Mars: Geological Formation or Archaeology? Square-shaped Structure Within an Arabia Terra Crater?

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ABSTRACT

An examination of a square-shaped structure within a crater in the Arabia Terra region of Mars is undertaken. Supportive images are provided by NASA's Jet Propulsion Laboratory's Mars Global Surveyor and the Mars Reconnaissance Orbiter spacecrafts. The images reveal the remains of a set of possible linear walls with 90-degree angles (as best as can be determined) at their corners that exhibit a high level of symmetry. The hypothesis of artificial design is presented based on an examination of possible artificial and natural mechanisms that could contribute to the structure of the features observed. Terrestrial comparisons of geological structures and geometrical designs are investigated. Further study and additional imaging of the structural components of this enigmatic feature are encouraged.

Keywords: Mars; Arabia Terra; square; walls; foundation; mounds; Mars Global Surveyor; Mars Reconnaissance Orbiter; Masada; White City; life on Mars; Anomalous Formations on Mars

1. Introduction

A Mars Global Surveyor image depicting a square-shaped structure (also referred to in the popular press as a "square-shaped formation") was brought to the attention of the first two authors in 2001 by independent researcher Richard C. Hoagland via his Enterprise Mission website (https://www.enterprisemission.org/). This square structure has generated a high level of interest and has been featured in numerous online news programs; however no serious scientific assessment has been offered until now.

2. The Square-shaped Structure (Mars Global Surveyor)

In November 2001 NASA released an image acquired by the Mars Global Surveyor (MGS) camera E10/00462. The image was taken in the winter, during the early morning hours with a resolution of 6.3 meters per pixel (Mars Viewer, MGS, 2001). The original orientation of the image was inverted, with south toward the top; it shows exposed material within a crater that includes a feature that appears to be square-shaped structure (Figure 1). The square-shape is offset with opposite corners aligned in a north south direction. The northern corner of the formation consists of an L-shaped wall-like structure that is partially buried by debris. The western and southern corners are visible, while the eastern corner appears to be covered by fine-grained deposits in this image; the western corner also appears to be covered to some extent with fine-grained deposits (note that "fine-grained" is a relative term in this context, given the resolution of 6.3 meters per pixel). A detail of the area is provided in figure 2, showing the outline of the square-shaped walls and linear impression.

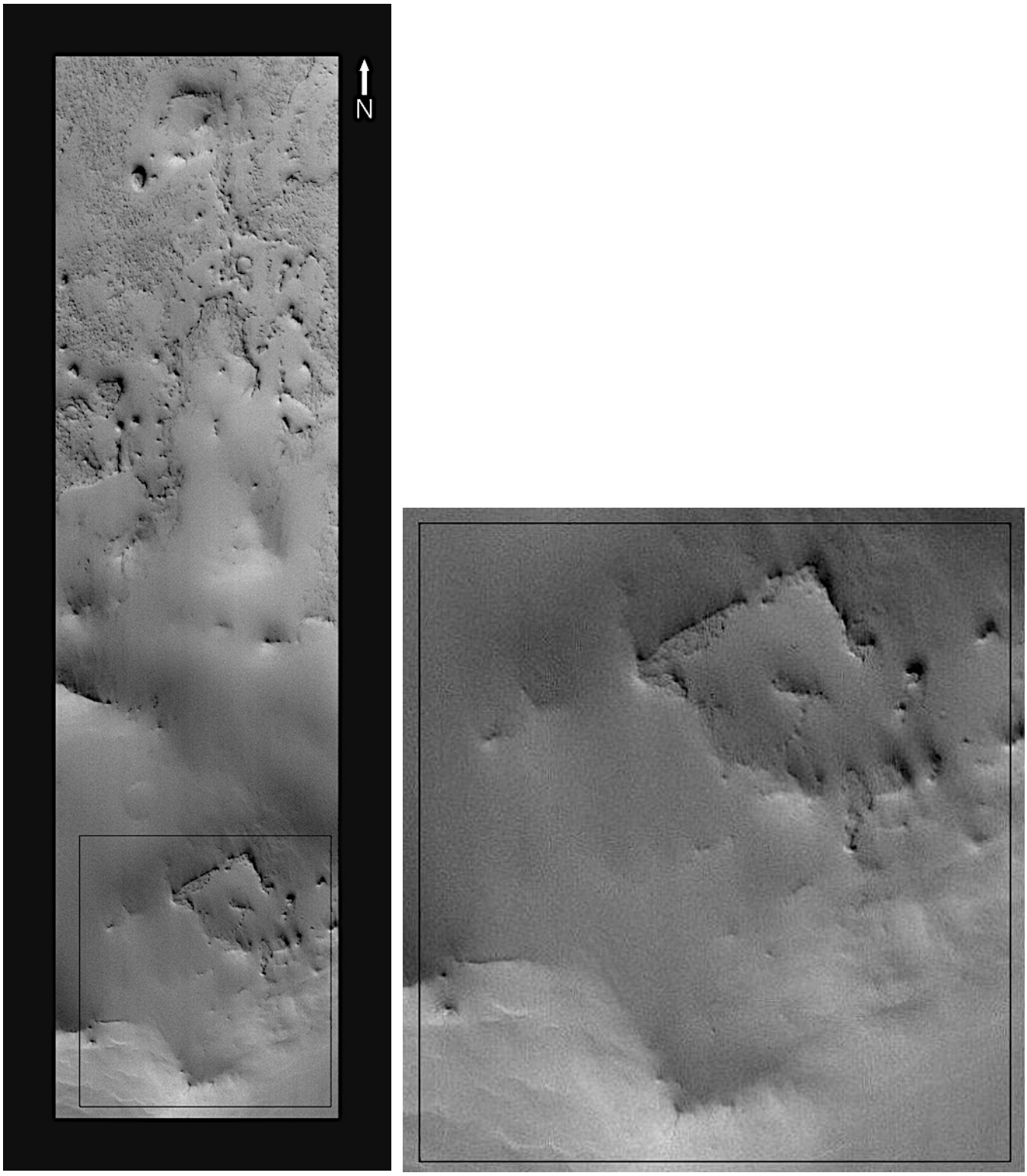

Figure 1 Square-shaped Structure. Detail of MGS image E10/00462 (2001). Left: Outlined and notated with orientation corrected by the first author. Right Detail of outlined area.

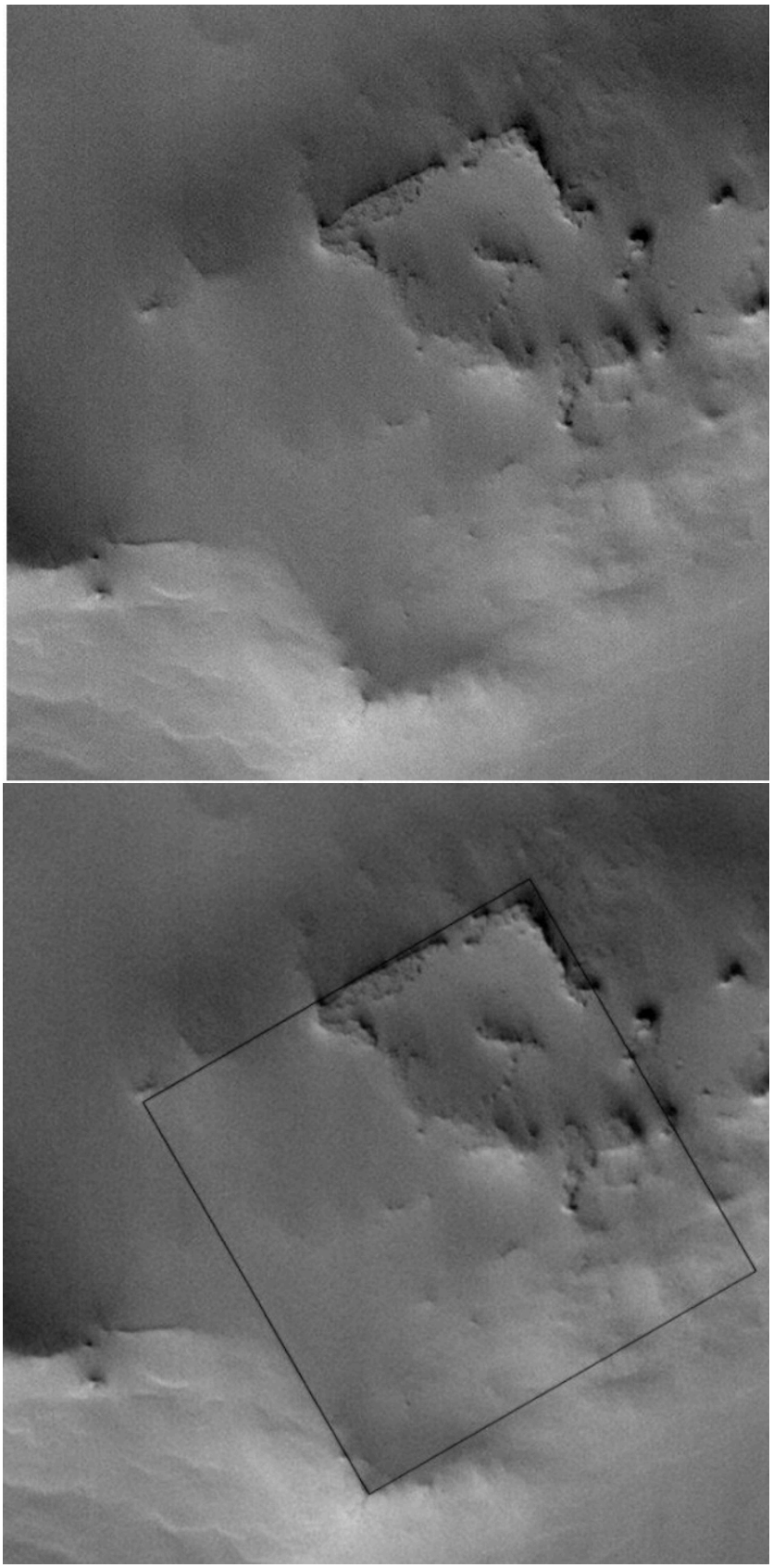

Figure 2 Square-shaped Structure. Top: Detail of MGS image E10/00462 (2001). Bottom: Square outlined by the first author. Each side of the square is approximately one mile (1.61 kilometers) in length.

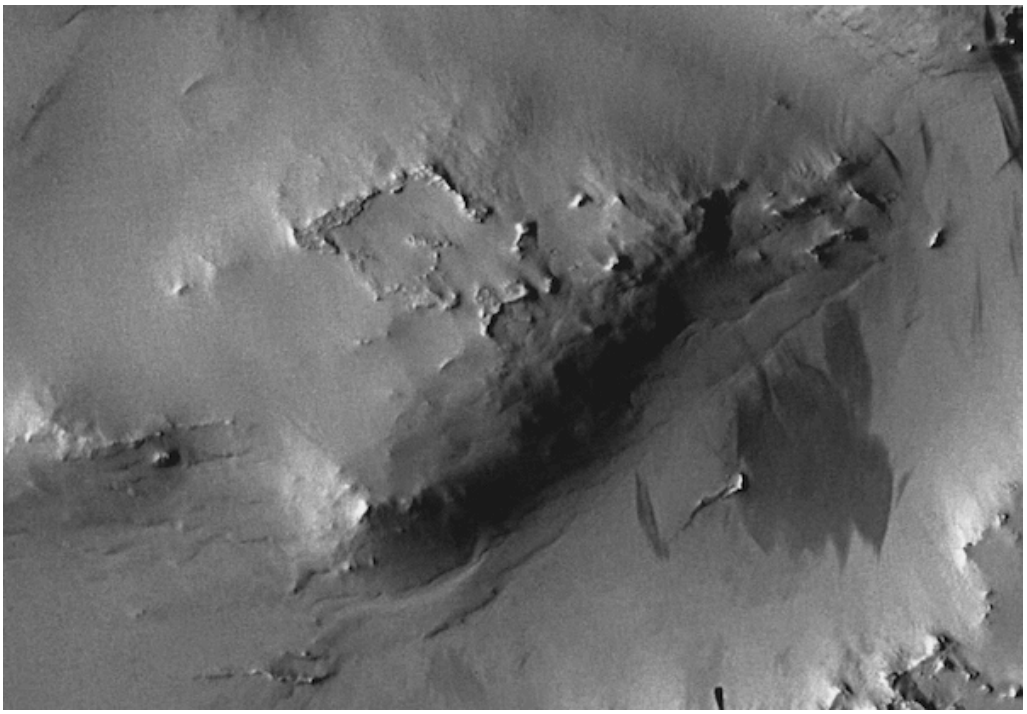

Figure 3 Square-shaped Structure. Detail of MRO HiRISE CTX P21_009232_2084_XN_28N332W (2008).

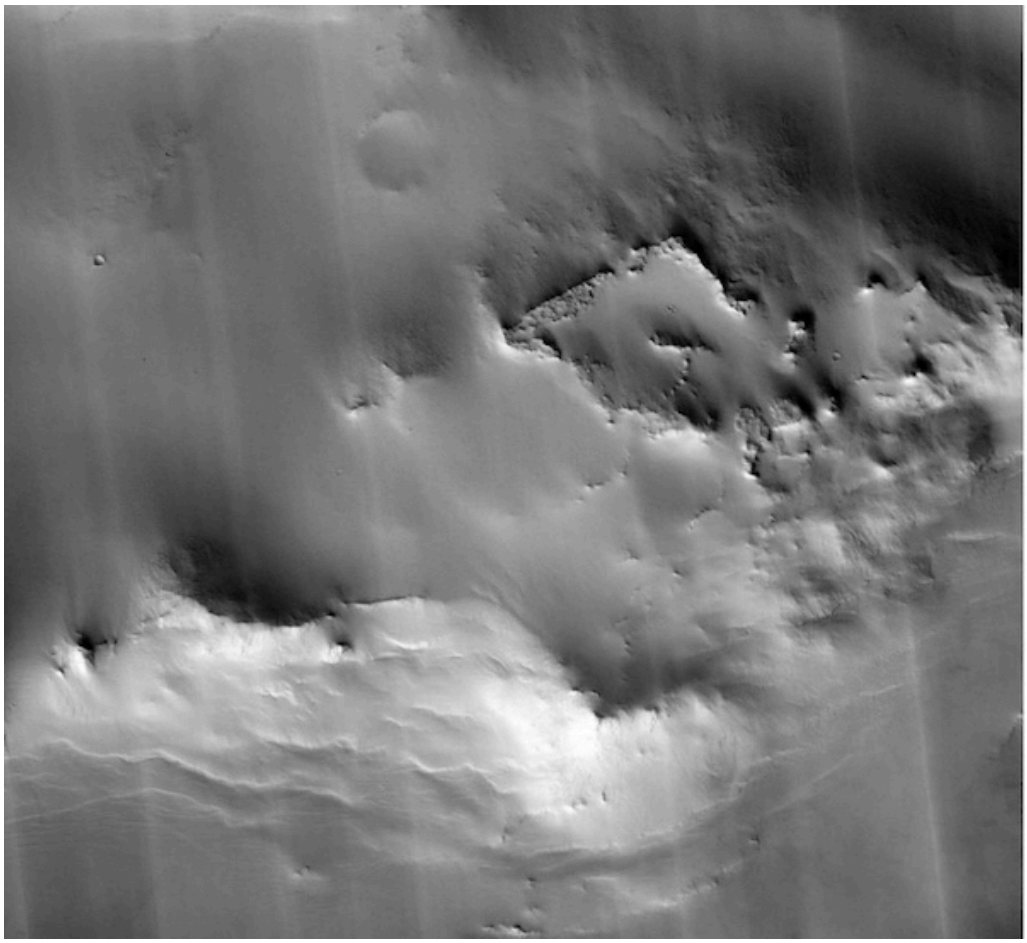

Figure 4 Square-shaped Structure. Detail of MRO HiRISE ESP_057534_2080 (2018).

3. The Square-shaped Structure (Mars Reconnaissance Orbiter images)

In 2008 the Mars Reconnaissance Orbiter (MRO) Context Camera (CTX) captured image P21_009232_2084_XN_28N332W (Figure 3) that included an expansive view of the area surrounding the western and eastern sides of the square-shaped structure. The image was acquired in the summer, during the early evening with a resolution of 6.3 meters per pixel (Mars Viewer, MRO, 2008).

The MRO HiRISE camera was utilized in the winter of 2018 to acquire another image of the square-shaped structure (Figure 4). It included an expansive view of the area surrounding the western side and addition features on the eastern side. The image ESP_057534_2080 was taken during the early afternoon with the highest resolution thus far acquired of the structure, registering at 50 cm per pixel (Mars Viewer, MRO, 2018).

Four years later the MRO HiRISE onboard CTX camera acquired another image of the square-shaped structure (Figure 5). This included an expansive view of the area surrounding the western and eastern sides of the square-shaped structure. The CTX image U06_073228_2083_XN_28N332W was acquired in the spring, during the early afternoon, with a resolution of 5.77 meters per pixel (Mars Viewer, MRO, 2022).

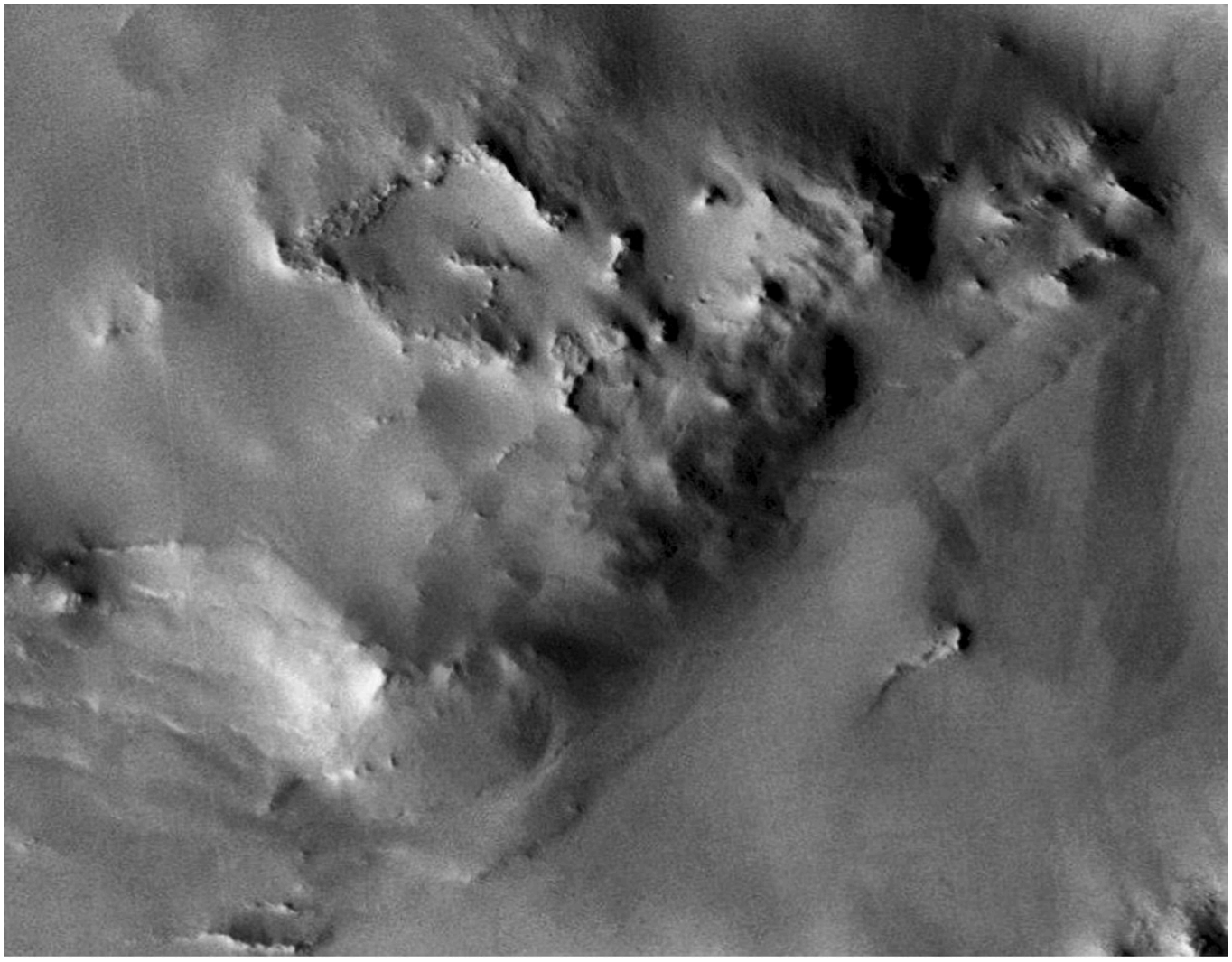

Figure 5 Square-shaped Structure. Detail of MRO HiRISE CTX U06_073228_2083_XN_28N332W (2022).

Table 1

Image Number	E10/00462	P21_009232_2084_ XN_28N332W	ESP_057534_2080	U06_073228_2083 XN_28N332W
Image Start time SCET	2001-11-04 T09:17:23.04	2008-07-15 T20:48:24.227	2018-04-11 T14:19	2022-03-11 T06:42:22.432
Resolution per pixel	6.38 m	6.38 m	50 cm	5.77 m
Emission Angle	18.07 °	18.33°	0.30°	0.09°
Incidence Angle	59.47 °	45.78°	62.00°	62.62°
Phase Angle	75.16 °	28.26°	62.40°	62.64°
Center Longitude	27.46	27.88°	27.795°	27.86°
Center Latitude	27.46	28.45°	27.655°	28.36°
Spacecraft Altitude	N/A	288.8 km	289.4 km	288.5 km
North Azimuth	93.38 °	276.09°	N/A	276.9°
Sun Azimuth	N/A	NA	NA	NA
Solar Longitude	359.56 °	99.16°	282.0°	188.39°
Local True Solar Time	9.17AM	8:48PM	2:19AM	6:42AM
Release date	11/04 2001	7/15/2008	11/04/2018	3/11/2022

TABLE 1 Comparison chart of considerable differences in the four images.

4. Mars Global Surveyor and Mars Reconnaissance HiRISE Ancillary Data

There are considerable differences in the timeframe, telemetry, sun angle, resolution and other factors of the four images of the square structure; a comparison chart is presented as TABLE 1.

The first image of the square-shaped structure, MOC image E10/00462 was acquired in the winter of 2001. It was taken in the early evening with an Emission Angle of 18.07° off nadir and a resolution of 6.38 meters per pixel. The second image, MRO CTX image P21_009232_2084_XN_28N332W was acquired seven years later in the summer of 2008. This image was taken in the evening with an Emission Angle of 18.33° off nadir and a resolution 6.38 meters per pixel. The third image, MRO HiRISE ESP_057534_2080, was acquired ten years later during the spring of 2018. It was taken in the early afternoon with an Emission Angle of 0.30° off nadir and a resolution of 50 cm per pixel. The forth image,

MRO CTX U06_073228_2083_XN_28N332W, was acquired four years later during the early spring of 2022. It was taken in the morning with an Emission Angle of 0.09° off nadir and a resolution of 5.77 meters per pixel. This set of four images show the square-shaped structure to be persistent throughout the twenty-one years that separate the images.

5. Geological Context for the Square-shaped Structure

The four images presented in this study all support the visual impression of a square-shaped structure (Figure 6). The square structure is nestled within a crater, located in the Arabia Terra region of Mars at about 28° latitude and 27° longitude (Figure 7). The area of study is situated in the northern region of the planet, which lies mostly in the Arabia quadrangle with a small portion bleeding into the Mare Acidalium quadrangle. It has a heavily eroded terrain that is densely battered with craters of various sizes, which indicates its great age. The topography also shows evidence of volcanic cones and calderas.
In response to public attention, NASA JPL spokesperson Andrew Good suggested that the 2018 Mars Reconnaissance Orbiter's HiRISE image (Figure 4) provides the best view of the square-shaped structure. He states "Look at the 'corner' that is really a Cliffside unrelated to the rest of the 'square," Good continues "The square-ness of the area is much less convincing in the MRO image. It's not the base of a pyramid. It's not the broken walls of a fortress. It looks like what it is: a geologic formation with mounds and prominent points" (Kooser, 2025).

Good's assessment that the square structure "[is] not the broken walls of a fortress", is not readily compatible with the context of the square structure. Due to the immense heat and pressure generated during a meteorite's impact the area would often exhibit **impact-melt rock** or **breccia.** The energy released can melt existing rocks, fusing them together into new forms or mixing them with fragments of the meteorite itself. A powerful impact can generate immense energy that can excavate and eject large quantities of broken rock and debris to the surface. One would not expect to find linear and geometric shapes, as is evident here, such as right angles and squares. The same analysis holds true if some of the observed craters are not due to physical impactors, such as meteorites, but rather were formed as a result of powerful plasma/electrical discharges associated with major solar outbursts of the past (Schoch with Ulissey, 2021).

According to another scientist at NASA's Jet Propulsion Laboratory, "Right angles are not common in nature. They are almost always formed by tectonic forces." In support of this argument, they offer a Mars Odyssey THEMIS image V44393002 (Figure 8) as an example of a naturally formed right angle found on Mars in the Sacra Fossae region of the planet (JPL, 2012).
Although the right angle observed at Sacra Fossae is similar in shape, it is an irregular corner produced by grooved trenches in the surface and does not exhibit the same type of 90° right angle, with high standing wall-like features, observed at Arabia Terras (Figure 8).

From a terrestrial (Earth-based) point of view, one might suggest that the square-shaped structure is some sort of fault-bounded and/or erosional-bounded plateau. Perhaps crudely similar to the Giza Plateau of Egypt, famous as the location of the Giza Pyramids and Great Sphinx (Sayed & Sonbol, 2020), or possibly some sort of horst and graben type of structure. However, there are serious reservations when it comes to hypothesizing such an origin for the square-shaped structure on Mars.

Firstly, although there are some slight indications of possible ancient tectonic activity on Mars (Michalski et al., 2024), it is not comparable to that observed on Earth and there is no known context on Mars for forming such a fault-bounded plateau or similar feature (possibly a graben-type feature).

Secondly, even on Earth a fault-bounded and/or erosional plateau or other feature with such regularity of structure as observed for the square-shaped structure on Mars would be highly anomalous, particularly in terms of apparent wall-like features bounding the structure, although one might

hypothesize igneous dikes forming in vertical cracks and fissures, with the surrounding country rock subsequently being eroded away to form wall-like structures. However, the required geological mechanisms and context for such features are not known on Mars.

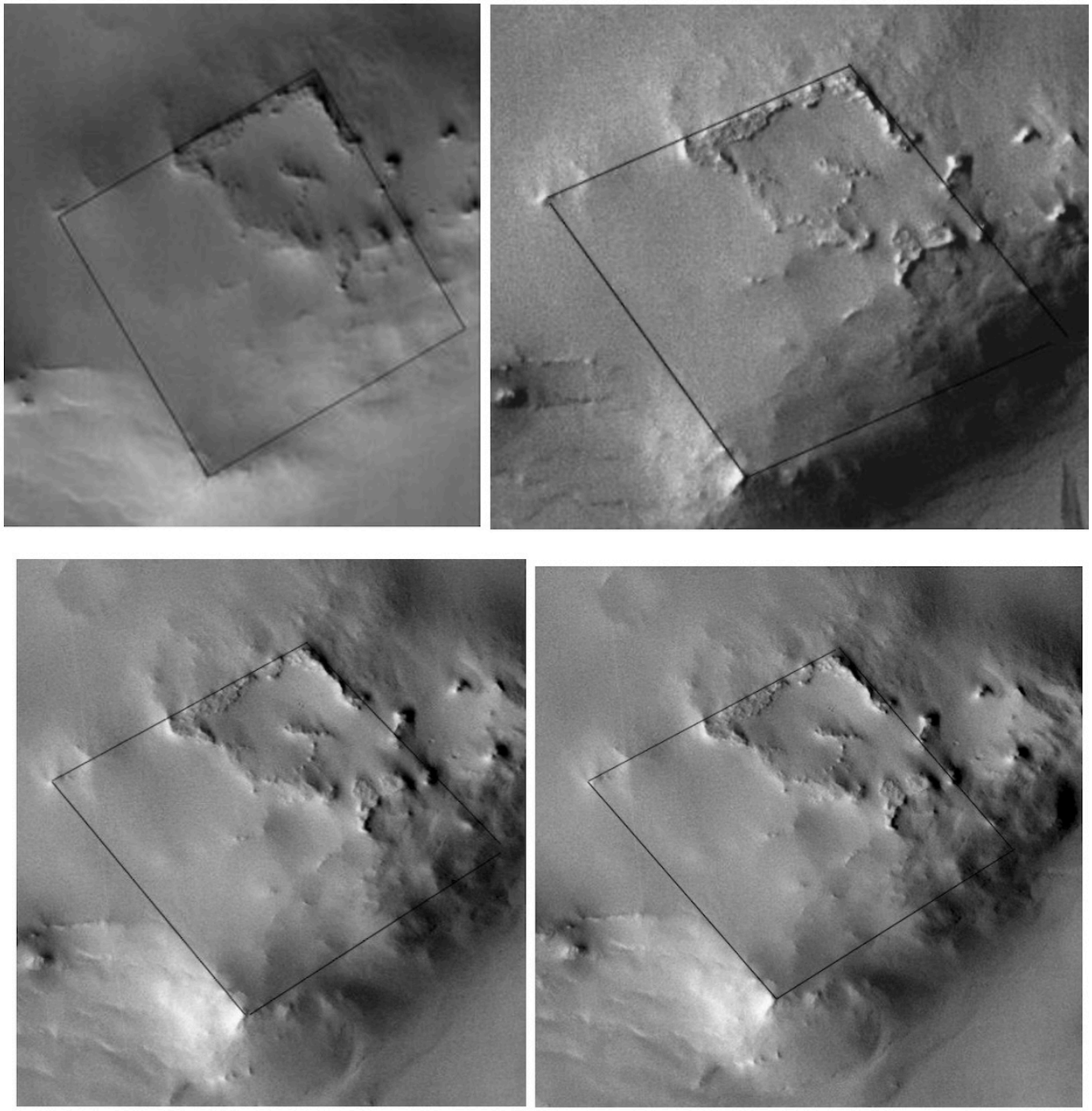

Figure 6 Square-shaped Structure. Top Left: Detail of MGS image E10/00462 (2001). Top Right: Detail of MRO HiRISE CTX P21_009232_2084_XN_28N332W (2008). Bottom Left: Detail of MRO HiRISE ESP_057534_2080 (2018). Bottom Right: Detail of MRO HiRISE CTX U06_073228_2083_XN_28N332W (2022). All images outlined by the first author.

Thirdly, even if we assume (for the sake of argument) that Mars does have faulting and other tectonic-like features that could account for the observed square-shaped structure (no matter how unlikely this may be), the square-shaped structure would not be expected to survive the major impact (or possibly a major plasma discharge) that formed the crater in which it is found, assuming the square-shaped structure formed first and the crater formed later.

Fourthly, and alternatively, if the crater formed prior to the square-shaped structure, then one would expect that the hypothetical fault lines would be much more extensive linearly than is observed in the photographs, intersecting and cutting across the rims of craters, including the major crater in which the square-shaped structure is found.

Fifthly, building on the previous comments and observations, if one hypothesizes that the square-shaped structure is some sort of fault-bounded feature, one would expect to find evidence of the faults extending beyond the wall-like features of the structure, yet such are not evident in the photographs. Thus, based on our observations of the square-shaped structure, we hypothesize that it is possibly not a natural feature comparable to a natural geological feature on Earth.

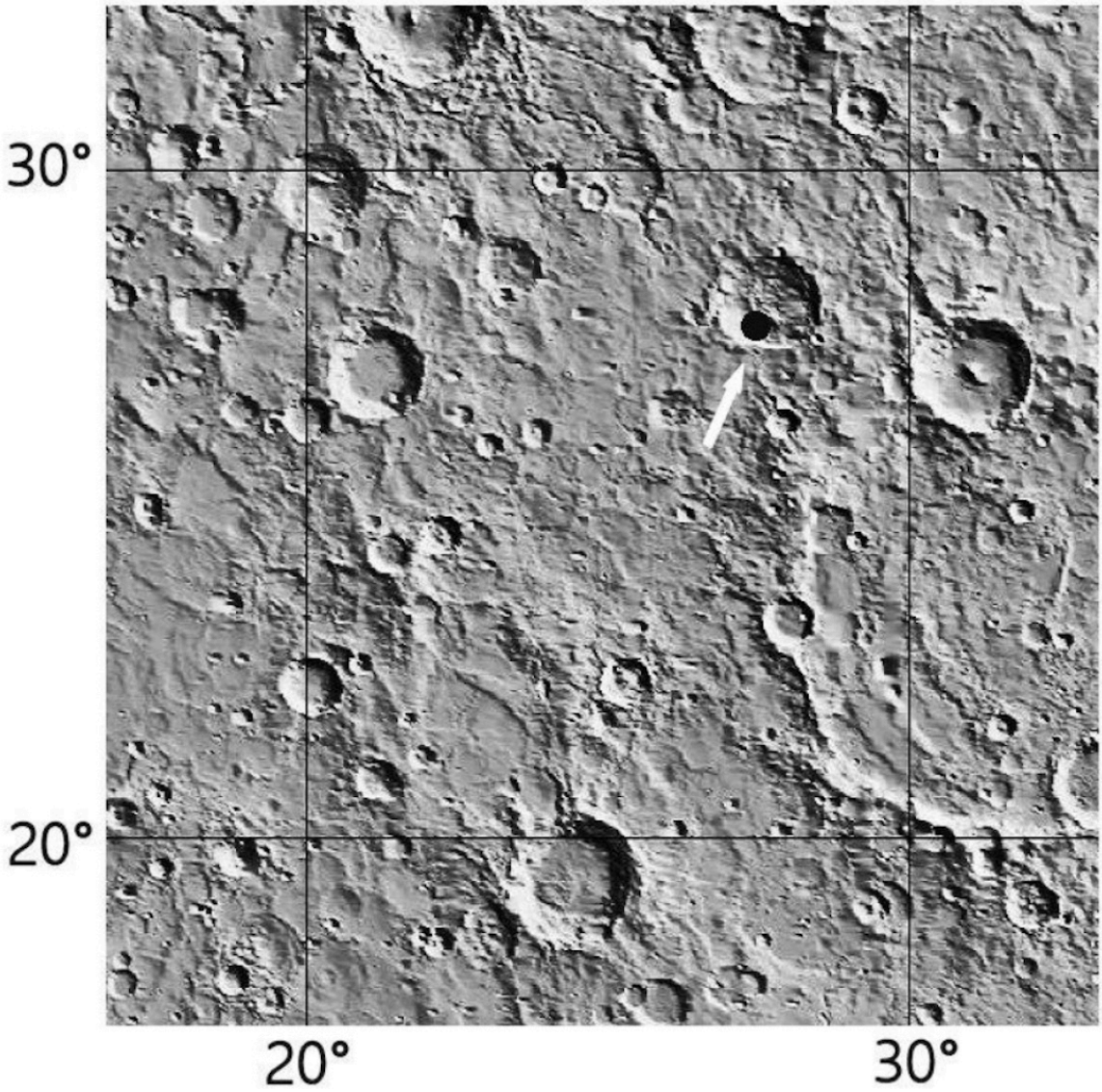

Figure 7 Arabia Terra region of Mars, showing location of Square-shaped structure. NASA Mola map. Notated by the first author.

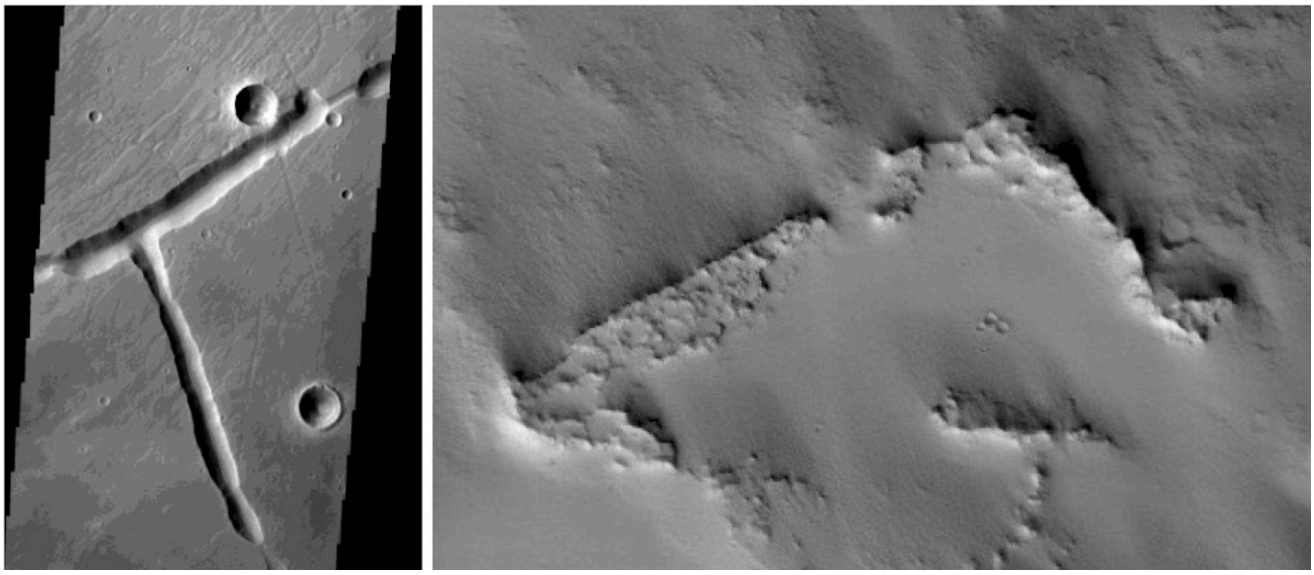

Figure 8 Right angle. Left: Detail of Mars Odyssey THEMIS image V44393002 (2011). Right: Detail of MRO HiRISE image ESP_057534_2080 (2018).

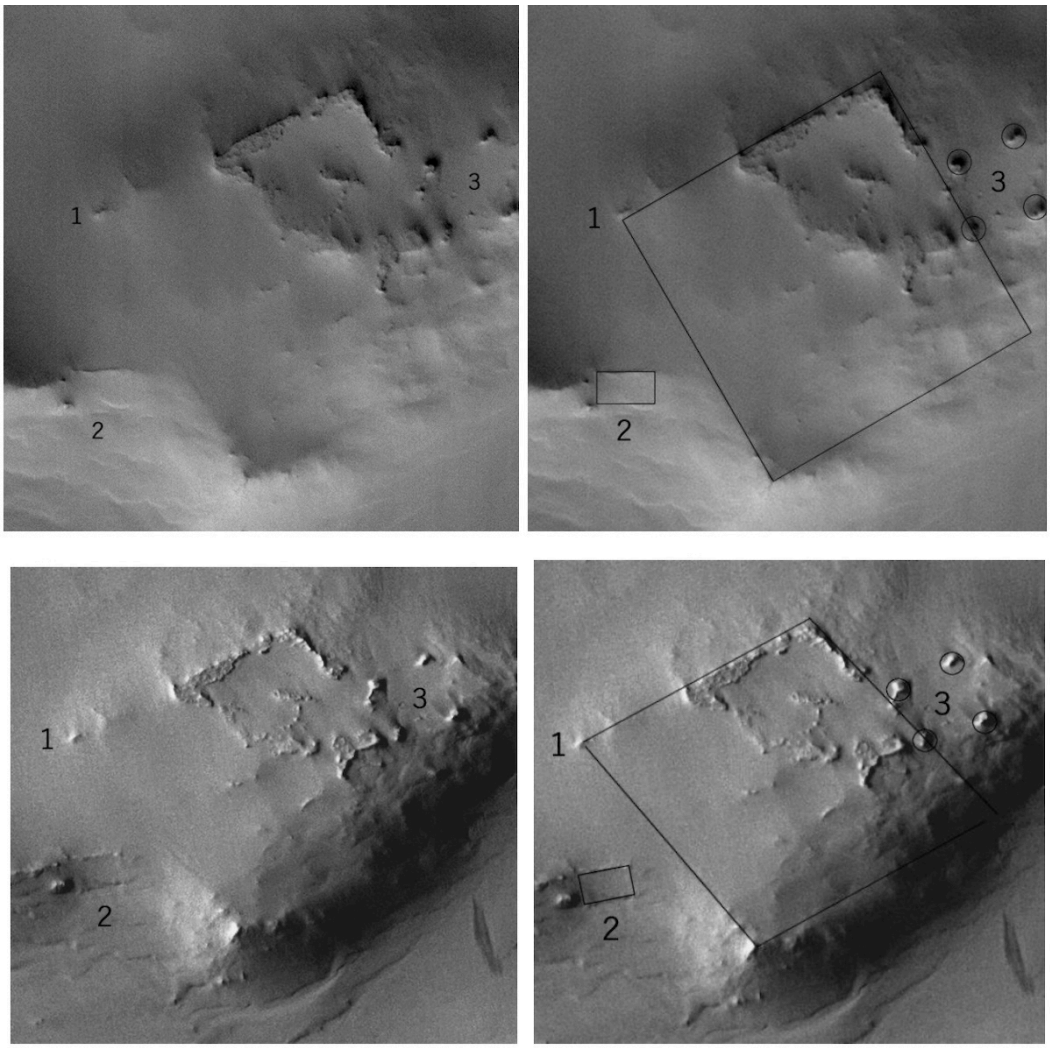

Figure 9 Three Quadrilateral Structures Top, left and right: Detail of MGS image E10/00462 (2001). Bottom, left and right: Detail of MRO HiRISE CTX P21_009232_2084_XN_28N332W (2008). Outline and notations 1, 2 and 3 by the first author.

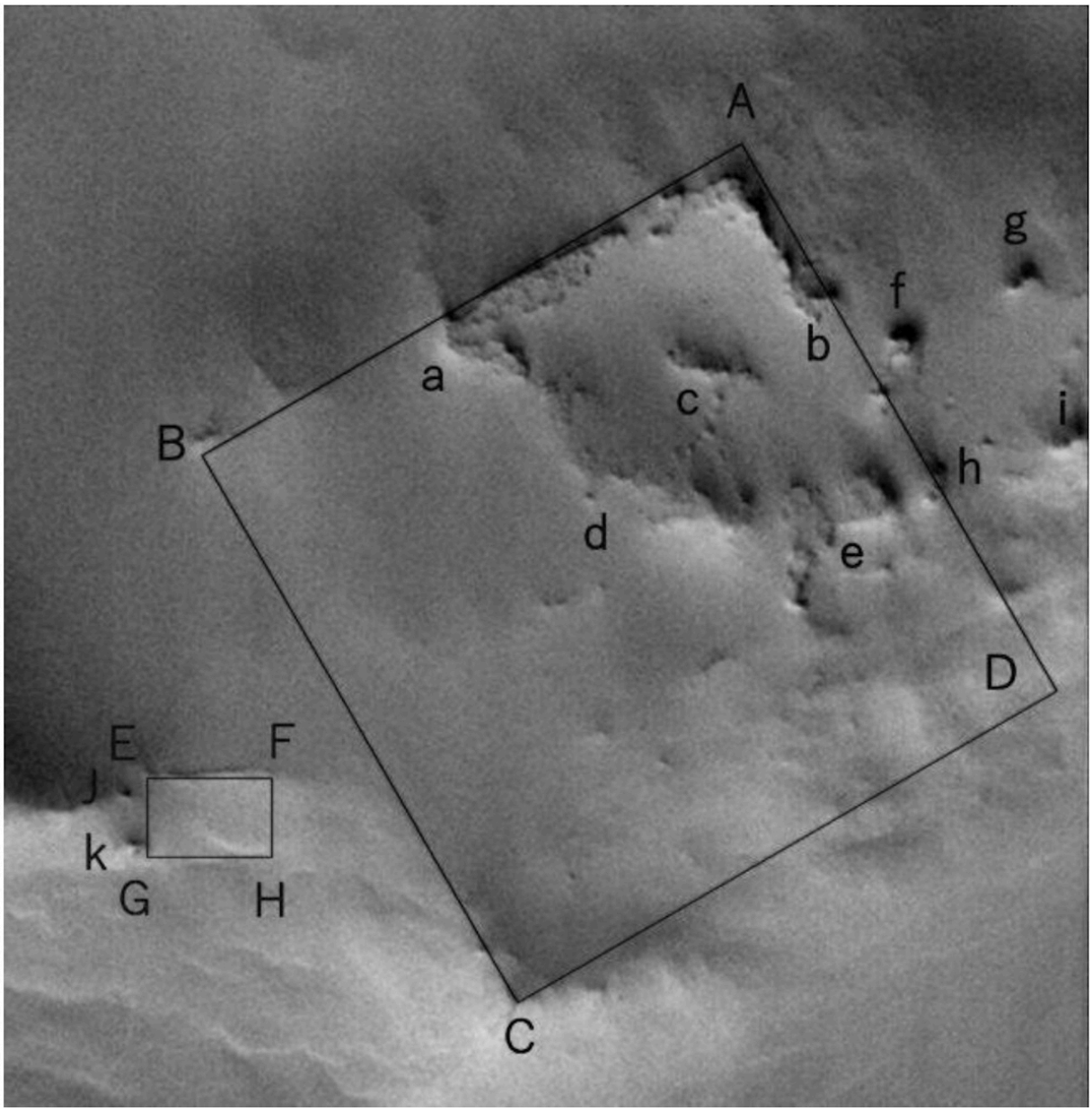

Figure 10 Three Quadrilateral Structures. Detail of MGS image E10/00462, outlined and notated by the first author.

6. Geometrical Analysis of Three Quadrilateral Structures

Utilizing the original 2001 MOC image E10/00462 and the 2008 MRO HiRISE CTX image P21_009232_2084_XN_28N332W as a reference (Figure 9), they provide the most accurate representations of the square-shaped structure and the topography surrounding its boundaries. The two images provide a templet to calibrate the positioning and orientation of the exposed, partial walls-like and foundation-like features as recorded in this set of MOC and MRO images showing this square-shaped structure and impression (Figure 9).

The area of study has three quadrilateral-shaped structures. The first is the large square-shaped structure that is the main focus of this study, labeled 1 in figure 9. The area also has a rectangular impression set within the ridgeline of the apparent “cliff”, labeled 2 in figure 9. The third structure is a cluster of four mounds set in a square configuration, labeled 3 in figure 9.

Beginning with the northern corner of the wall-like feature in the 2001 MOC image E10/00462 (Labeled **A** in figure 10), it forms a right angle with an elongated L-shape. The southwestern portion of the apparent wall extends down three quarters of the way from point **A** to point **a,** measuring approximately 2900 feet (884 meters) long. The southeastern portion of the wall extends a fourth of the way down from point **A** to point **b** measuring approximately 850 feet (259 meters) long. The western corner of the square structure is labeled **B** in figure 10. The corner is partially created by a short, linear wall that extends in a southwestern direction, without a defining angle. The northwestern wall measure approximately one mile (1.61 km) from point **A** to point **B**. The southern corner, labeled **C** in figure 10, forms a right angle within a notched pocket, which is set within the peak of a downward slope. The eastern corner, labeled **D** in figure 10, is undefined and only visible by the intersection of the projected linear sight lines created by the northern corner labeled **A** and the southern corner labeled **C**. The distance between the northwestern corner, labeled **B** and the southern corner, labeled **C** is just over one mile (1.61 km) in length. The internal distance from the northern corner labeled **A** to the southern corner labeled **C** is approximately 1.7 miles (2.7 km) long. The overall square shape of the structure is highlighted by the contrast between the tonality of its interior surface and the surrounding topography.

The northern interior of the square-shaped structure has exposed wall-like features labeled **c**, **d,** and **e** that appear as fragmented and truncated wall-like and foundation-like features of various shapes. The eastern side of the square-shaped structure has a set of four irregular shaped mounds that form a square pattern labeled **f**, **g**, **h**, and **i** in figure 10. The four mounds exhibit a common distance shared between their opposite corners. The distance between the two mounds labeled **f** and **g** is 1,425 feet (434 meters), while the distance between the two mounds labeled **h** and **i** is also 1,425 feet (434 meters). The distance between the two mounds labeled **f** and **h** is 1,735 feet (529 meters), while the distance between the two mounds labeled **g** and **I** is also 1,735 (529 meters).

Along the western ridge line there is a rectangular impression set within its cliff wall. Its rectangular shape is created by four dark linear groves cut into its surface. The rectangular imprint is denoted by four right angled corners labeled **E**, **F**, **G**, and **H**. The distance between the northwestern point, labeled **E** and the northeastern point, labeled **F** of the rectangular imprint is approximately 1343 feet (409 meters) in length, while the distance between the southwestern point, labeled **G** and the southeastern point, labeled **H** is also approximately 1343 feet (409 meters). The dark outline of the rectangular imprint may be the result of an exposed subterranean structure that has leached a liquid substance (possibly water?) around its borders. Notice the dark seeps flowing down the western ridge wall-like feature in the 2008 MRO CTX image (Figure 3) and again in the 2022 MRO CTX image (Figure 5). These dark outlines may be created by liquid flows caused by seasonal climate change. The 2008 MRO CTX image (Figure 3) was acquired in the summer while the 2022 MRO CTX image (Figure 5) was acquired in the spring.

There is also a set of two small circular mounds imbedded within the cliff wall on the western side of the rectangular imprint labeled **j** and **k** in figure 10, which are approximately 83 feet (25 meters) apart.

One of the most common techniques used by archaeologists to identify the remains of partially buried structures is to perform a careful ground survey. They begin by examining any raised surface features such as linear mounds, aligned stones, and walled foundations, or any changes in soil color and composition. Finding a square or rectangular surface feature could indicate the presence of a partially buried structure (Smiti, 2024). The discovery of a pair of quadrilateral structures within a restricted area of any given location could be regarded as a coincidence. but finding a set of three quadrilateral structures in the same restricted area could be described as probable intentional pattern.

7. Martian Comparison of the Square-Shaped Structure

Located in the central region of Cydonia, far below the famous "Face", is a square-shaped impression set within a topography of small rocks and large boulders. The structure was first observed in a Mars Odyssey THEMIS image by a member of the Society for Planetary SETI Research, Dr. Mark Carlotto (Figure 11). The THEMIS image 101024002 was acquired in the spring of 2002 during the evening with a resolution of 99 meters per pixel (Mars Viewer, THEMIS, 2002).

Carlotto noted a square-shaped impression set within an area that resembled what he called "rubble" that covers about 1000 sq. km (Carlotto, Mark J. Ph. D (2002). The square-shaped impression set within the rubble appears to conform to an organized pattern. The orientation of the square-shaped impression is offset with opposite corners of the square and aligned in a north to south direction. In figure 11 the shape of the square impression is highlighted by an outline. Notice the THEMIS image reveals a very crisp linear impression that appears to have the remains of a very distinct square shape.

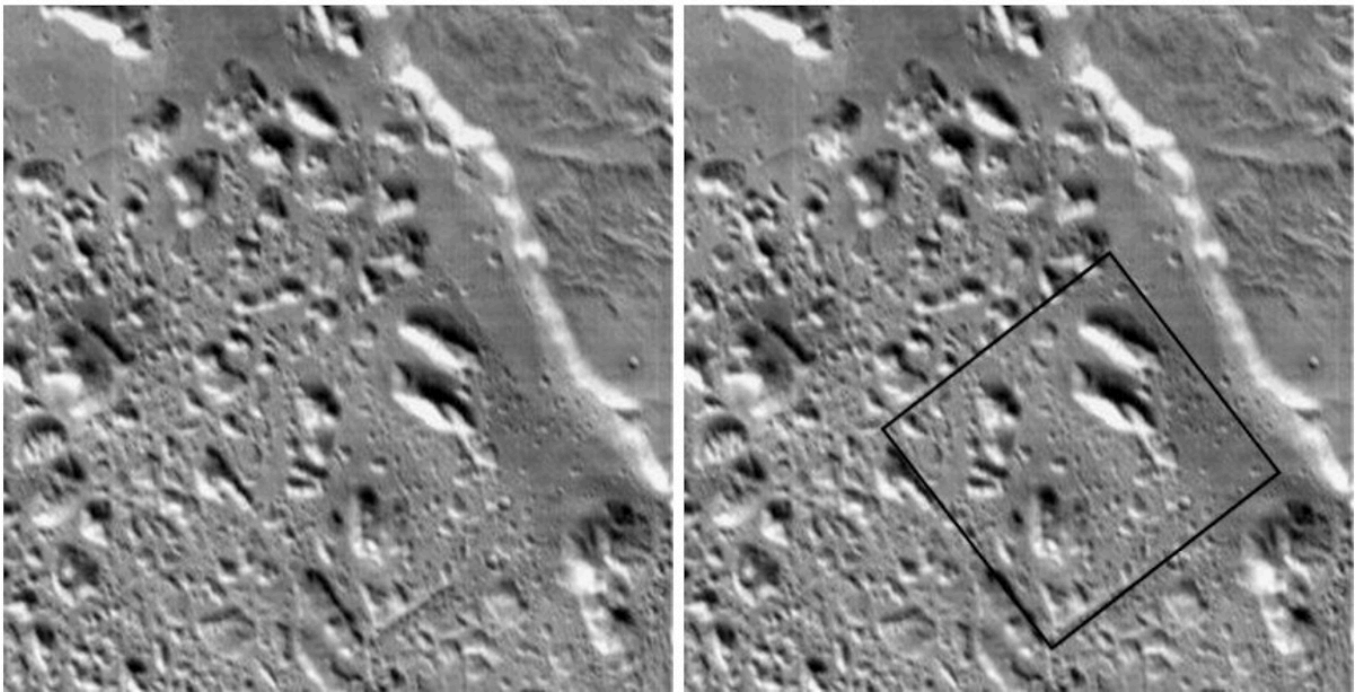

Figure 11 Square impression, Cydonia Mars. Left: Detail of Mars Odyssey THEMIS 101024002 2002. Right: Outlined by the first author.

8. Terrestrial Comparison of the Square-Shaped Structure

There are the partial remains of a square-shaped earthen mound structure located in Montgomery County, Ohio (Figure 12). The structure is composed of seven surviving linear mounds that create a square that covers thirty-one acres, while one of the eastern sides is missing (Squier & Davis, 1848). Similar to the uneven boundaries of the square-shaped structure observed within the crater on Mars, the foundational walls of the earthen mound in Ohio are also incomplete and are aligned in a north to south direction.

Inspired by the legend of the lost "White City" mentioned by conquistador Hernando Cortes in a 1526 letter sent to King Charles V of Spain (Cortes, 1868), in 2009 Ramesh L. Shrestha and William E. Carter of the University of Houston and a field team from the National Science Foundation (NSF) and the National Center for Airborne Laser Mapping (NCALM) utilized laser mapping technology to chart the

forest floor of Mosquitia in Belize. Over the course of a week, the team flew over a 60 square mile (155 square km) area of the remote forest of Honduras shooting billions of laser pulses at the ground to create a 3D digital map of the topology beneath the jungle canopy. The LiDAR data captured evidence of architectural ruins that include a city plaza dotted with pyramids and agricultural terraces (Figure 13) that were covered in dense rainforest (Tolley, 2012). The plaza measures approximately 410 feet (125 meters) on each side (Carter & Fisher, 2012). As a comparison the base of the Great Pyramid at Giza in Egypt measures approximately 756 feet (230 meters) on each side (Lehner & Hawass, 2017).

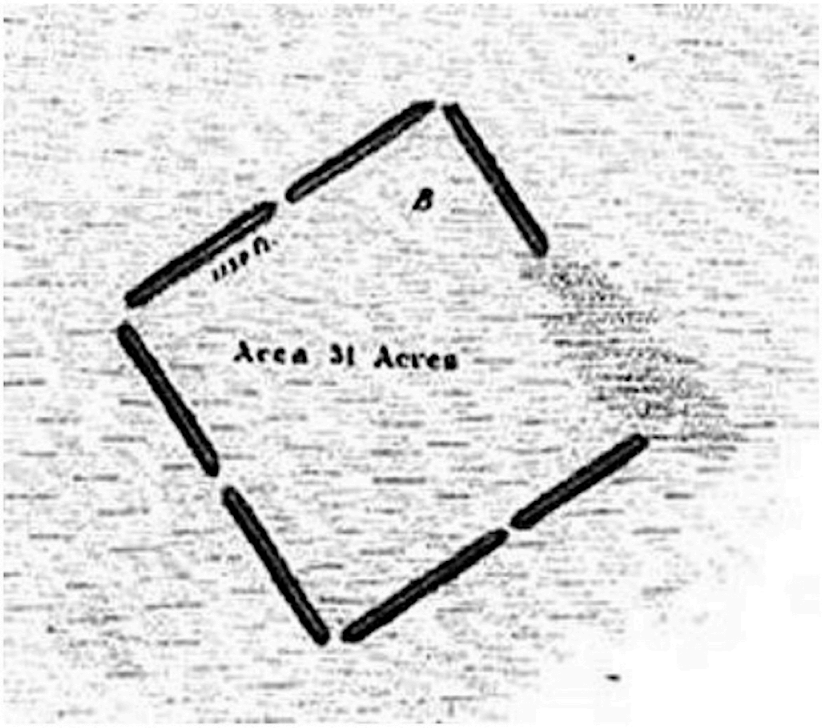

Figure 12 Square-shaped mound. Montgomery County, Ohio. Detail of Plate XXIX, No.1, Squier & Davis (1848).

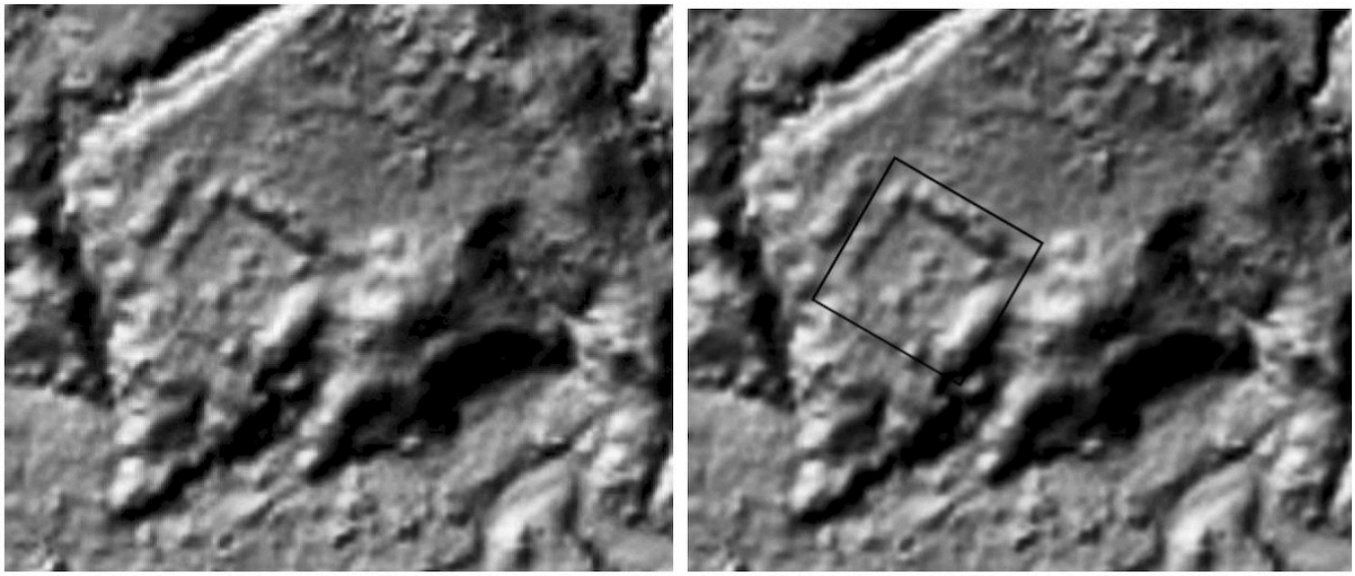

Figure 13 White City square structure. River valley in Caracol, Belize. LiDAR. Left: Detail of LiDAR shaded elevation map. Right: Outlined by the first author.

The researchers consider the most significant structure revealed by the LiDAR imaging to be a square-shaped impression resting above a ridge line (Figure 13). As observed with the north-south orientation of the square-shaped structure on Mars and the square-shaped mound in Ohio, the square-shaped structure discovered in Belize is also offset with opposite corners aligned in a north south direction.

William Carter, research professor in the Department of Civil and Environmental Engineering at the University of Houston (American Scientists, 2025), believes the LiDAR data reveals the first indications of what appears to be man-made structures in the natural topography. Seeing the straight lines and right angles of the impression, Carter said "I'm the only person right now on the planet that knows that there's these ruins" (Daily Mail Reporter, 2012). Archeologist Christopher Fisher and Stephen Leisz of Colorado State University, in Fort Collins, have taken part in the Honduras project and are part of a group of archeologists who have extensively studied LiDAR images. Leisz says "We use LiDAR to pinpoint where human structures are by looking for linear shapes and rectangles. . . . Nature doesn't work in straight lines" (American Geophysical Union Reporter, 2013). When questioned about the possibility of finding structures on the planet Mars, Carl Sagan remarked, "The first indication of intelligent life on Earth lies in the geometric regularity of its constructions" (Sagan, 1985). It would be interesting to hear what Sagan and Leisz would have to say about the straight lines of a square appearing on Mars.

Positioning a fortress on the top of a cliff and near its edge provides a great defensive posture and the ability to view the lower terrain for advancing threats. This idea is expressed in the construction of the ancient fortification of Masada, in southern Israel, situated on top of an isolated rock plateau (Figure 14). Built as mountain fortification during the first century BCE, it is located about 1300 feet (400 meters) above the eastern edge of the Judean Desert overlooking the Dead Sea (Yadin, 1966). Notice the southern corner of the fortification rests on the edge of the cliff face.

Figure 14 Masada, Israel. 1st century BCE. Image source Google Play.

9. Cultural Reference

In 1790 the United States Congress passed the Residence Act that approved the creation of a federal district for the nation's capital along the Potomac River (Figure 15). The exact location of the federal district was to occupy land donated by the states of Maryland and Virginia and would take on the initial diamond shape of a square measuring 10 miles (16.1 km) on each side, totaling 100 square miles (259 square km) (Crew et al., 1892). In 1862 a detailed map of the area was produced by Arnold, E. G (Library of Congress, 1862). Referred to as the District of Columbia, notice its square-shaped boundaries are positioned with two of its opposing corners aligned in a north-south orientation. As below, so above.

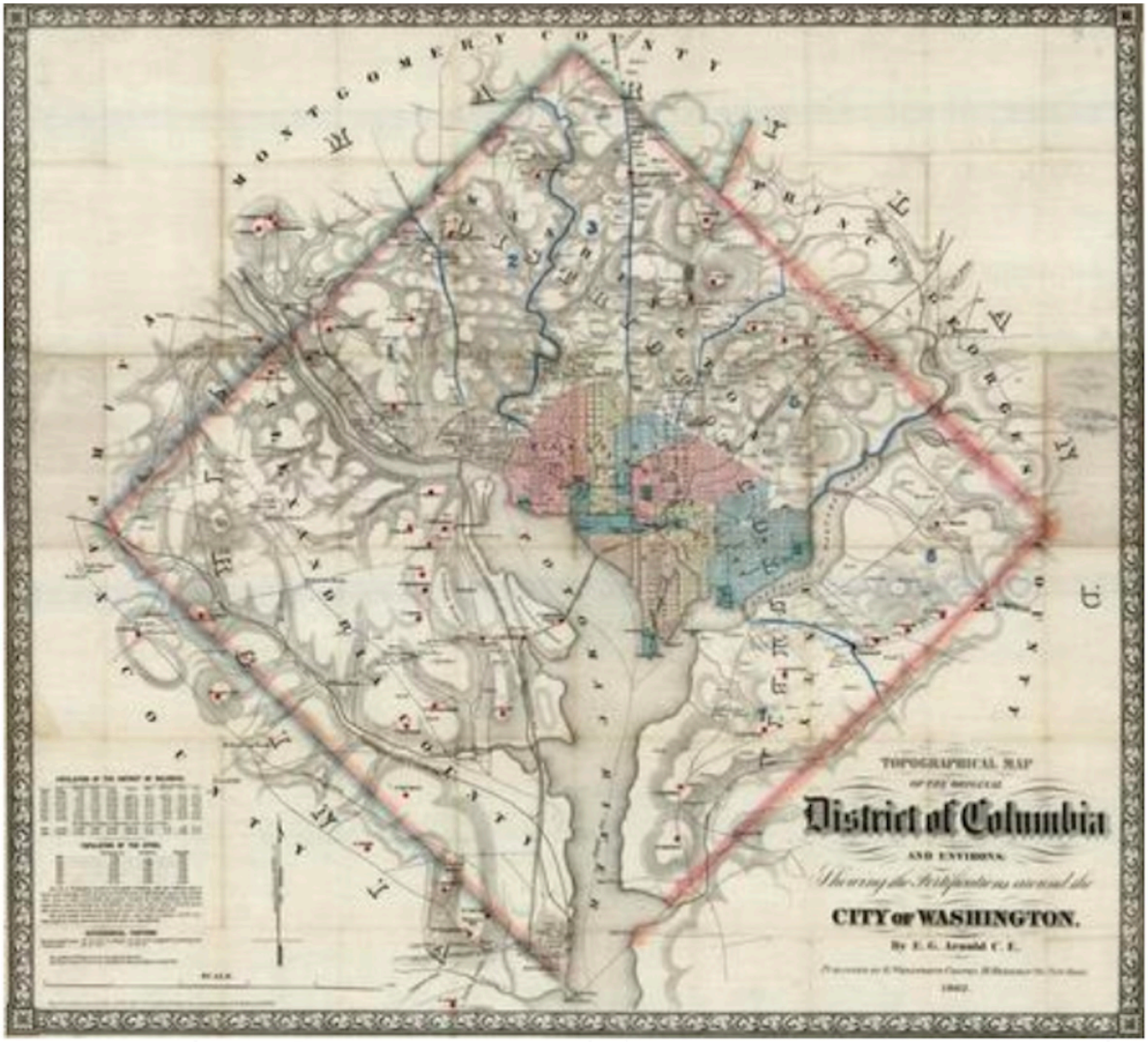

Figure 15 The District of Columbia, Washington D.C., Arnold, E. G. (1862). Image source: Library of Congress, Geography and Map Division. Notice the square-shaped boundaries.

10. Conclusion and Recommendations

The segmented linear wall-like features forming the square-shaped structure within the Arabia Terra region of Mars are consistently depicted in four images taken by two different NASA spacecraft during four different seasons and times of day over a twenty-one-year period. The geometric design of this square structure is highly symmetrical despite the actions of natural depositional and erosional agents. As there are no known geological mechanisms that are capable of creating a square form of linear wall-like features with individual right angles inside a crater, we may tentatively hypothesize that this structure could be some form of a large-scale artifact; that is, it was artificially created. In his 2021 paper *Evidence Of Alien Activity on Mars*, Dr. Steven Maxwell Beresford suggested that this square-shaped structure "appears to be the ruins of an ancient walled settlement built by intelligent beings" and "The square contains smaller features that also appear to be ruins" (Beresford, 2021). In January 2025, the square-shaped structure came to the attention of Elon Musk on his X social media platform, and he suggested that, "We should send astronauts to Mars to investigate" (Anderson, 2025).

In a paper published in the Journal of Astrophysics and Aerospace Technology it has been argued that NASA has already found evidence of past life on Mars. Their paper compiles a set of NASA photographs, provided by the Rover Curiosity, showing examples of what resembled partially buried humanoid bones, skulls and even an entire body within the Gale Crater on Mars (Joseph, et al, 2023).

Considering the historic study of potential life and artificial structures on Mars, beginning with the positive results for microbial life recorded by the Viking mission's *Labeled Release Experiment* (Levin, Gilbert V. et, al. 2016) and the discovery of a five sided D&M Pyramid found at Cydonia (Carlotto, Mark, 2002) and the wedge and dome, Keyhole Structure, observed in Libya Montes (Haas, George J. et al. 2016), this square-shaped structure provides additional support for a broader investigation by independent planetary scientists.

We conclude that the geological mechanisms that would be needed to produce a square-shaped structure within the Arabia Terra region would be highly unusual and exhibit a level of geometry and symmetry that is unequaled within currently known Martian aerography. We recommend that both NASA and the imaging team at the University of Arizona direct the current MRO spacecraft to acquire addition images of this anomalous surface feature. New high-resolution images could be acquired at different seasons and times of day under various sun angles for further analysis. The survey could also greatly benefit from subsurface sensing with ground penetrating radar to acquire structural mapping of the area. If this square-shaped structure is found to be consistent in geometric design, we would encourage the pursuit of "ground truth" and recommend this site as a prime candidate for the study of potential archaeological artifacts on Mars.

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