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Mars landing site choices and unusual surface features

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Abstract

Until now Mars probes have been controlled by onboard software and radio communication with Earth. The main focus of interest has been the geological character of the planet. The next step may be landing a human crew, whose observations will go beyond questions of geology. Observers on the ground will seek to determine whether life in any form exists on the planet today, or has existed in the past. Of primary importance would be the selection of landing areas optimizing this goal. Such areas would certainly be those bearing an indication of water or a past shoreline. Here we consider the value of selecting such an area which is also the site of surface features of particular interest, in conjunction with which past or present signs of living organisms would lend significant extra interest.

INTRODUCTION

Mars as we know it today appears inhospitable to life. Recent discoveries in the biological sciences, however, suggest that living organisms are capable of surviving in extreme conditions. We cannot therefore rule out the possibility that some form of organic life has existed on Mars and may exist even in the conditions there today. In terms of a search for evidence of past or present life forms by a human mission to Mars there are a number of intriguing candidates for a landing site and base camp. Such sites would include proximity to a possible former shoreline or former river flow, or even to water, most likely in the form of ice, which exists at the poles and also may exist within the confines of some craters (see below)[1]. There have also been signs of possible water spouts or geysers on Mars[2].

Figure 1 gives the approximate location of putative shoreline based on Mars MOLA data and interpretation of Martian surface features. Digital elevation models (DEM) were processed in geographic information systems (GIS) to create contour elevation vectors used as the approximate shoreline. The center of this image is approximately 40.3° North Latitude, 9.7° West Longitude.

In Figure 2, an April 1998 MGS photo shows a possible location of water-ice in a crater in the Cydonia area of Mars. Note the high albedo of the floor surface and the apparent reflection of the floor surface on the crater wall. The crater identified in Figure 2 contains a floor which appears to be composed of different material than the crater walls. Upon closer inspection it was disclosed that the crater floor had a different and higher albedo than the walls of the cra-

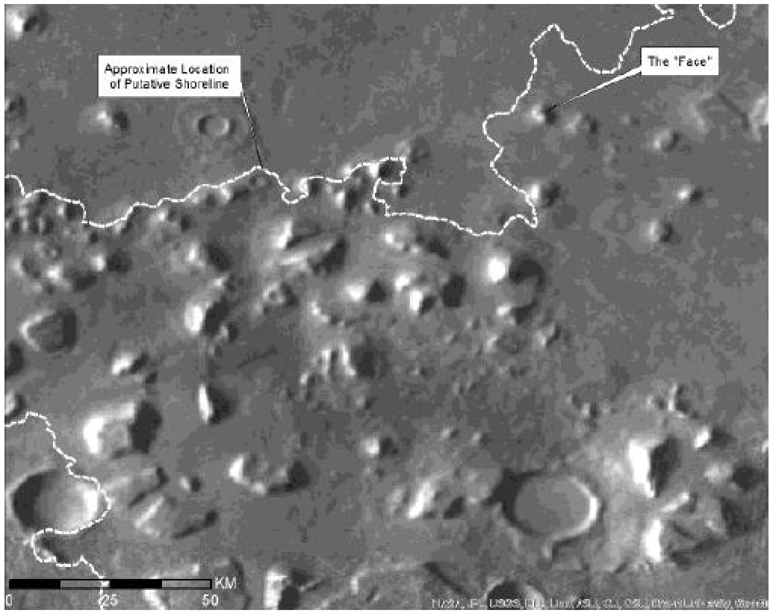


Figure 1 : Approximate location of shoreline

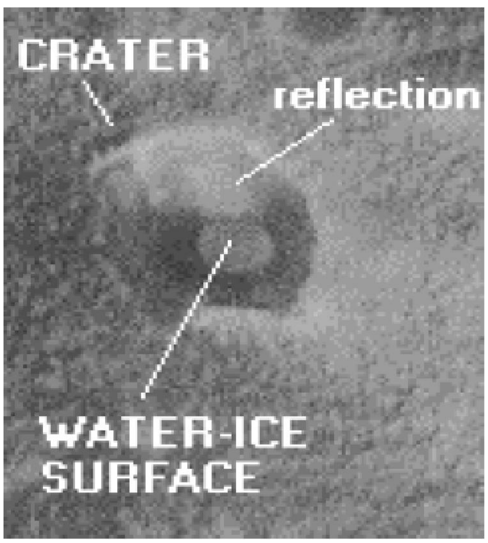


Figure 2 : Water Ice crater

ter and the surface of the surrounding plain. It was also noted that there was a patch of high albedo material on one portion of the crater wall. This high albedo "patch" was determined to be a possible reflection of ambient light reflected from the crater floor. The floor of the crater was determined to be a different material, based on the albedo and the surface texture. The albedo of the floor material is quite high as compared to the crater walls and surface materials. The crater floor also was found to have a very smooth surface and formed a distinct boundary where the floor met the crater wall. The coordinates of the Ice Crater are: 40.9 degrees north latitude, 9.9 degrees west longitude.

In addition to such parameters as those listed above, we here consider one further factor that may lend special interest to any particular candidate for a landing site. If, on the surface of a planet, there were signs of former intelligent habitation or a visit to the planet of intelligent beings, this plus such things as former shorelines or evidence of extant water would lend additional impetus to the selection of such a site.

Consideration of this possibility lies within the purview of Planetary SETI or pSETI, the search for signs of past or present intelligent life by observations undertaken on the surface of a planet in contrast to a remote search for extraterrestrial intelligence as carried out by listening for signals from distant stars (SETI). Although the focus on the search for extraterrestrial intelligence has been almost exclusively in terms of SETI, today pSETI investigation is increasingly arguable as a subject for scientific study. There have been recent suggestions by scientists that in addition to monitoring for radio signals SETI should consider the possibility that unmanned robotic probes, sent from distant star systems, might be present (or might have been present) within the solar system[3]. The surface of a planet such as Mars, or the surface of the Moon, should have an equal claim on our attention in this respect. If there were in advance some surface formations identified that might be worthy of ground investigation by human explorers seeking to determine their possible artificiality (or even their status as geologically anomalous), and if such formations were located in close proximity to the other features, such as a former shoreline, etc., this would change the situation with respect to a desirable landing site.

Making such a determination in advance by using evidence supplied by robotic rovers and orbiting cameras requires the development of a consistent and careful methodology for evaluation of data in terms not of strictly geological considerations but of such things as cultural, aesthetic and mathematical characteristics, since such characteristics are among those we find among examples on our own planet. We do not speak here of fantastic claims made in popular media, based on flawed methods of analysis aided by overactive imagination, but of subjecting any indications of intelligent intervention on a planetary surface to rigorous methodology.

Are there, then, any features on Mars that under a more careful methodology are sufficiently anomalous as far as natural origin is concerned, that they may serve as a magnet for the choice of a landing site for a future mission to Mars? What naturally comes to mind is the feature known (and most often ridiculed) as the "Face on Mars." We do not here propose to argue in favor of this highly controversial object as particularly relevant to our discussion. It will suffice to mention that despite the onslaught of ridicule directed toward the "Face" there have as a matter of fact been careful analyses carried out which, in our opinion, renders the question of its possible artificiality still an open question. On its own, however, the formation is insufficient at this juncture to add to any argument for selecting its location as a possible landing site. But there is a more likely feature which, by coincidence or not, lies in the vicinity of the "Face." This feature is the peculiar pattern found in a group of nearby objects that have been termed "mounds." We turn our attention to these objects and the methodology used for their evaluation

GEOMETRY OF THE PENTAD OF MOUNDS

Figure 3 is from the 1976 Viking Satellite (image number 35A72) and shows the classic early morning image of the so called "Face on Mars" (upper right). On the

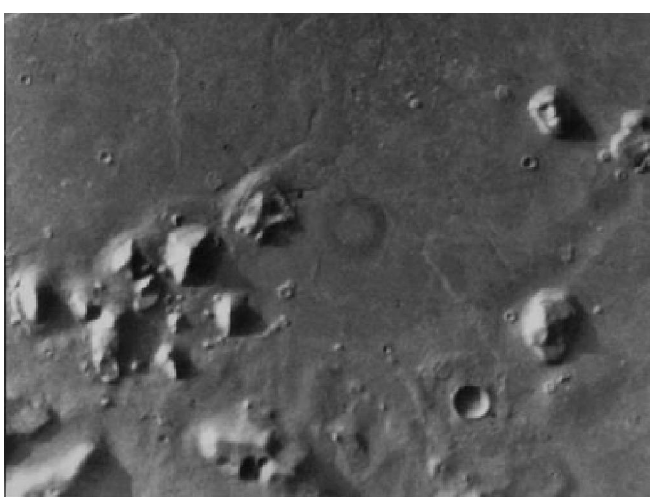


Figure 3 : A portion of viking frame 35A72

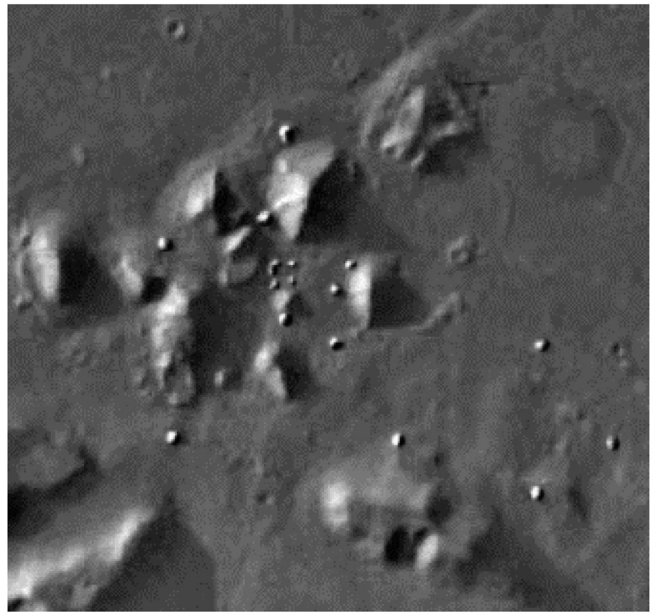


Figure 4 : Highlighted mounds from viking frame 35A72

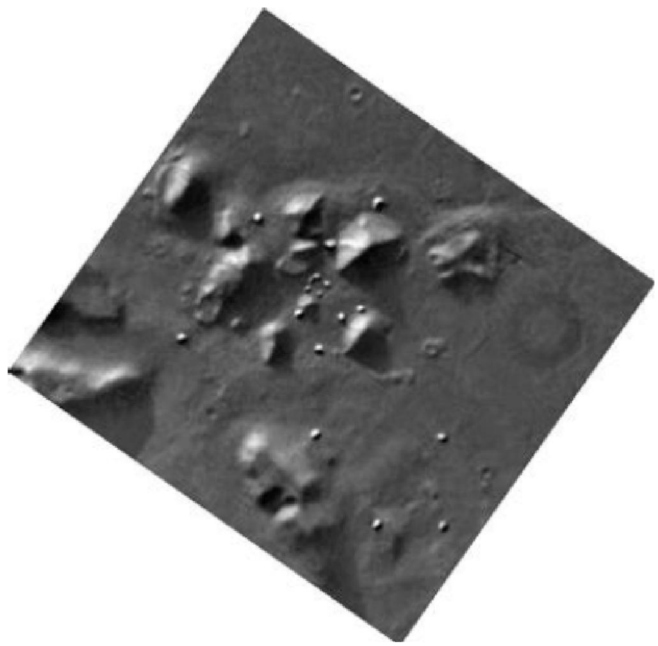


Figure 5 : Rotated version of Figure 4

left side of the image are a number of other surface features of roughly the same size as the Face. However, the objects discussed in this paper are the much smaller mound like features, about 1 to 3 acres in size, and scattered about in the bottom left quarter of the image. Beyond their common size and relative isolation, they display a high degree of reflectivity. In this image, most of them cast shadows that come to a point. Unlike the Face and other anthropomorphic features, the interest these objects generate is not the objects themselves but rather their angular placements relative to one another.

For clarity, we highlight the 12 mound-like features of interest in Figure 4. The surrounding terrain is relatively free of candidates classifiable as mounds of that size. Thus, they were not preselected from a field of many. Some that look similar are not included. (The electronic form of Reference 4 is at the SPSR site http://spsr.utsi.edu/ and describes the mound selection criteria and statistical aspects in more detail.)

We focus on the angular placements of these features[5,7]. So for further clarity, the image is rotated so that in Figure 5 the bottom two mounds are positioned horizontally. Of the twelve, we focus on the five that are most isolated from the larger land masses. The five-mound region is magnified and the mounds are designated in Figure 6 by the letters GEDBA. The 4 right angles (GEA, EAB, GAD, and ABD) in the relative placements of the mounds are self-evident.

In the table below we provide the raw position data given in terms of pixels from an orthorectified version of this figure, one for which the image correctly represents angular placements. (Note that these measurements do not take into account the fact that these mounds may be at different elevations on the surface.) Beneath each mound letter are the x and y coordinates (accurate within one pixel and relative to some arbitrary origin) of the center of the mound and the x and y extensions of the roughly rectangular boundaries of the mound. The angles measurements quoted below were obtained from the mound coordinates. Each pixel represents about 47 meters. This table together with MGS coordinates of 40.83° N, 9.88° W of the mound labeled G, will allow each of the mounds to be precisely located on the Martian surface.

The angle measurements are 88.7° ± 3.9, 35.0° ± 1.9, and 56.3° ± 2.8 degrees for the triangle GEA and 90.0° ± 3.9, 34.8° ± 1.5, and 55.2° ± 2.4 degrees for triangle EAB. We see that within measurement errors that these two triangles (Figure 7) are not only similar but congruent right triangles.

Triangles GAD and ABD (Figure 8) are also right triangles with measured angles of 88.2° ± 2.7, 36.6° ± 1.7, 55.2° ± 2.4 and 90.9° ± 5.4, 36.5° ± 2.2, and 52.6° ± 3.3 degrees respectively. Within measurement errors, these triangles are therefore not only are similar to each other but to the previous two right triangles. Altogether, there are four similar right triangles among this isolated group of just five mounds.

Mound G	Mound A	Mound D	Mound E	Mound B
327	326	252	278	277
-305	-407	-404	-337	-441
4	3	4.5	5	3.5
4	5	3.5	3.5	4

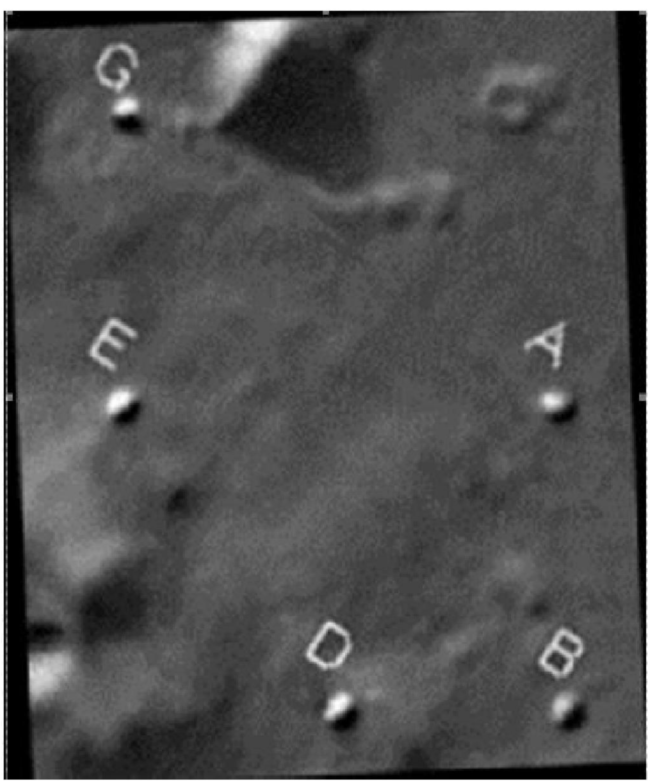


Figure 6 : Closeup of pentad of mounds displaying four right angles

In addition, as seen in Figure 9, there is a related isosceles triangle ADE with angles of, 55.6° ± 2.9, 53.2° ± 2.7, and 71.1° ± 3.2 degrees. The angles and size of this triangle, again within measurement errors, show not only that it is isosceles but two triangles of the size of the small right triangle ABD would fit tightly within its boundaries.

The above measurements were made separately for each triangle with the vertices at the respective centers of each of the three mounds. Now consider what we call a "coordinated fit". In this fit, one uses the same fit point in each mound for all triangles that have one of their vertices in that mound. By varying those 5 common fit points, it is possible to have the vertices in such a position that the four right triangles mentioned above are similar or congruent to a high degree of precision (less than 0.2 degrees). Right triangles have angles: 90, 45 + t/2, 45 - t/2. Analytic geometry shows that this precise coordinated fit to 4 similar right triangles is possible only for t = arcsine (1/3) radians, or about 19.5 degrees. This is an example of what could be called the self-replication property for this t value[4-5]. That is, for this special value the

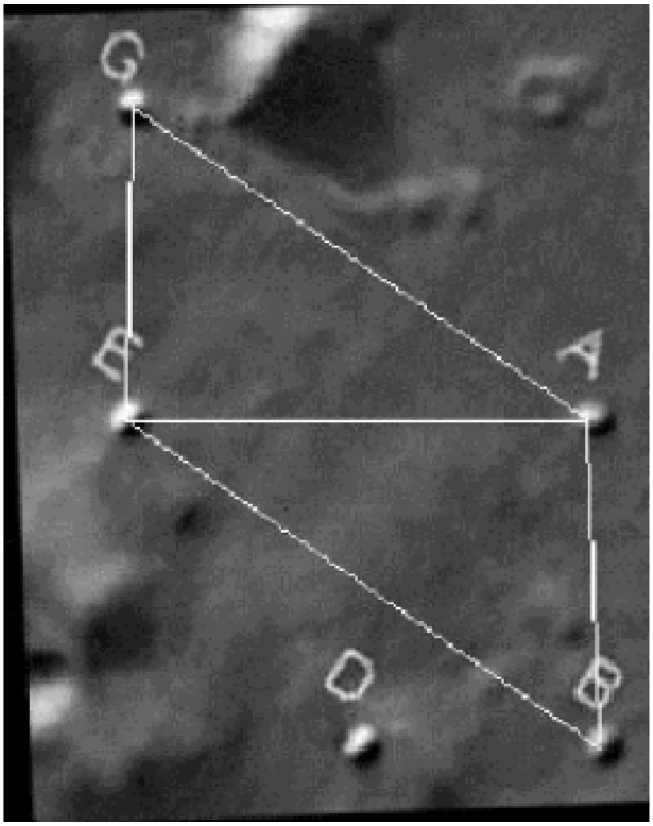


Figure 7 : Two congruent right triangles

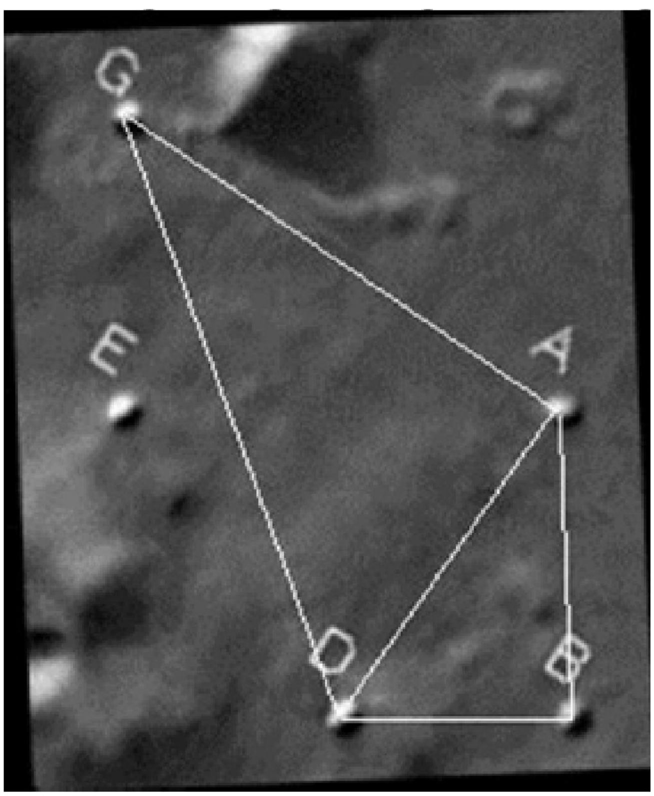


Figure 8 : Two further similar right triangles

number of appearances of these triangles is a maximum. For other values of t, a coordinated fit shows that not only can these not be all right triangles, but they cannot be all similar. Furthermore, for this unique

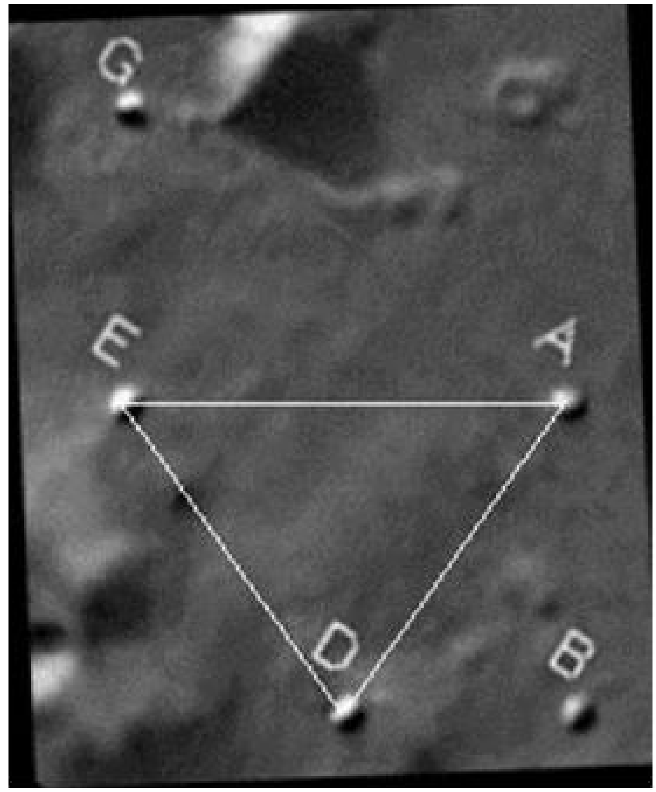
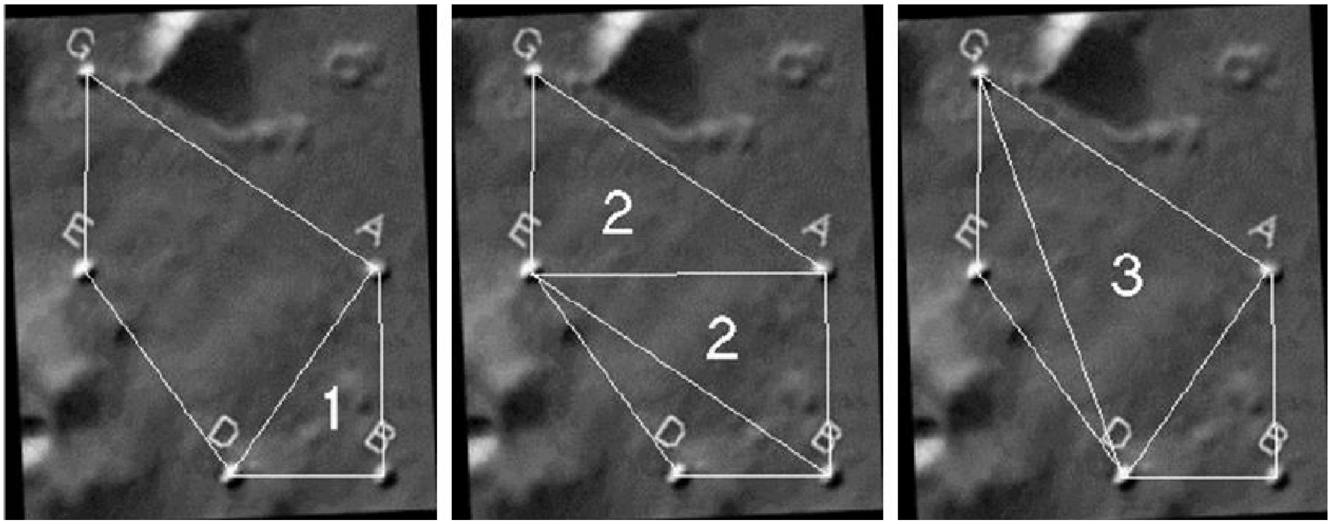


Figure 9 : Related isosceles triangle

t value, triangle ADE is precisely isosceles with angles of 45 + t/2, 45 + t/2, and 90 – t and two copies of ABD would fit precisely within its boundaries. One can also show[4-5] that the ideal geometry corresponding to t = 19.5 degrees are (within measurement errors) at the centers of the five mounds.

A curious property of this pentad of mounds is that the three different sizes of the four similar right triangles are ordered by the first three (prime) numbers. As indicated in Figure 10a, we take the area of the (ABD) to be 1 unit of area. Then the area of each of the two congruent middle sized ones (GEA and EAB) is 2 units (see Figure 10b) and that of the large one (GAD) is 3 units.

The sizes of these three similar right triangles correspond to the first three prime numbers. It is also intriguing, as seen in Figure 11, the next prime number 5 appears (in a self-referent way) as the area of the entire five-sided pentad. As a result, the pentad of mounds displays the concept of area, with a correspondence to the first 4 prime numbers. Stepping down one dimension from areas to lengths, one finds that paralleling the basic 1,2,3 sequence of areas is the same sequence of lengths of pertinent sides of the triangles relative to one another. Let us take the shortest side (BD) of the smallest triangle (ABD) to be 1. Then, with our ideal geometry, (again well within the estimated measurement errors) the middle side (EA) of the middle sized triangle (GEA) is 2, and the longest



Figures 10a, 10b, 10c : The 1,2,3 sequence of areas of similar right triangles

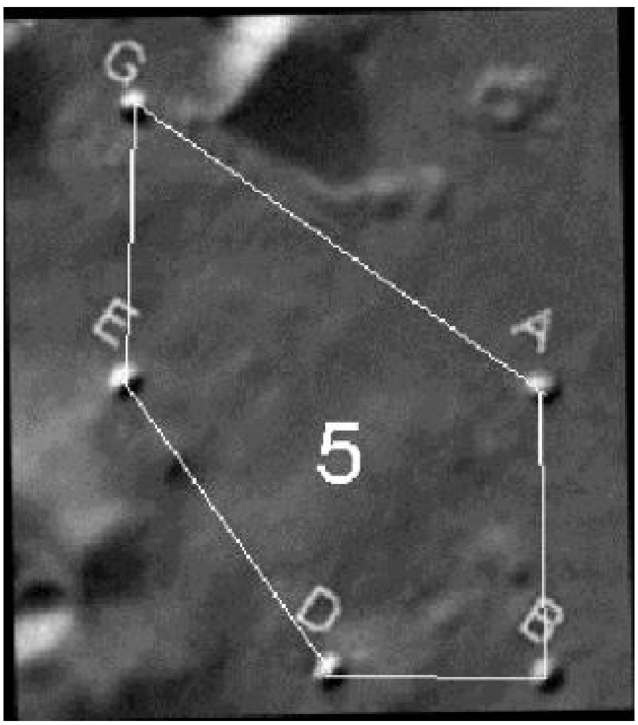


Figure 11 : Area of 5 units for the pentad

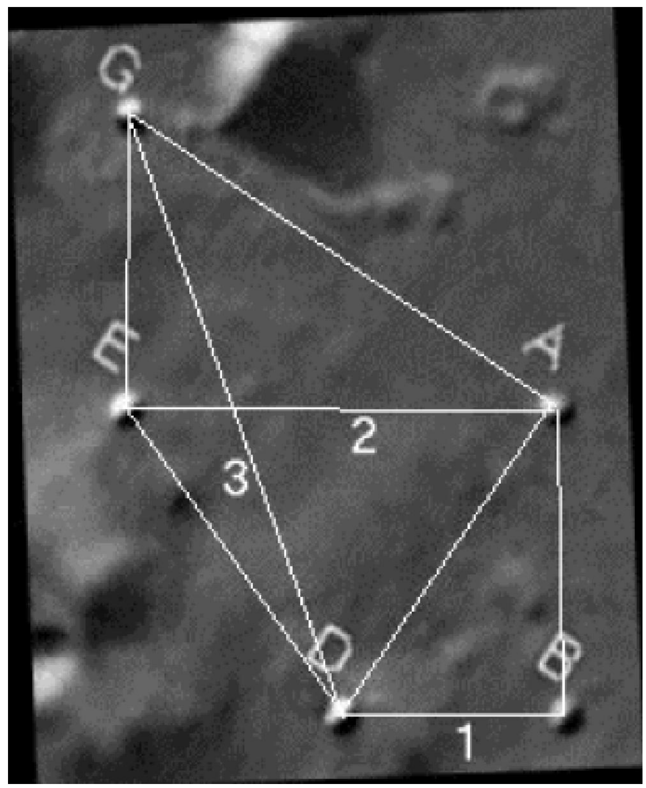


Figure 12 : The 1,2,3 sequence of lengths similar right triangle sides

side (GD) of the largest triangle (GAD) is 3. As Figure 12 emphasizes, in sequence of size (triangles ABD, GEA and GAD), the three basic aspects of the sides of a right triangle: opposite and adjacent to the smaller acute angle, and hypotenuse, are ordered 1,2,3 sequentially with their side lengths (opposite of ABD, adjacent of GEA, and hypotenuse of GAD). This 1,2,3 sequence is repeated a third time in the ratios of the sides of each similar right triangle of $\sqrt{1}$,$\sqrt{2}$,$\sqrt{3}$. Beyond that, one can show[7]that all 10 inter-mound distances are multiples of $\sqrt{2}$ and/or $\sqrt{3}$.

Geometrically, the origin of these tantalizing basic geometrical and prime number features lies in the fact that these five mounds are at 5 of the 8 nodal points of a special rectangle called the square root of two rectangle (Figure 13). The “2 rectangle is special in that bisected at its exterior long side, it produces two smaller replicas of itself. The rectangles containing the triangles EDA and GAD have the same proportions as the larger rectangle that contains both The 45 degree right triangle is the only other geometrical object having such a duplication property.

Let us now consider two of the remaining 12 mounds. Interestingly, the inclusion of mound P on the far left (Figure 14) produces the additional triangle PGE having angles of 92.1° ± 3.8, 32.1° ± 1.8, and 55.8° ±

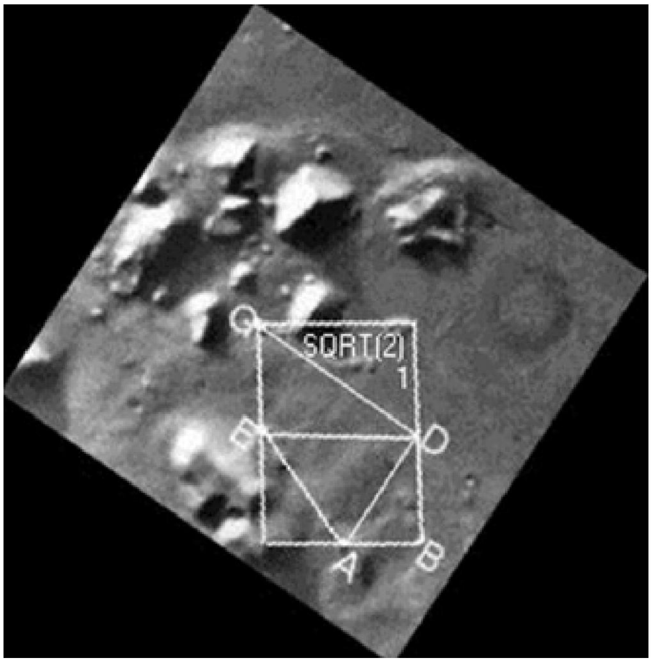


Figure 13 : Relation of pentad of mounds to “2 rectangle

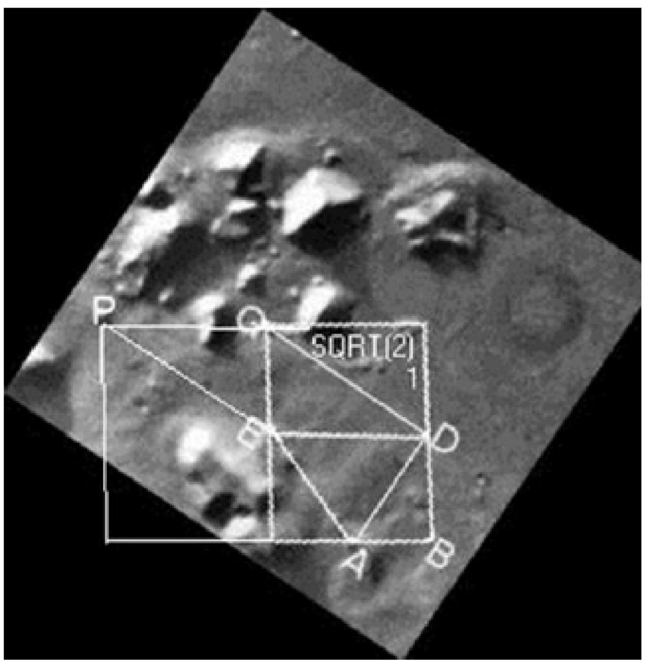


Figure 14 : Mound P and extended rectangular grid

2.7 degrees. These angles are close enough to the ideal of 90°, 45-t/2 = 35.3, 45 + t/2 = 53.7 (with t =19.5 degrees) so that a precise 6 mound coordinated fit (within 0.2 degrees) can be easily obtained, giving a fifth right triangle similar to the four above and congruent to two of them. In addition, there is a hint of a double sized √2 rectangle. (Two corners of the inferred rectangle do not exhibit mounds.) This √2 grid-like feature was discovered by Professor Stanley McDaniel (see Reference 7). For the ideal geometry, the enclosed area of the 6 mound hexad of mounds is 7, the next prime number after 5.

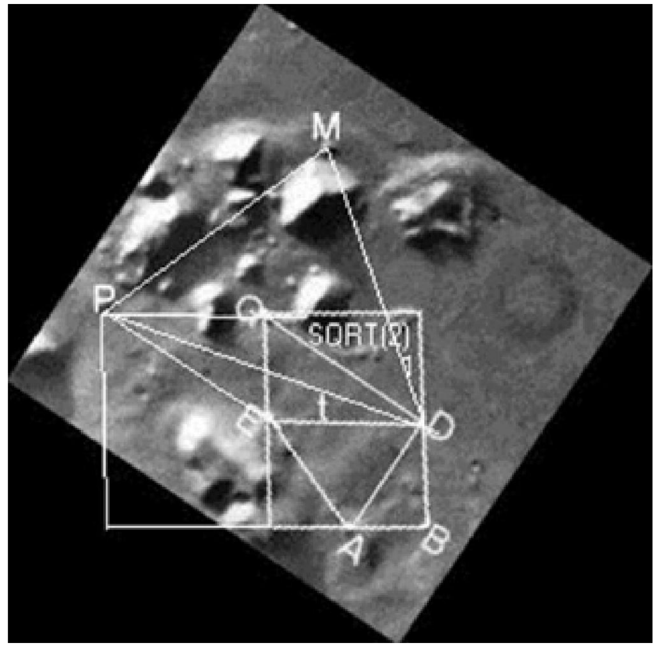


Figure 15 : Mound M with isosceles PMA similar to ADE

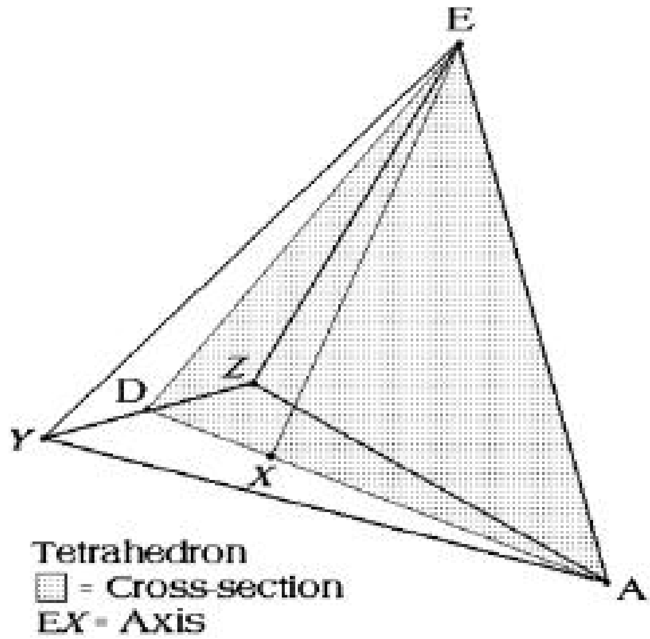


Figure 16 : The isosceles triangular cross section of the tetrahedron

Including mound M (Figure 15) produces a large replica PMA of the triangle ADE as seen by the respective angles of 55.1°, 54.7°, 70.2° versus 55.6°, 53.2°, 71.2°. Both are close enough to the ideal of, 45 + t/2 = 54.8, 45 + t/2 = 54.8, 90 - t =70.5(with t =19.5°) so that a precise 7 mound coordinated fit (within 0.2°) can be easily obtained, giving us two similar isosceles triangles and five similar right triangles. However, the coordinated fit points to the ideal are not as close to the center as with the original pentad of mounds.

Let us step up from two to three-dimensional space. Note that the similar isosceles triangles PMA and ADE have the same proportions as the triangular cross section interior to the tetrahedron obtained by a perpendicular bisection of the tetrahedron (Figure 16). The right triangle EXA has the same proportions as the ideal 5 similar right triangles between the 7 mounds so far included.

If we include mound O, then this connection to the solid geometry of the tetrahedron becomes emphatic. One finds that OPG in Figure 17 can have a coordinated fit (with the other 7 mounds) to that of an equilateral triangle. The astounding connection is that the ratio between its area and that of the isosceles ADE is identical to that between the external (equilateral) face and internal cross sectional area (isosceles) of triangles of a tetrahedron. This is exact given the ideal geometry since the √2 rectangular grid implies that length PG = ED.

In the Appendix the images and angle measurements of these same mounds are given using the more recent and higher resolution images of the HiRes Mars Express satellite. As the measurement show there, the angles we obtain with the new images are very close to the ones obtained from the original Viking image. Our conclusions above therefore and discussions below remain unaffected.

THE PENTAD OF MOUNDS, THE ELECTRON, AND MAGNETISM

There is a further property of the pentad of mounds that is also quite striking. One of the authors was preparing lecture notes on molecular quantum mechanics and came upon the following sentence: when the spin of two electrons combine to give a larger spin, "the relative orientation of the individual angular momentum (spins) are the same in all cases (the angle is about 70 degrees)"[8].The opening angle ADE of 70.5 degrees for the ideal geometry is precisely that same angle. This follows from the fact that the spin of the electron is quantized. Its magnitude can only be $\hbar\sqrt{3}/2$, while measuring the component of its spin along any direction can only give $\hbar/2$. (The symbol ' is Planck's constant divided by 2π). In a constant magnetic field the electron's magnetic moment (due to its spin) precesses about the field direction with the short side forming the axis of a cone (see for example either of the two congruent right triangles in Figure 7). This precise, unalterable geometrical description of the electron's spin projection and magnitude is modeled exactly by the ratios of the mound separation distances corresponding to the similar right triangles. That is, the ratio of the length of the hypotenuse and short side is exactly √3 for the ideal geometry of the mounds (DA to DB for the mounds) *and* for the ratios of the angular momentum magnitude of the precessing electron in a magnetic field to it component along the magnetic field.

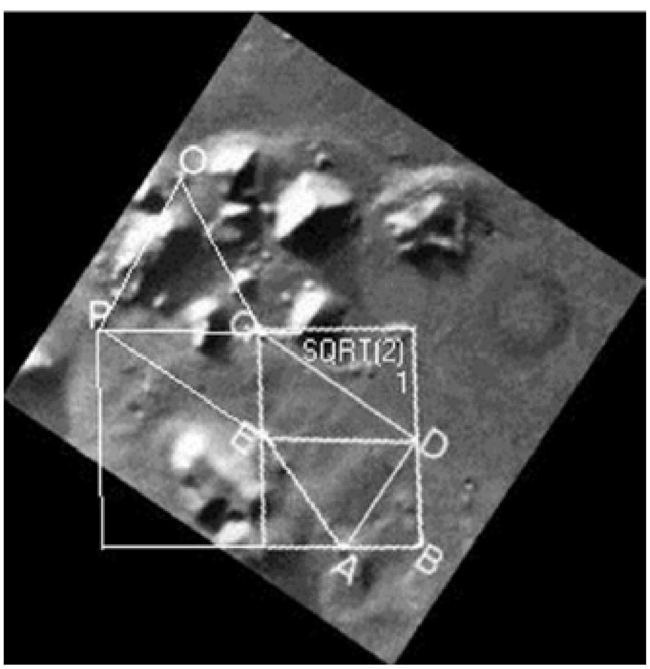


Figure 17 : Mound O and related equilateral triangle

One could say that through the angle ADE in the triangle of Figure 9, the physical basis of magnetism itself through combined spins is explicitly displayed. That is, the triangle ADE graphically demonstrates the only way physically possible for the spin and thus the magnetic moments of the electrons to combine to give a nonzero and higher magnetic moment. The rules of addition of two angular momentum dictated by the laws of quantum mechanics allows only two way for the spins of two electrons to combine. In one way the spins exactly cancel, giving rise to no magnetism. The only other way they combine is portrayed in Figure 9. The only relative angle possible to produce a higher spin and thus a higher magnetic moment, a stronger magnetic field, the only way that two electrons, each having spin.$\hbar/2$, can combine to give spin $\hbar$ is to be oriented relative to one another by the angle ADE. If one views the two electrons as spinning along axes pointing along the legs AE and AD respectively then the only way that the intrinsic magnetism of the associated magnetic moments of the two electrons can be enhanced is if the two axes are aligned along the ADE angle of 70.5 degrees.

POSSIBLECULTURAL SIGNIFICANCE OF THE MOUND PLACEMENTS

If the mounds are artificially placed, then it is reasonable to propose aspects of cultural significance of their angular placements. The first aspect is purely geometrical. We refer the reader to Figures 10a-b-c and 12. They display fundamental features of area and side lengths of special right triangles in the pentad configuration that are connected and interconnected to the first three natural numbers. In Figures 16 and 17, these features are found in turn to connect to the simplest Platonic solid, the tetrahedron and through it to the equilateral triangle and the isosceles triangle which doubles in proportion those special right triangles.

The second aspect is the display of two related fundamental scientific facts concerning the electron. First the angular momentum,a feature of the electron itself, is shown by the right triangles displayed in Figures 7, 8, and 10 (the same could be said for the quarks since they have the same spin as the electron). And secondly, how the electrons combine with one another to enhance their magnetic properties is show in Figure 9. (What is not shown is the resultant spin magnitude. It would be represented by a line pointing straight up from the vertex D perpendicular to the line EA).

The thirdaspect is related to the sqrt2 rectangle displayed in Figures 13 and 14. Surprisingly, the golden section can be obtained from the various proportions and ratios generated within the sqrt2 rectangle. Reference 7 discusses this connection in a paper by Mark A. Reynolds[9]. First one constructs a sqrt2 rectangle from a square. This is accomplished by starting with the square and drawing the arc of a circle having as its center one corner of the square (say A) and its radius the diagonal of the square (AC). Where the arc meets an extended side of the square at E determines the length of the long side of the resulting sqrt2 rectangle. This arc (having radius AC) is visible on the right in Figure 18 below. Since the radius AC is sqrt2 times AB, ABEF is a sqrt2 rectangle.

Next, the remainder of the sqrt2 rectangle is divided

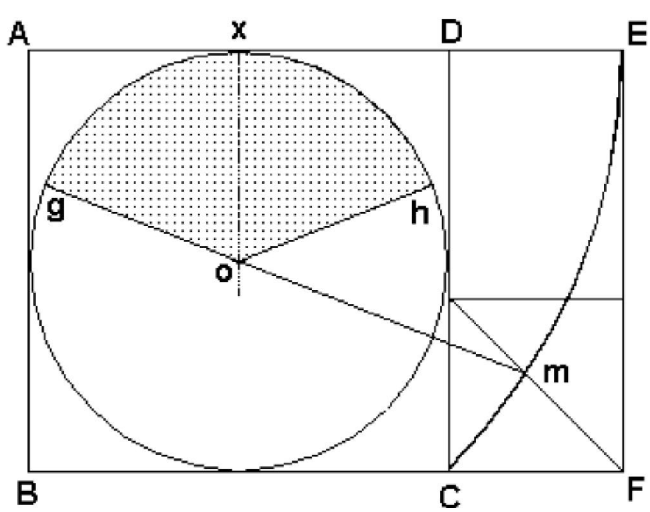


Figure 18

by constructing a square of sides equal to length CF (the small rectangle above this square is again a sqrt2 rectangle). Point m is now determined as the intersection of the arc with the diagonal of the small square. When a line is drawn from m through the center o of the large circle, angle gox = 68.75 degrees within a small margin of error. Doubled, this yields angle goh, the desired golden ratio arc of 137.5 degrees (the remaining arc being 222.5 degrees.)

One of the probable uses of such geometric measurements in ancient times lies in the possibility of laying out architectural lines having symbolically significant ratios, e.g. on the ground of a proposed site by pacing out first a square, drawing an arc on the radius of the diagonal to create a sqrt2 rectangle, and then inferring further values by utilizing the productive elements of the rectangle (such as the golden ratio just described). McDaniel points to articles[10] by John A. R. Legonwhich presents data indicating that the layout of the three pyramids at Gizeh, Egypt (including the Great Pyramid) is based on a rectangle having as its sides sqrt 2 and sqrt 3.

What is most interesting about the Legon data is that it implies an application of the "dynamic rectangle" concept to the distribution of a group of architectural structures. According to Ghyka[11] these "dynamic" rectangles (such as the sqrt2 rectangle) were thought to produce "the most varied and satisfactory harmonic subdivisions and combinations" for use in art and architecture[7]. points out that at Cydonia on Mars we have, perhaps, an analogous situation. As seen in Figures 13 and 14 the moundsare distributed according to the "dynamic" sqrt 2 rectangle. The cultural implication may be that the distribution of mounds (if they are artificial) is architectural or aesthetic in intent. Geometry being a universal science – one could conjecture that extraterrestrial intelligence might be responsive to the same concepts of harmonic proportion as those appreciated in terrestrial cultural traditions. This ties in nicely with the aspect discusses at the beginning of this section. By that is meant the possibility that the distribution of mounds may have been intended as a kind of signal, one created that could only be understood by a civilization advanced enough in mathematics and geometry to interpret and respond to a more complex geometric pattern. Here we have one that speaks to a symbolic and aesthetic side of culture in addition to a purely scientific one as with the fundamental physical features of angular momentum of the electron and quark.

Of course, the pattern of mounds may be simply a natural formation; but if it is, it would appear to be a geological oddity because of the very low probability of the distribution having occurred by random forces. Against the idea of a natural origin, we have the following questions and answers. Does the mound geometry conform to some understandable grid? The mound geometry conforms to a sqrt2 rectangular grid. The mound geometry is quite rich, not common place. Is there any recognizable cultural or symbolic quality in the patterns that might provide a clue to possible meaning or utility?The geometry conforms to a recognizable mode of architectural aesthetics and is capable of expressing symbolic, mathematical, and scientific meaning.

Clearly, the probability of either possible intentional design or radical geological anomaly for the mound configuration at Cydonia gives more than sufficient reason to warrant high priority for continuing active investigation of this site.

POSSIBLE GROUND ZERO INVESTIGATION STRATEGIES FOR THE MARS ANOMALIES

We conclude by considering what sorts of ground investigation may beappropriate for determining the character of the anomalous features inaddition to geological and biological goals of a crewed mission. We first focus on the mounds as a determination of their artificialnature would be more straightforward than for the "Face". It isthe angular placements of the mounds as seen from the Viking 1976satellite that are anomalous and cannot be readily accounted for bychance geological settings or arrangements (see references 4 and 5). It was not their shape that drew attention to them as with the "Face". While a ground level assessment could determine if there are obvious aspects to the individual mounds that would point unambiguously to an artificial origin, it may be more likely that erosive effects would ultimately eliminate those aspects. In that case search for evidence beneath themounds may be decisive. If a particular mound was a natural feature,then there would always be associated with its surface prominence acorresponding subsurface geological structure. On the other handfor any structure that has a foundation that has been excavated priorto construction, there would be clear geologic "discrepancies" thatwould point toward non-natural activity. Properties of soils or rocksadjacent to the structure would be markedly different than propertiesof soils remote from the structure. Ground Penetrating Radar(GPR) would be one technique to determine the structure of soils andbedrock. Also, gravity meters could be used to measure the localdeviation in gravity due to mass directly below an object. Togetherthese tools, among others, could be used to provide a cross checkto determine decisively if a mound is a natural geological feature oran artificial one put together atop an otherwise flat area.

The "Face" will be more problematic since if it is artificial, becauseof the sheer scale of the mesa, it would appear to be a modification ofan existing landform. Thus searches for evidence of artificiality wouldbe limited to investigating surface modifications, and so the abovetechniques for the mounds would not be applicable. The main element ofunderstanding eroded vs. artificial modification is to understand theerosion and weathering processes involved. For Mars, water is a likelycomponent, wind is definitely a component, and other mass wasting mightalso contribute. Water will abrade rocks to form rounded sediments overtime, wind will sandblast items to give them a shiny appearance, andmany features would still be angular. Mass wasting may causesignificant changes in a short time, i.e. landslides, or may causesmall changes over a long period of time, i.e. creep. Since weatheringand erosion would overprint an existing sculpted object, that task isall the more difficult in this case. Ground penetrating radar fromsatellites may be useful for examinations of hardened areas underneathlayers of dust or sand. One factor would be to look for repeatingpatterns that are not typically formed by geologic processes. Thesewould be more likely found in areas that were more sheltered fromerosion. Stonework would also normally produce a large amount ofdebris.

APPENDIX -HIRES MARS EXPRESS IMAGE OF CYDONIA MOUNDS

Below in Figure 19 is an overhead image of Cydonia,including the area of the mounds from HiRes Mars Express with a resolution of 13.7 meters/pixel compared with 47 meters/pixel for the Viking image. It has about the same orientation as the Viking image Figure 4. A small black dotis placed at the center of the mound locations of each of the 12 mounds of Viking image 35A72 given in Figure 4 above. The x and y locations of each of the twelve mounds was used to compute the angles of the special triangles with the new image. The angles listed are for the right triangles and isosceles triangles for the Pentad (see Figures 6-9). Also included are mound P, mound M, and Mound O (see Figures . 14,15,and 17) as they are also involved in triangles that are close to ideal right, isosceles and equilateral triangles.

In degrees, the ideal right triangles have angles of 90.0, 54.7, 35.3, while the ideal isosceles have angles of 70.5, 54.7,54.7 and of course the ideal equilateral has angles

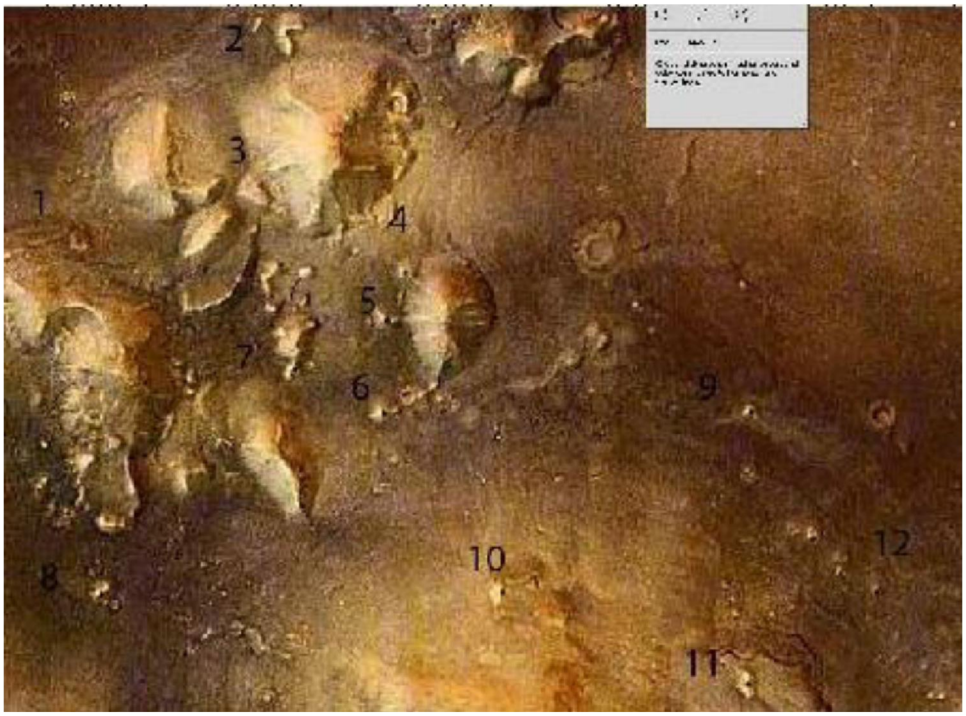


Figure 19 : Mars express image of Cydonia mounds

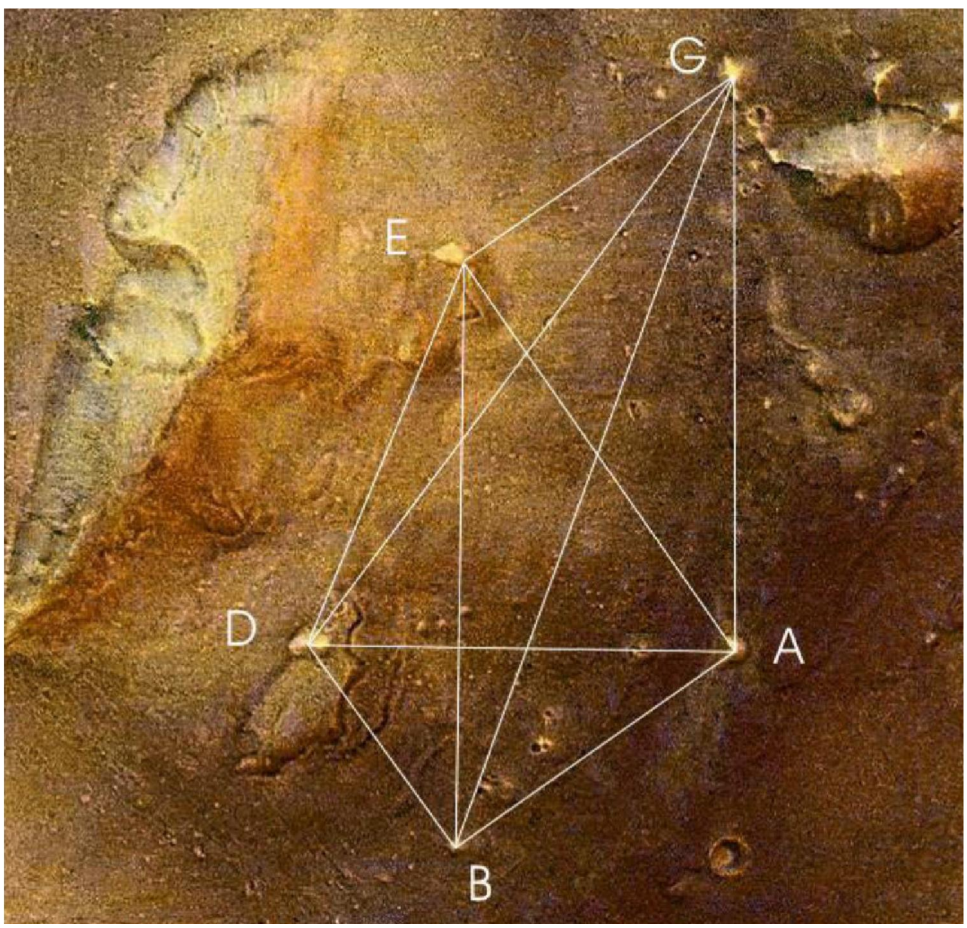


Figure 20 : The pentad of Cydonia mounds from HiRes mars express

of 60,60 60. For ease of comparison the angles from the Mars Express are given just above the angles from the Viking image. The uncertainties are comparable. The angles listed correspond to those at the listed letter labled vertex.

D A G 36.5 89.653.8

D A G 36.6 88.2.55.2

E A G 56.4 35.6 88.0

E A G 56.3 35.0 88.7
E D A 54.0 69.8 56.1
E D A 53.2 71.1 55.6
B D A 35.553.590.9
B D A 37.1 53.6 89.3
B E A 89.635.654.9
B E A 90.3 35.0 54.7
P E G 90.957.032.1
P E G 92.1 55.8 32.1
M P A 55.056.268.9
M P A 55.1 54.7 70.3
O P G 62.160.9 57.0
O P G 61.7 60.7 57.5

As one can see, the angles in both sets of data are close to each other and the ideals. The above sets of data are the triangles that corresponded to what appeared to be the centers of the mounds in both sets.. In the figure below the numbers 1,2,3,4,5,6,7,8,9,10,11,12 correspond to mounds O,M,L,K,J,G,Q,P,A,E,D,B. In Figure 20 below is given the Pentad of mounds. This particular image is rotated relative to Figure 6 by about 50 degrees and about 90° relative to Figures 4 and 19. The color figures were taken from the European Space Agency images at http://www.esa.int/spaceinimages/Images/2006/09/Cydonia_region_colour_image2

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