

## Analysis of Mars Odyssey THEMIS Imagery of the D&M Pyramid

New THEMIS imagery of the D&M shows it is a highly symmetrical object and is apparently related to other objects in the Cydonia complex.

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### Introduction

In 1979, while analyzing Viking imagery of the Face on Mars, DiPietro and Molenaar, discovered a huge pyramidal formation due south of the Face<sup>1</sup>. This object, which has become known as the D&M Pyramid, was later analyzed in detail by Torun<sup>2</sup>. He considered a variety of natural processes: fluvial deposition/erosion, aeolian deposition/erosion, mass wasting, volcanism and even crystal growth. None could account for the D&M Pyramid's unusual shape. Some planetary scientists have suggested that the D&M Pyramid and other landforms in the Cydonia region are the result of differential erosion. Erjavec has shown that differential erosion cannot in itself explain the diversity of morphologies found in this part of Mars<sup>3</sup>.

In the same highly oblique April 1998 image which targeted the Face, the Mars Global Surveyor (MGS) imaged the northeast corner of the D&M Pyramid<sup>4</sup>. Recently, the Thermal Emission Imaging System<sup>5</sup> (THEMIS) aboard the Mars Odyssey spacecraft acquired a 19 meter/pixel visible image over a 53.4 by 22.5 km portion of Cydonia containing the Face, D&M, and the eastern portion of the City (Fig. 1). In the 1976 Viking images, the D&M was illuminated from the northwest with the sun low in sky so that the east side of the object was shadowed. The higher solar elevation angle in the 2002 THEMIS image reveals the first fully illuminated image of this object.

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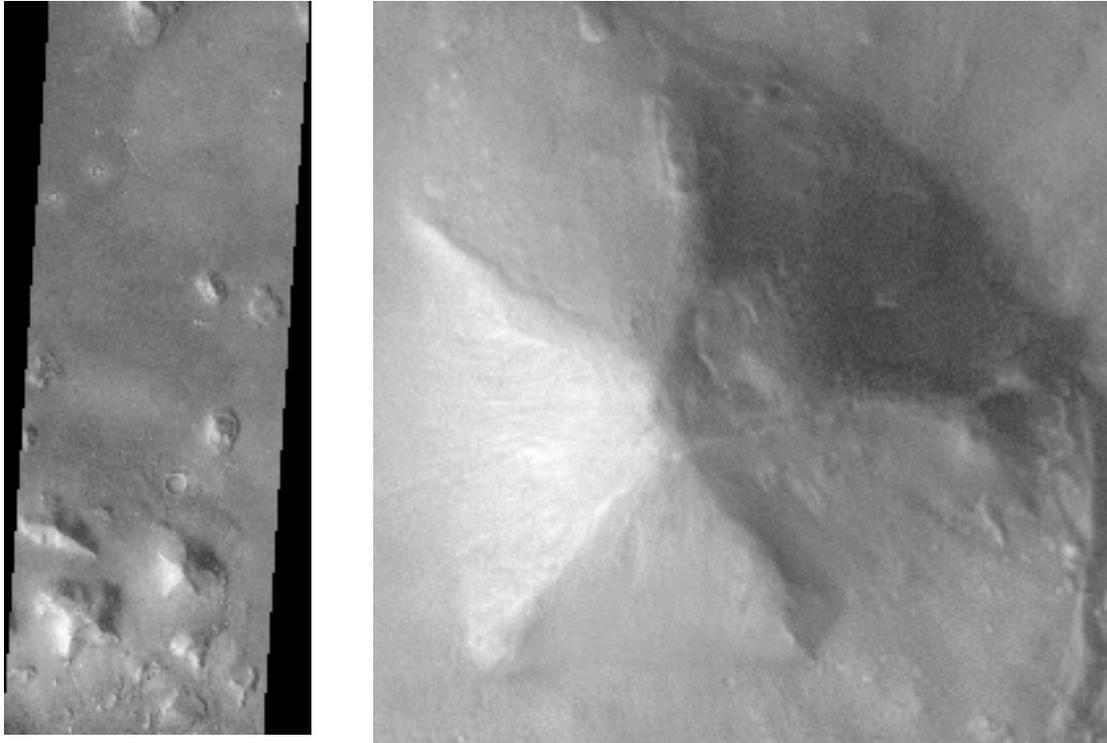
<sup>1</sup> V. DiPietro and G. Molenaar, *Unusual Martian Surface Features*, Mars Research, Glenn Dale MD, Fourth edition, 1988.

<sup>2</sup> <http://www.his.com/%7Eetharsis/pyramid/geomorphology.html>

<sup>3</sup> <http://hometown.aol.com/erjavecj/cydonia/page1.htm>

<sup>4</sup> <http://martianenigmas/Articles/cydoniaUpdate/index.html>

<sup>5</sup> <http://themis.la.asu.edu/>



**Fig. 1 Full THEMIS visible image strip 20020413a (left) and portion containing D&M Pyramid (right) at full resolution of 19 meters/pixel.**

## **Analysis**

Our previous analysis of the Face<sup>6</sup> confirmed its structure to be highly symmetrical. The THEMIS image shows the D&M to possess a high degree of symmetry as well. In Fig. 2 the image has been rotated so that the hypothetical axis of symmetry is aligned with the vertical axis. Fig. 3 plots the Marola symmetry measure<sup>7</sup> which was used previously to locate the axes of symmetry of the Face in the April 2001 MGS image. The peak of the curve indicates the horizontal position which maximizes the symmetry measure. In Fig. 2 we alternate between the original and left-right flipped versions of the D&M Pyramid. Although signs of erosion are present, a high degree of bilateral symmetry still exists. We note the difference between the left and right "arms" of the formation. The end of the left arm appears to have collapsed. Previously it has been conjectured that this may be an opening leading into the D&M Pyramid. Perhaps an image acquired in the morning with the sun illuminating the the east side might help to determine the nature of this feature.

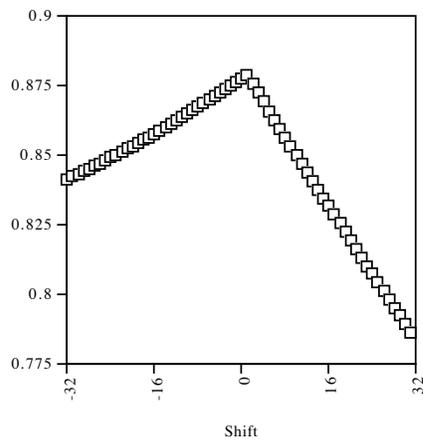
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<sup>6</sup> Carlotto, M.J., "Analysis of the April 2001 Image of the Face on Mars," *New Frontiers in Science*, Vol. 1, No. 1, Fall 2001 (<http://www.newfrontiersinscience.com>).

<sup>7</sup> Marola, G., "On the detection of the axes of symmetry of symmetric and almost symmetric planar objects," *IEEE Trans. Pattern Analysis and Machine Intelligence*, Vol. 11, No. 1, Jan. 1989.



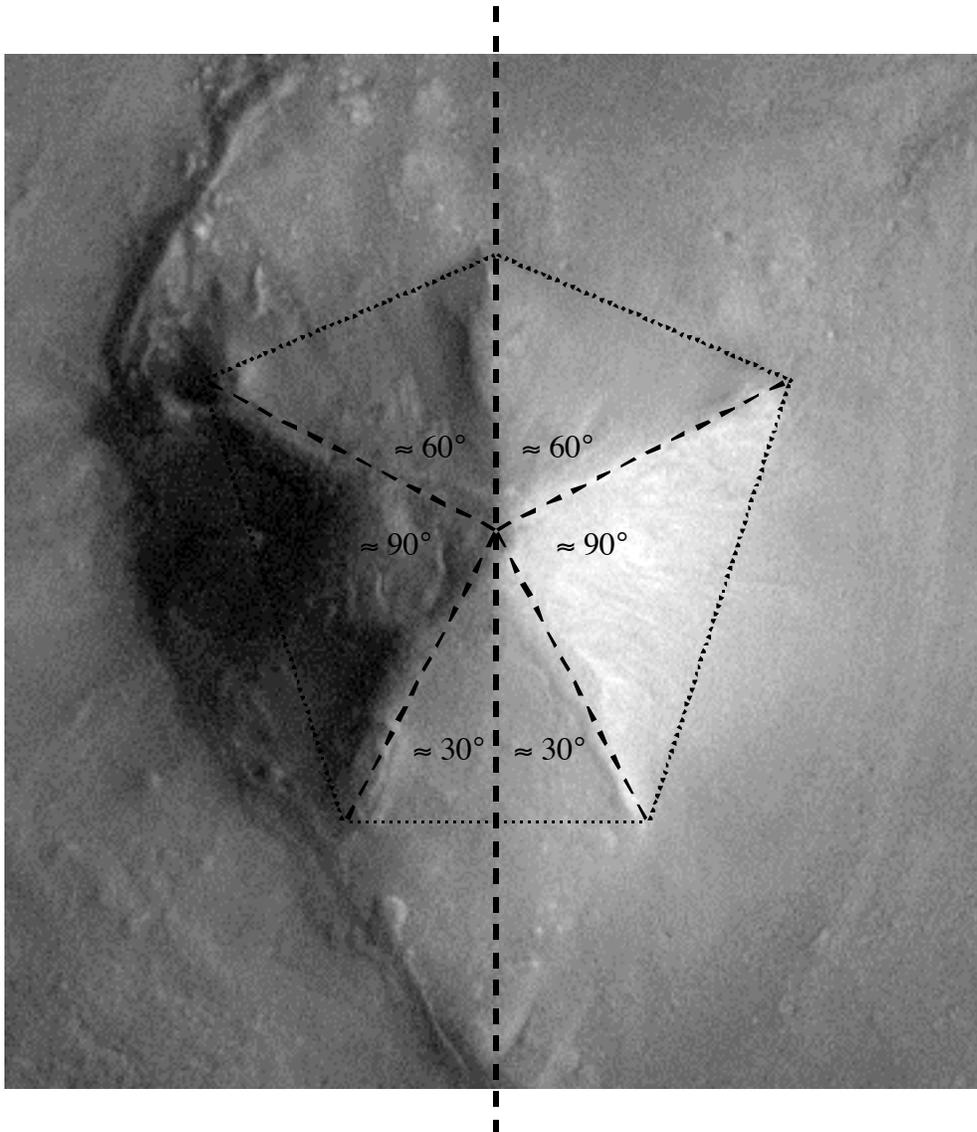
**Fig. 2 D&M Pyramid rotated so that axis of symmetry is along vertical axis. Dynamic GIF alternates between original and left-right flipped images.**



**Fig. 3 Plot of Marola symmetry for horizontal shifts of image of D&M.**

## Interpretation

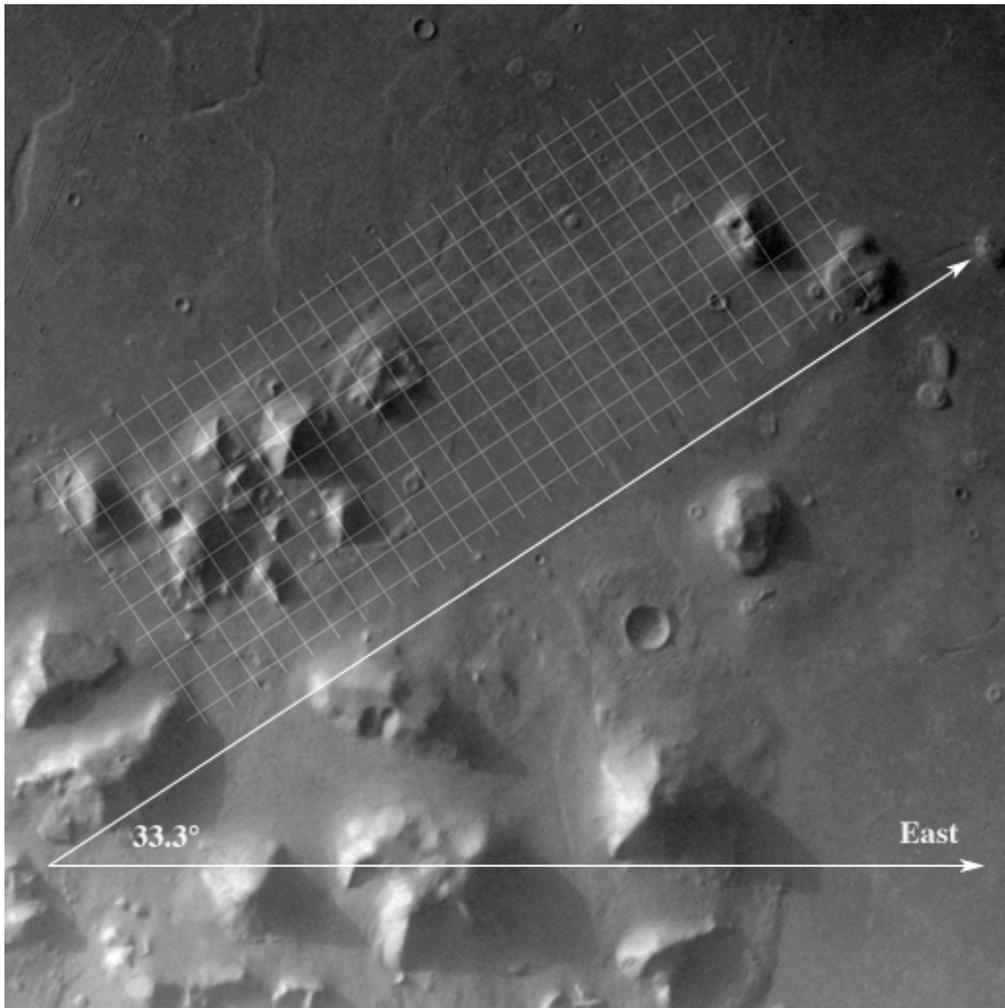
A simple and elegant geometry may be responsible for the symmetry of the D&M Pyramid. Torun identified a number of relationships in its internal geometry which suggested an underlying plan based on tetrahedral geometry<sup>8</sup>. As shown in Fig. 4 the presence of angles approximately at 30°, 60°, and 90° suggests that the faces of the D&M can be described by isosceles and right triangular facets. However, more precise angular measurements may also confirm Torun's original model.



**Fig. 4 Geometrical model of the D&M Pyramid. Dynamic GIF shows original, flipped, and summed (original plus flipped images) with hypothetical geometrical model overlaid.**

<sup>8</sup> <http://www.his.com/%7Eetharsis/pyramid/geometry.html>

It is interesting to note certain similarities and relationships with other objects in the Cydonia complex. As seen in Fig. 5, the D&M's axis of symmetry lies roughly in the direction of the grid established by Crater and McDaniel in their analysis of the mounds<sup>9</sup> and aligned with the major axis of several other larger objects in the complex<sup>10</sup>. The new THEMIS image also confirms that the south facet of the D&M Pyramid faces almost exactly due south as previously thought<sup>11</sup>.



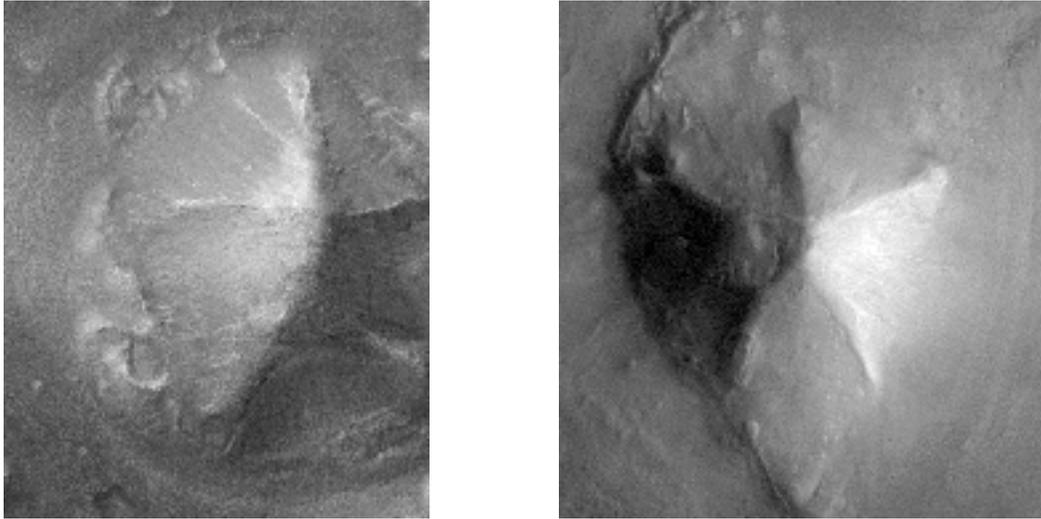
**Fig. 5 Cydonia complex. Dynamic GIF alternates between map-projected Viking and THEMIS images.**

<sup>9</sup> H.W. Crater and S.V. McDaniel, "Mound configurations on the Martian Cydonia plain," *Journal of Scientific Exploration*, Vol. 13, No. 3, 1999.

<sup>10</sup> M. J. Carlotto, "Evidence in Support of the Hypothesis that Certain Objects on Mars are Artificial in Origin," *Journal of Scientific Exploration*, Vol. 11, No. 2, 1997.

<sup>11</sup> *ibid*

This new image also resolves the long-standing debate over the number of sides of the D&M Pyramid. That it is a five-sided object calls reminds us of the five-sided geometry of the Starfish Pyramid<sup>12</sup> within the City. Although the shape of the Starfish Pyramid in the April 1998 MGS image (Fig. 6) is slightly distorted due to its off-nadir imaging geometry, the similarity in shape between these two objects is remarkable.



**Fig. 6 Starfish (left) and D&M (right) pyramids viewed from north.**

## **Summary**

The existence of a high degree of symmetry in the Face and the D&M Pyramid, two objects with completely different morphologies, less than 20 km apart, further strengthens the hypothesis that this collection of objects may be the eroded remains of ancient artificial structures on the Martian surface. It is recommended that THEMIS imagery further west over the Starfish Pyramid in the City be acquired to ascertain its true shape so that it can be compared to that of the D&M Pyramid.

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<sup>12</sup> <http://martianenigmas/Articles/newMGS/newMGSpyr.html>