this would survive long after any metallic and plant based buildings would have eroded away, for example there may have been pumps used but long gone. With the candidate artifacts the dams may give a highly misleading impression of what was there, they would just be the only large scale structures that could survive for over hundreds of millions of years on Mars.

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[ii] Why we must go to Mars: The King's Valley. Amazon (2011)
[iii] P04_002559_2013_XN_21N298W
[iv] Amazon books, see also at xenoarcheology.org for a free copy.
[v] http://www.uahirise.org/
[vi] "Branched Features on the Floor of Antonialdi Crater" http://hirise.lpl.arizona.edu/ESP_012435_2015
[vii] "This picture by MRO shows seasonal polar caps on Mars. When springtime on Mars occurs, this dry ice evaporates and causes some erosion of the surface. This erosion gives us "araneiform" terrain (various formations on the surface, such as "spiders," "caterpillars" and "starbursts")."
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[xi] **http://wiki.ubc.ca/images/2/23/Branches.gif**
[xii] https://en.wikipedia.org/wiki/File:Rockfish_around_kelp_monterey_bay_aquarium.jpg
[xiii] Undergraduate science student, University of Queensland, Australia. **Gregory.orme@uqconnect.edu.au**
[xiv] Many crater gullies have been mapped: The comparison of topographic long profiles of gullies on Earth to gullies on Mars: A signal of water on Mars **doi:10.1016/j.icarus.2015.03.009**

[xv] Martian gullies in the southern mid-latitudes of Mars: Evidence for climate-controlled formation of young fluvial features based upon local and global topography
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[xvi] Magnetization, Paleomagnetic Poles, and Polar Wander on Mars **Kenneth F. Sprenke**, **Leslie L. Baker**, **Icarus**
Volume 147, Issue 1, September 2000, Pages 26–34
[xvii] The paleo oceans of Mars, Lunar and Planetary Inst., MECA Symposium on Mars: Evolution of its Climate and Atmosphere p 20-22 (SEE N89-10780 01-91)
[xviii] Lunar and Martian Resource Utilization: Cement and Concrete Authors: Lin, T. D., Workshop on Using In Situ resources for Construction of Planetary Outposts, http://adsabs.harvard.edu/abs/1998uisr.work...12L
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[xx] GULLIES POTENTIALLY FORMED BY WATER FROM THE SUBSURFACE. K. J. Kolb1 , A. S. McEwen1 , V. C. Gulick2 , and the HiRISE Team, http://www.lpi.usra.edu/meetings/lpsc2007/pdf/1391.pdf
[xxi] Photo used by permission, Penman's dam in Paris, Ontario.
[xxii] Photo from Wikipedia.

[xxiii] **https://commons.wikimedia.org/wiki/File:Batad_Rice_Terraces.jpg**
[xxiv] For example, layers in a crater wall: http://static.uahirise.org/images/2007/details/cut/PSP_004052_2045_cut_b.jpg
[xxv] For example these layers are all parallel to each other:
http://www.nasa.gov/mission_pages/MRO/multimedia/20070717-3.html
[xxvi] These do not form dams: http://www.reuters.com/article/2007/06/29/us-mars-idUSN2837762220070629