THE

Martian Enigmas

A Closer Look

ELECTRONIC EDITION

by

Mark J. Carlotto

With love to my family,
especially my children,
who are living in interesting times.

Acknowledgments

Thanks to Vince DiPietro and Greg Molenaar for finding the original image of the Face on Mars and for taking the time to look for that second image which NASA claimed didn't exist, to Dick Hoagland for recognizing the importance of their discovery, for his many contributions, and for organizing, along with Randy Pozos, the Independent Mars Investigation group. Thanks to Tom Rautenberg, a member of that group, for coming to Boston in the winter of 1985 with two Viking data tapes. During the next few years I spent many hours analyzing the imagery on those tapes. I am indebted to my former employer, TASC, for allowing me to work on this project after hours, and owe a great deal to my colleagues there for many fruitful discussions on image processing, shape-from-shading, and fractals. Thanks to Brian O'Leary who collaborated with me on the shape-from-shading analysis of the Face, and to Dan Drasin, who has been involved in the Mars investigation from the beginning, for his many contributions to the first edition of *The Martian Enigmas*. I would also like to thank Erol Torun for his contributions to the first edition of this book, Jim Erjavec and Ron Nicks for allowing me to include their work in the revised edition, and Ananda Sirisena and Chris O'Kane for their recent work in the U.K. Finally, I thank Stanley McDaniel and the members of the Society for Planetary SETI Research for their efforts in moving the investigation of the Martian anomalies into the scientific mainstream where it belongs.

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Foreword

Several books and numerous magazine and newspaper articles have been written about the Face on Mars. Every now and then another outrageous story appears in some tabloid that claims alien messages are being beamed to earth from inside the Face, or that other faces have been found on Venus, one of which looks like Elvis! However, a few scientific articles have seriously addressed the Face, a mile-long formation on the surface of Mars that was imaged by one of the U.S. Viking orbiter spacecraft in the summer of 1976.

This book summarizes the results from the technical papers that have been written about the Face and other enigmatic objects on Mars, and reproduces visual materials not previously available to the general public. It is not a personal view of these objects and does not itself speculate on their origin or meaning, although it necessarily reports some of the more striking observations and speculations of other researchers. Neither is it a history of the fifteen year debate that has galvanized public and professional opinion. Planetary scientists, almost without exception, insist that these enigmatic features must be natural geologic formations. Others state with complete certainty that they are the product of ancient, alien intelligence. Those of us in the middle are not sure.

It is recognized that the scientific community often tends to treat investigations into extraordinary phenomena as pseudoscience not on grounds of methodological integrity but of subject matter alone. This, however, does not agree with the scientific method. Science is a dispassionate process by which any subject matter may be freely and legitimately investigated. Science does not tolerate taboos, a priori judgments, circular reasoning, ridicule or double standards. In science, one point of view requires as much impeccable proof or disproof as another.

Broadly speaking, scientific method is based on gathering observations and data, and then generating hypotheses and assembling them into testable theories. Tests may then be performed that are reproducible by others and subject to peer review so that a consensus may be arrived at. Granted, the transience of many unusual phenomena like UFOs can tend to make their scientific investigation difficult. But the Face on Mars belongs to a different class of phenomenon: it is in no hurry. When we return to Mars we will find the Face and its entourage of enigmatic structures patiently awaiting our scientific curiosity just as they have for perhaps millions of years.

It is often argued that extraordinary claims require extraordinary evidence. In this case we are fortunate because the issue can be resolved by an extraordinary opportunity — a return to Mars that is already scheduled and funded. Hopefully in 1993, when NASA's Mars Observer reaches the Red Planet, high resolution imagery can be carefully collected under controlled conditions and the truth determined once and for all. Until then, those who speculate will continue to speculate, the skeptics will continue to doubt, and others like myself will continue to analyze the existing data.

It has been said that the Face on Mars is either completely natural or it is artificial; in terms of what is at stake here, there is no middle ground. Those who believe it is natural argue that no firm evidence even for microbial life has been found on Mars, so how could an object like the Face possibly exist? All will readily admit, however, that there is still much to be learned.

For now, the challenge is to gather data, develop experimental and evidential criteria, and prepare carefully for the re-imaging of Mars. It is perhaps premature to speculate too vociferously on the origin or meaning of this mystery; for now, it is simply there.

Readers will note my use of descriptive names such as "City" and "Fortress" throughout this book to identify certain Martian features. These shorthand terms have been coined by independent investigators over the past decade and are routinely applied for the sake of convenience and consistency. They do not imply an endorsement of particular interpretations of these objects.

— Mark J. Carlotto

Preface to the First Edition

I have always been fascinated by space exploration. When I was twelve I wrote a letter to Wernher von Braun, one of my childhood heroes, for advice on rocket fuels. Being a "basement bomber" [someone who experiments with homemade rockets and rocket fuels] somehow I lived through my teen years, and in the early seventies, as the Apollo program was winding down, I entered Carnegie-Mellon University. Initially a physics major, I switched to electrical engineering as my interests began to shift from space exploration to digital signal processing and electronic music. On entering graduate school at CMU, I became interested in image processing and optical computing. In 1981 I completed my PhD and joined TASC, a high-tech firm just north of Boston.

Several years later, in the Autumn of 1985, I came across an article about the "Face on Mars" in the *Boston Globe*. At first I thought it was some kind of joke; nevertheless I was curious and soon acquired two computer tapes of Viking Orbiter imagery. Initially my goal was simply to produce high-quality enhancements of the images, but as I became drawn into the investigation I learned that there was much more to this issue. For one thing, the Face was extremely controversial — in fact, the "experts" had already decided it was an optical illusion. Although I am not a planetary scientist and therefore not an "expert," I was not convinced. I found it hard to believe that such a compellingly humanoid form could occur naturally, least of all in immediate proximity to a diverse collection of other unusual objects, some quite geometric in shape and arrangement. My intuition told me to take a closer look.

I questioned NASA's conclusion that the Face was simply a "trick of light and shadow;" however, without additional images of the Face taken in significantly different lighting conditions and perspectives, and at higher resolutions, it was hard to disprove. But being involved at the time with a computer-vision technique known as "shape-from-shading," I realized that I could attempt to derive the actual three-dimensional shape of the Face from the available images. This 3-D information would then allow me to use computer-graphics techniques to create synthetic views of the Face as if viewed from different perspectives and under different lighting conditions.

The results were quite positive, and so I submitted a paper to the planetary science journal *Icarus*. The manuscript was immediately rejected on the grounds that the Face was of no scientific interest. I revised the paper, but as Icarus was unwilling even to consider a revised manuscript I submitted it instead to the journal *Applied Optics* where it was published shortly thereafter in the summer of 1988.

Skeptics have talked about the undeniable human tendency to see faces in just about anything from clouds to tortilla chips. Although this fact by itself does not constitute disproof of extraterrestrial intelligence, it does underscore the need for more objective ways to discriminate between natural and artificial forms; therefore I initially sought some means to determine whether the Face and certain nearby objects were quantitatively different from the surrounding terrain. Coincidentally, a colleague of mine had just developed an algorithm (computer routine), based on fractal mathematics, to find man-made objects in aerial and satellite photographs. Immediately we tried it on the two key Viking frames, 35A72 and 70A13, and were astonished by the results: the Face was the least fractal (and one could conclude least natural) object in both images. The results were published in early 1990 in the *Journal of the British Interplanetary Society* after being rejected by *Nature* on grounds similar to those used by Icarus.

This book appears on the eve of another U.S. mission to Mars, whose advanced orbiting spacecraft will carry, among other sensors, a high-resolution camera capable of resolving objects as small as one meter in size — compared with only fifty meters in the case of the old Viking orbiters. Armed with this remarkable instrument, enough scientific curiosity and a more intimate understanding of the Martian anomalies themselves, we could conceivably have a definitive answer to one of humankind's oldest questions within a very short time.

The central purpose of this book is to reveal both to the scientific community and to the general public much of what is already known about these mysterious structures on Mars, with a view toward encouraging their further study and understanding.

Specifically, the book presents the best available reconstructions and enhancements of the existing Viking imagery, explains the image-restoration process itself, summarizes the key research results obtained to date by several independent investigations and refers the interested reader to related publications.

The Martian Enigmas is based on over five years of independent research performed on advanced computer systems. I apologize in advance for the jargon — it is hard to avoid; however, it should not affect the real message here: that despite what the "experts" say, the origin of these enigmatic objects on Mars is still an open question.

— Mark J. Carlotto, Summer, 1991

Preface to the Second Edition

Six years ago, *The Martian Enigmas* was first published. Since then, much has happened, but in some ways, little has changed.

In August of 1992 NASA lost contact with the Mars Observer spacecraft as it approached the Red Planet. For some the loss seemed suspicious after the failure of two Russian probes in 1988. But most of us were simply frustrated that after the spectacular successes of the Voyagers' Grand Tour of the solar system in the 1980s and Magellan's radar imaging of Venus in the early 1990s, we still had no new imagery of Mars.

In the summer of 1996 a group of NASA scientists published a paper in the journal Science in which they claim to have discovered evidence that microbial life may have once existed on Mars. Overnight, the planetary science community's earlier view that life could not exist on Mars started to change. And it was based not on the discovery of an actual live microbe but on circumstantial evidence; that is, on evidence with other possible interpretations. In many ways like the evidence presented in *The Martian Enigmas* and other books which suggest that certain structures on Mars might be artificial in origin. Evidence that the planetary science community has not only ignored but has ridiculed. In fact, NASA made it quite clear when they made their historic announcement about the discovery of microbes that they had no intention of looking for "little green men" on Mars, with obvious reference to the Face and other unusual objects that have been under investigation for over twenty years.

The second edition of this book appears as we reach for Mars once again. At this point, the first edition is somewhat dated, containing historical references to Mars Observer, and to plans under consideration at that time for exploring Mars. The new edition contains all of the material from the first edition with a considerable amount of new information added. Included are several new chapters. One summarizes and analyzes the existing body of evidence for artificiality and shows that collectively it is the extraordinary evidence required by Carl Sagan and other skeptical scientists to justify the extraordinary claim that these features on Mars are artificial. This chapter also contains several new research results that have not been previously published which add further support to the claim for artificiality. Another chapter written by James Erjavec and Ronald Nicks discusses possible geological mechanisms to explain these formations. Their analysis suggests that geology in itself cannot satisfactorily explain the diversity of forms, patterns of organization, and subtly in design exhibited by this unique collection of objects on Mars.

Also contained in this edition are updates to our current plans to explore Mars, and an examination of NASA's recent announcement concerning the possible discovery of extraterrestrial micro-organisms. The nature of the evidence for microbes is shown, in essence, to be no different than that for the existence of large artificial structures on Mars. The intent is to highlight a glaring inconsistency in NASA's philosophy towards planetary exploration and the search for extraterrestrial intelligence. An inconsistency that is particularly troubling as many of us are, once again, unclear as to NASA's true intention to image these enigmatic objects on the surface of Mars.

— Mark Carlotto, Spring 1997

Preface to the Electronic Edition

The previous edition of *The Martian Enigmas* was published while the Mars Global Surveyor was *en route* to the Red Planet more than ten years ago in the Summer of 1997. Soon after the spacecraft arrived at its destination, in response to a great deal of public interest in these objects (and some lingering scientific curiosity within NASA as well), a picture was taken of the Face and released to the public within hours. That night an "enhancement" of the raw data produced by the Jet Propulsion Laboratory was shown on the evening news. Having downloaded and analyzed the raw data earlier in the day, the image I saw on TV did not look anything like the one in front of me on my laptop. More of a corruption of the data than an enhancement, the image released without comment by JPL/NASA and accepted without question by the media had, to the delight of critics, "settled" the debate over the Face once and for all.

My second book, *The Cydonia Controversy* picks up where this book leaves off, examining the debate over the Face and other objects on Mars within a broader political and scientific context. With all of the advances in computers and Internet technology since the first edition I have decided to release an electronic version of *The Martian Enigmas* that contains material, primarily animated content, not previously available to the public. As you examine this material, ask yourself if the question of whether the Face on Mars is artificial or not has been settled, or does some lingering doubt, some curiosity remain?

— Mark Carlotto, Winter 2008

I. THE MYSTERY

"O my God, look at this!" — Viking project scientist, Toby Owen, July 1976.

On the surface of Mars lies a formation that looks remarkably like a humanoid face. Forever staring up into the vastness of space it has attracted our attention. For some, that is why it is there, beaconing us to come and explore. Others believe that it is simply an odd looking geological landform — a formation carved over the ages by the random forces of nature. That it is our imagination and our need to find other life in the universe that makes us see it as a intelligently crafted object.

And perhaps this is all that could be said of the Face on Mars. Provided it was alone. But it is not alone. Nearby are other strange looking objects. Some quite geometrical in shape. A number of them look like pyramids, one apparently five-sided. Moreover the objects seem to be arranged on the Martian surface in an organized pattern. Again, maybe it is our imagination tricking us into seeing something that is not there. But there is more.

Looking closer we see that there are subtle details within the Face as well as several of the other objects. Details that should not be there if these objects are natural. Logically these details should have been obliterated by erosional processes rather than preserved.

But once again we stop ourselves and ask: Could all that we see be image or processing artifacts? Questions that need to be asked whenever one interprets digital satellite imagery. And once again the answer seems to be no. What we see is present in more than one image. In fact all of these objects were imaged at least twice — about 35 days apart under slightly different sun angles.

If the Face on Mars and nearby pyramidal objects are artificial, they beg us to compare them with the Egyptian Sphinx and pyramids. But there is no comparison. These objects on Mars are enormous even by the standards of those that built the pyramids on the Giza plateau. The Face is over a mile long and is three times taller than the Great Pyramid. Where the Great Pyramid has four sides, each about 687 feet long, this apparently five-sided pyramid on Mars has sides well over a mile long. The pyramids on Mars are roughly 100 times larger in area and 1000 times greater in volume than the Great Pyramid, one of the largest structures on Earth!

The enormity of scale of these objects on Mars would seen to imply that they cannot be real. They must be natural geological formations. But then again, since the gravity on Mars is about one third that of Earth, one, with the same technology, could build structures considerably larger. But then again we are at a loss to explain them because we cannot even explain how the Egyptian pyramids were built let alone scores of other terrestrial enigmas.

So we seem to have a real mystery on our hands.

The possible detection of artificial structures on another planet would be among the most important discoveries in the history of mankind. It should have triggered a major revolution in scientific, social, and philosophical thought. But it did not. The best minds on Earth should be trying to figure out why it is there and be working toward a mission to Mars to find out. But they are not.

Perhaps we have not been ready. For up until recently even the possibility of finding microbes on Mars was considered remote. But with the recent discovery of what appear to be fossilized micro-organisms in a meteorite thought to be from Mars, scientific attitudes are changing. And the public seems hungry for more. Visionaries are beginning to talk of Mars as the next frontier. Engineers have developed low-cost solutions to get us there. Scientists are even talking about terraforming Mars — transforming it into another Earth.

Meanwhile the Face on Mars waits patiently for us. It has waited for millennia. It can wait a little longer.

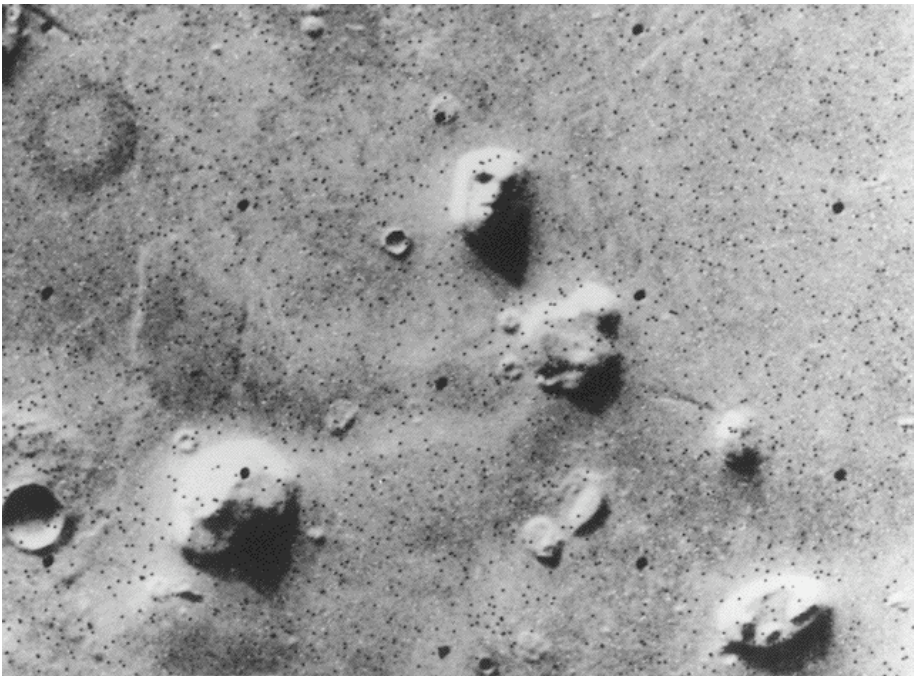

Figure 1 Original picture of Face on Mars released by NASA in July 1976. Batch processing of the image has completely obliterated all facial detail. (NASA)

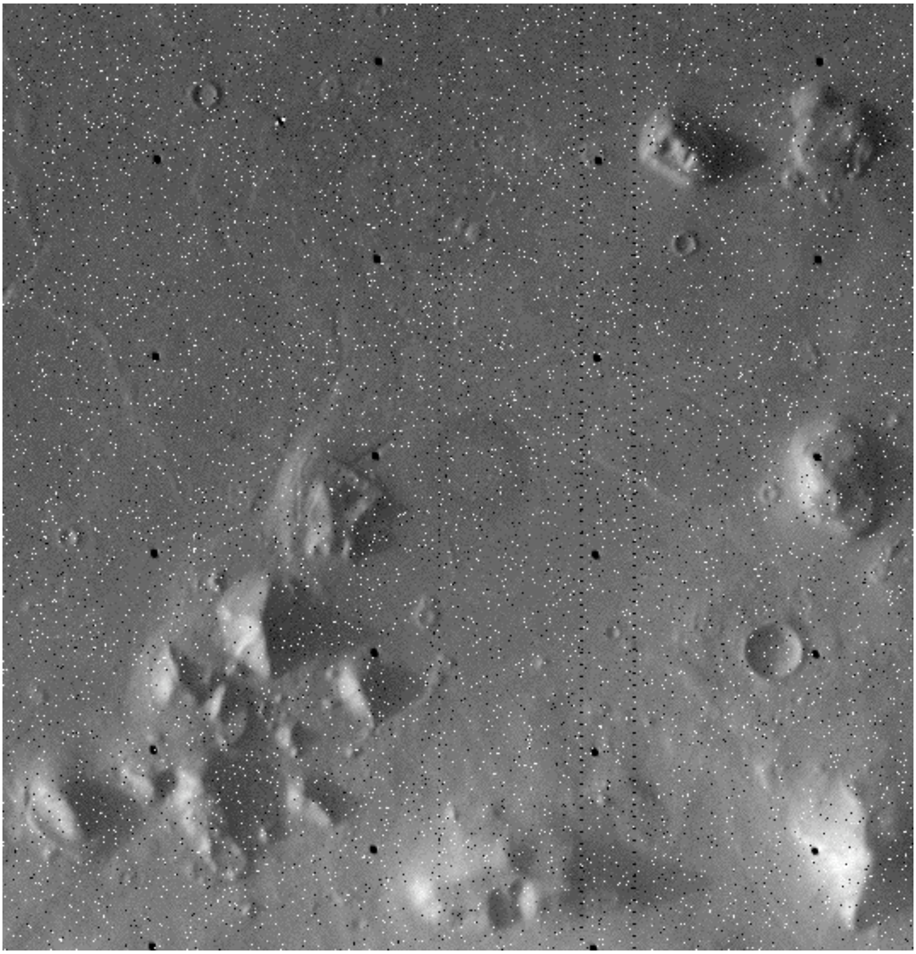

Figure 2 Larger portion of the original Viking Orbiter image showing the Face and nearby structures. By reducing the amount of contrast enhancement, the Face becomes more interesting. It is curious that no one noticed any of the nearby structures which in some ways are even more unusual that the Face itself.

Return of the Martian Canal Builders

Our interest in Mars is a relatively recent phenomena. It began late in the 18th century as gradually improving telescopes showed Mars to be like earth in some ways. This touched off speculation about life on Mars which grew in the 19th century and led to the great Martian canal controversy. And almost a century later the canals still haunt us.

Shortly after the Face was first imaged in the summer of 1976, the noted geologist Harold Masursky quipped, "This is the guy that built all of Lowell's canals." Most planetary scientists seem to agree with Hal Masursky, Carl Sagan, and others who say the Face on Mars, like the canals, is an illusion. According to Sagan, "Lowell always said the regularity of the canals was an unmistakable sign that they were of intelligent origin. This is certainly true. The only unresolved question was which side of the telescope the intelligence was on."

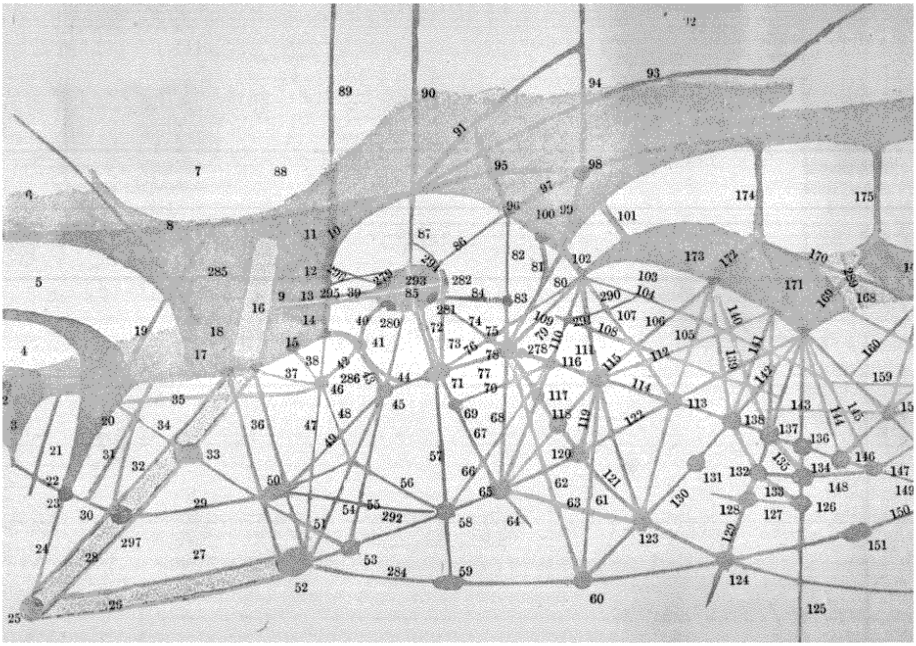

Figure 3 Portion of an early map of Mars drawn by Percival Lowell showing the canals.

While some planetary scientists are open to the possibility that the Face and nearby objects may be artificial, that they deserve a closer look, most either do not, or will not see the Face as anything other than a strange looking rock formation. While this may seem strange, it is, in fact, to be expected. According to Thomas Kuhn in his book the *Structure of Scientific Revolutions*, normal science is based on paradigms, ways of looking at the world. "No part of the aim of normal science is to call forth new sorts of phenomena; indeed those that will not fit into the 'box' [that the paradigm supplies] are often not seen at all."

A large fraction of the planetary science community is made up of geologists. And geologists see Martian surface features simply as geology. They do not see the possibility that the Face might be artificial because they can not. It lies outside of their discipline.

Other scientists refuse to see the Face as an artificial object because its existence would undermine their world view. If it is artificial then either it was built by a technological civilization native to the planet, by visitors from outside of our solar system, or by a previous technological civilization from Earth.

So they ask, how can there be a human face on Mars? At best Mars was wet and warm for its first billion years. It took five billion years for life to start and evolve on earth to its present form. How could the same thing have happened on Mars in only one billion years?

Or they ask, if it was constructed by visitors from outside of our solar system, why did they pick a human face? Were they humanoid? Whether they were Martians or visitors from outside of our solar system, the human form creates another problem. According to Darwin, evolution does not follow a predefined path. It seeks no goal. Perhaps it is even random. So how can the same form evolve on two different planets, each with radically different histories?

Or, they ask, how could it have been built by an earlier race of humans from Earth. They speculate that it is millions, perhaps, billions of years old. But even if it is only tens of thousands of years old, how could it have been built by men who were just discovering stone tools at the time? They say that there is no evidence of an earlier advanced technological civilization on Earth. Yet there are many ancient mysteries that we still cannot explain.

If the Face on Mars is artificial it will trigger a major paradigm shift. And science has historically resisted such shifts. This too must be factored into what is happening. Could the desire to protect the paradigm cause some scientists to be a little too zealous? To bend the rules of the game a little? Not merely to be skeptical but to go on the offensive and try to discredit those who believe the Face may be artificial. To distort the truth a little. Never to mention certain researchers by name — researchers who have actually subjected their work to peer-review and have had it published in technical and scientific journals. Research that presents strong evidence about not just one isolated anomaly, but a collection of unusual formations. The diversity of which is hard to explain.

Or could the desire to protect the paradigm cause other scientists to go into a state of denial, to say the Face can't be there so it isn't? To make the whole matter into a joke?

I raise these questions because many people look to scientists for answers. What should I think about this face on Mars? Could it be real? What does it mean? If science ridicules the Face on Mars, so will the people who rely on these scientists to help them sort out the facts. They too will think that it is just a joke. Undoubtedly they will be entertained by tabloid accounts of ruined temples on Mars, the voice of Elvis Presley emanating from the Face on Mars, and other such nonsense. But ultimately they may be misled.

So what evidence does exist to support the claim that the Face and other nearby objects on Mars are artificial in origin? The late astronomer Carl Sagan's famous quote, "Extraordinary claims require extraordinary evidence," place the responsibility for providing the evidence on the individual or group which makes the claim. Most will admit that there is no single piece of direct evidence, no "smoking gun," to support the claim for artificiality. But what about circumstantial evidence? Evidence that can have other interpretations. So how much evidence is there? Just a few interesting coincidences, or is there more?

The recent announcement concerning the possible discovery of fossilized micro-organisms in a meteorite has sparked tremendous interest in Mars exploration. This is certainly an extraordinary claim. But is the evidence that extraordinary? Some scientists say no. Even the researchers admit that each individual piece of evidence has other interpretations, and that their conclusion is based on not one piece of direct evidence (a live microbe) but on several pieces of indirect evidence pointing to the same conclusion. It is the convergence of circumstantial evidence that leads them to conclude that they have found a fossilized microbe.

But the point here is not whether the evidence is strong or weak but rather that the question of microbial life is being debated at all. In other words, why is the search for microbes more scientific than that for artificial structures? Perhaps because finding microbes is less likely to upset the paradigm than the discovery of a mile long humanoid face on Mars.

Since the early 1960s, radio-telescopes have been used to search for signals from outside of our solar system. The search for extraterrestrial intelligence (SETI) is predicated on the assumption that there are a sufficient number of advanced technological civilizations in the galaxy to warrant such a search in the first place. Could a small number of these technological civilizations have developed the technology for space travel, and one of them, in the distant past, visited our solar system, perhaps Mars, and left artifacts on its surface? One would think that if the search for extraterrestrial radio signals is a legitimate scientific endeavor, why isn't the search for extraterrestrial artifacts? Again, could it be that the discovery of radio signals from a star system many light years away would be much less threatening than the discovery of real physical artifacts practically next door to us on Mars?

So aside from the possibility that the Face on Mars could upset many of our treasured paradigms, why isn't the study of the Face scientific? Clearly the phenomena itself is within the realm of science. The hypothesis that the Face is artificial is falsifiable. It can be tested.

Some scientists say the imagery is too blurry, not detailed enough to support the claim for artificiality at this time. That it is only through a magical thing known as "image processing" that one can be made to see. And what one then sees is not really there. It is noise in imagery enhanced through the improper use of image processing techniques. But is that really the case? Have so many people been simply the victims of "wishful seeing," of having their perceptions biased by their expectations, by what they want to see?

Perhaps it is the methods that have been used or the reasoning of the researchers that is unscientific. But what if the methods have actually been tested. For example, what does one make of a mathematical technique which detects manmade objects in terrestrial satellite imagery that happens to find that the Face is the least natural object within this part of Cydonia? Or the results of a three-dimensional analysis of the Face that shows that it retains its appearance over a wide range of lighting conditions and perspectives? In other words, that it is not an optical illusion?

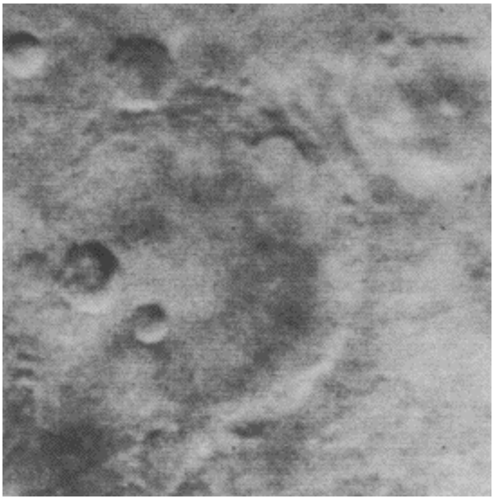

Figure 4 First picture of Mars taken by Mariner 4 spacecraft in 1965. (NASA)

The Face on Mars reminds some scientists of the great controversy over the canals on Mars (Figure 3) around the turn of the century. With gradually improving telescopes, astronomers were beginning to see indications of subtle Martian surface features for the first time. For many, their eyes integrated these subtle patterns into linear features. Some even interpreted these lines to be waterways built by Martians to distribute water over their dried out and dying planet. But then as the telescope continued to improve, astronomers began to realize that the canals were an illusion after all. Many of today's scientists believe that this is exactly what is happening when it comes to the Face on Mars. That higher resolution images will prove the Face and other objects to be natural rock formations.

Perhaps. But opinions about the possibility of life on Mars have changed dramatically over the years — from Percival Lowell's canals, to the dead planet imaged by the early Mariner probes, to the enormous volcanoes, great canyon systems, and channels carved by water discovered by Mariner 9 and later confirmed by Viking.

One lesson is clear, particularly when it come to Mars: be prepared for the unexpected.

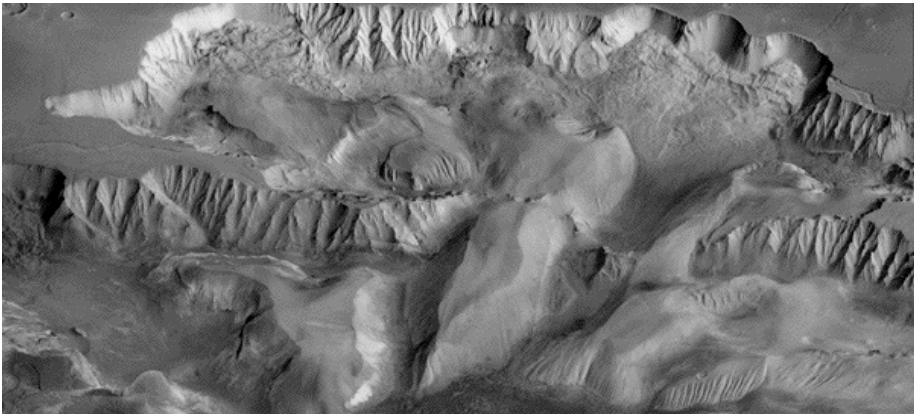

Figure 5 Candor Chasm generated from Viking Orbiter imagery shows its complex geomorphology, shaped by tectonics, mass wasting, wind, and perhaps by water and volcanism. (USGS)

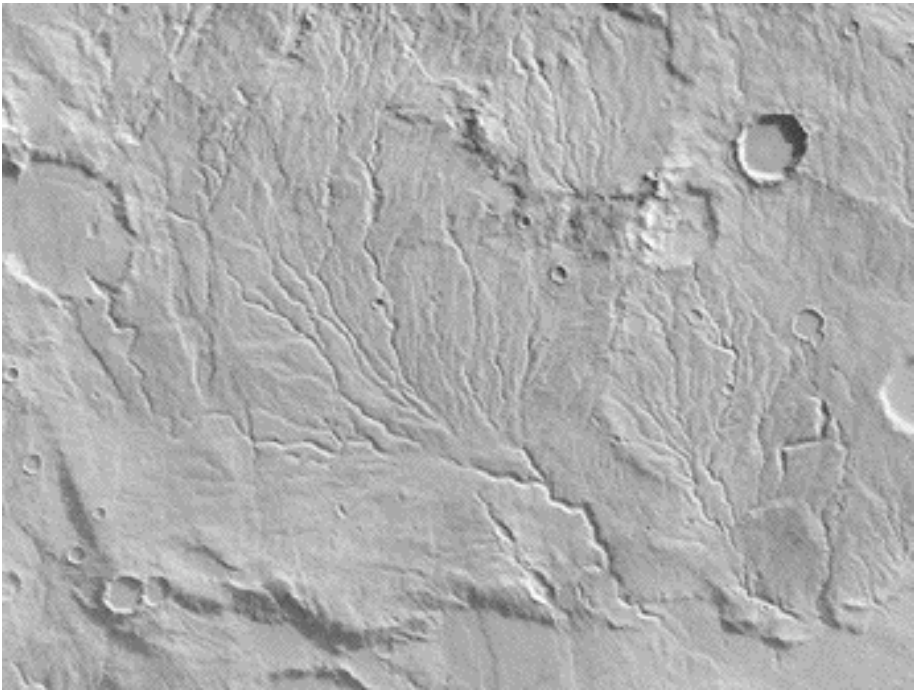

Figure 6 Valley network on Mars resembling terrestrial drainage systems where channels merge together to form larger channels. (USGS)

II. REDISCOVERY

"The discovery of life on Mars would be hailed as one of the most significant discoveries of the 20th century." — Norman Horowitz, 1986

In July 1976, one of NASA's Viking Orbiters acquired an image of what appeared to be a humanoid face staring straight up into space from the surface of Mars (Figure 7). The Martian face was located in a region known as Cydonia (pronounced sid-DOE-nee-ah) in the planet's northern hemisphere, which initially had been considered as a possible landing site for Viking (Figure 10). At first there was some excitement; but then, according to NASA, a second image that was reported to have been acquired several hours later over the same area showed nothing unusual. As a result the feature was dismissed as an apparition — an oddity of light and shading — and was soon forgotten.

Several years later two engineers working at NASA's Goddard Space Flight Center, Vincent DiPietro and Gregory Molenaar, rediscovered the forgotten image of the Face while searching through the archives of the Viking mission at the National Space Science Data Center (NSSDC). Upon undertaking their own investigation they found, misfiled in the NSSDC archives, a second, corroborating image of the Face taken at a slightly different sun angle, not several hours but thirty five orbits later (Figure 8). They also noted that several hours later would have been well after sunset and that the Viking orbiter would then have been at quite some distance from Cydonia.

DiPietro and Molenaar's own digital image enhancements showed the Face to be a reasonably bisymmetrical object having well-defined features that suggested eyes, a ridgelike nose, a mouth and a surrounding headpiece or helmet. The visage seemed structurally and aesthetically sophisticated compared to the cartoonish, two-dimensional "faces" found in random landforms both on Mars and on Earth. Although the work was conducted in a technically responsible manner, because of its controversial nature, their findings were published independently of the planetary science community [1].

Initial criticism of DiPietro and Molenaar's findings centered on the human tendency to find faces everywhere. In other words, finding a feature that resembles, to whatever degree, a humanoid face in isolation on Mars tells us nothing. But in a subsequent investigation motivated by their work, other objects were found that seemed to be related to the Face [2]. In particular, science writer Richard C. Hoagland, of the Independent Mars Investigation Team, noticed that the Face appeared to be aligned with a collection of roughly pyramidal objects to the southwest that did not appear to fit the geology of this part of Cydonia. He termed it the "City," and went on to show that solstice alignments between the Face, key objects in the City and other nearby anomalous features are satisfied approximately every million years, the last alignment having occurred about a half-million years ago. Others observed that the City and the Face were located near the apparent shoreline of an ancient northern sea that once may have existed on Mars.

These and other results of that study were presented in 1984 at the *Case for Mars* conference in Boulder, Colorado. Critics responded that artificial objects could not occur on Mars because no life, let alone a technological civilization capable of creating such objects, could possibly have developed there in time according to current theories. Neither could the possibility of interplanetary colonization be taken seriously.

Meanwhile the independent investigation had continued to enlist broader interdisciplinary support in other technical and scientific communities. Early in 1985 I received several computer tapes containing some twenty Viking Orbiter images of the Face and other interesting objects, and began to produce state-of-the-art enhancements using the best available image processing techniques. This chapter contains much of this early work, which later appeared in books by Pozos [2] and Hoagland [3].

The Viking Mission

Viking I and II (sometimes referred to as A and B) were identical spacecraft, each consisting of an orbiter and a lander. One of the Viking mission's mandates was to determine whether life existed on Mars, now or in the past.

When Viking I reached Mars in the Summer of 1976, it settled into an egg-shaped orbit synchronized with the planet's 24 hour, 37 minute rotation. At periapsis (its closest approach to the planet's surface), the orbiter switched on its two electronic cameras and recorded a long swath of overlapping pictures that were later beamed to Earth somewhat in the manner of a television transmission.

NASA knew from its earlier Mariner missions that Martian terrain is rugged. One of the purposes of Viking's mapping of Mars was, therefore, to determine safe touchdown sites for its landers, as free as possible of potential hazards such as boulders and crevasses. Since Viking's cameras could only resolve (distinguish) objects larger than about 50 meters (150 feet) during this phase of the mission, it took most of its pictures in the late afternoon when small features would cast long shadows, making potential landing obstacles more easily visible.

Viking's transmissions were received at the Goldstone Tracking Station in California's Mojave Desert and fed in real time to the Jet Propulsion Laboratory (JPL) at the California Institute of Technology in Pasadena. There they were converted into over 60,000 photographic negatives, each about five inches square and each representing about a thousand square miles of the Martian surface when taken at Viking's lowest orbital altitude. The contact prints made from these negatives were intentionally produced with relatively high contrast in order to make landing hazards and other features stand out more visibly. While this technique made the Face easier to notice, it also tended to suppress any fine detail.

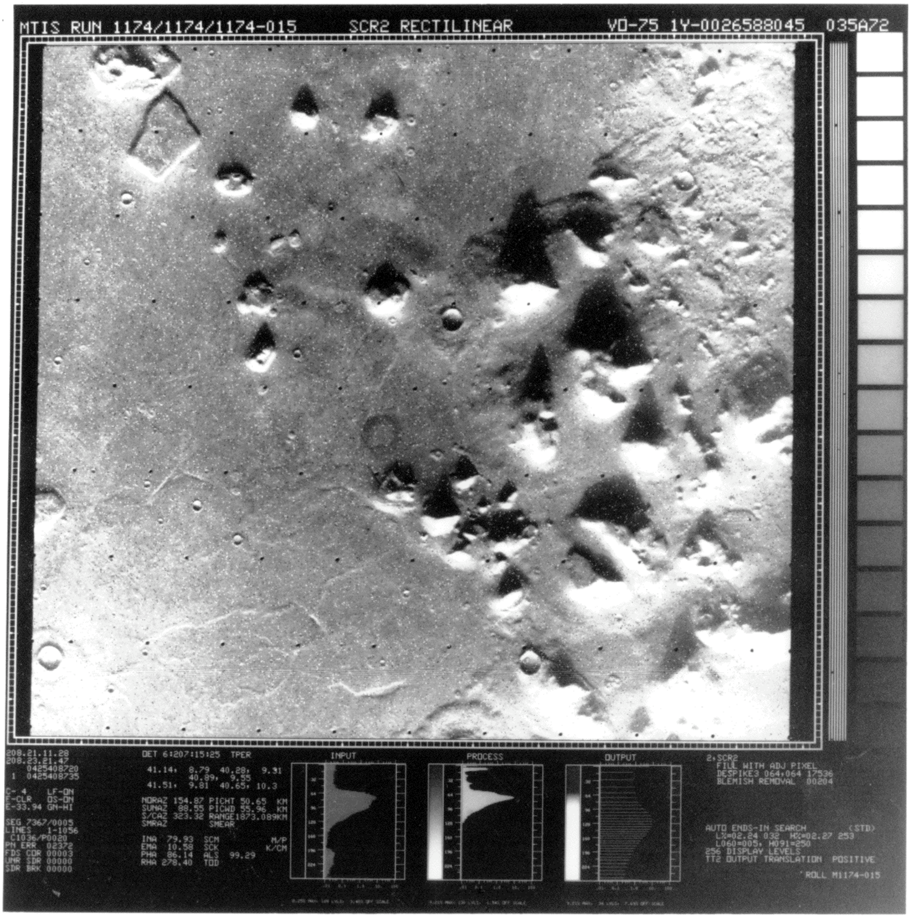

Figure 7 The original image, 35A72, showing the Face (inverted, just above and left of center). The image was taken late in the afternoon during the Martian summer with the sun at about 10° above the northwestern horizon. The image covers an area about the size of the state of Rhode Island. It is noted that if the Face was artificially constructed from the ground up it would be a relatively large structure by our standards: 2.5 km long (roughly 1.5 times the length of San Francisco's Golden Gate Bridge) by 2 km wide, by about 400 meters high at its highest point (about as tall as New York City's World Trade Center) as indicated by the length of its shadow. If the product of landscaping alone, it would approximate in magnitude many of Earth's great civil engineering projects.

Viking's images are identified by their frame number. For example, 35A72 was taken on the thirty fifth orbit by the "A" spacecraft, and was the seventy second image taken during that orbit. Frames 35A72 and 70A13 are the highest resolution (most detailed) images available of the Face and were taken near periapsis when the spacecraft was about 1500 kilometers from Mars. At that altitude the image resolution at the Martian surface was about 50 meters per pixel. The other frames are much less detailed, taken near apoapsis (the highest altitude achieved in Viking's elliptical orbit) approximately 33,000 kilometers away [4].

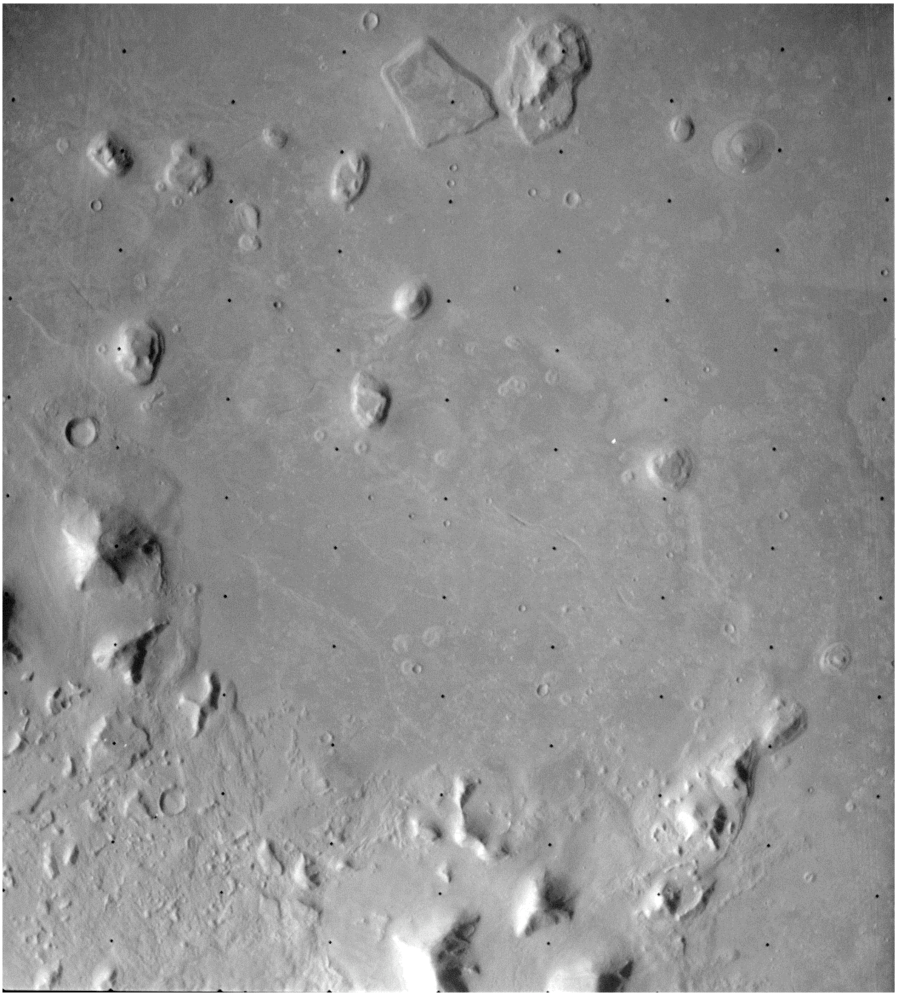

Figure 8 The second image, 70A13, containing the Face (upper left), found by DiPietro and Molenaar several years later. This image was acquired 35 orbits (about 35 Martian days) later with the sun about 17° higher in the sky. In this image, more of the right, shadowed side of the Face is visible.

Only a few images of the Face on Mars are known to exist: 35A72 (the original image discovered at JPL), 70A13, (the second image, found by DiPietro and Molenaar), and several other lower resolution images taken later in the mission: 673B54, 673B56, 753A33, and 753A34 (Figure 9). As far as is known, no enhancements, enlargements or contrast controlled prints of the Face were produced by NASA for purposes of study or analysis. The discovery frame, 35A72, was displayed momentarily as a curiosity, then simply filed away.

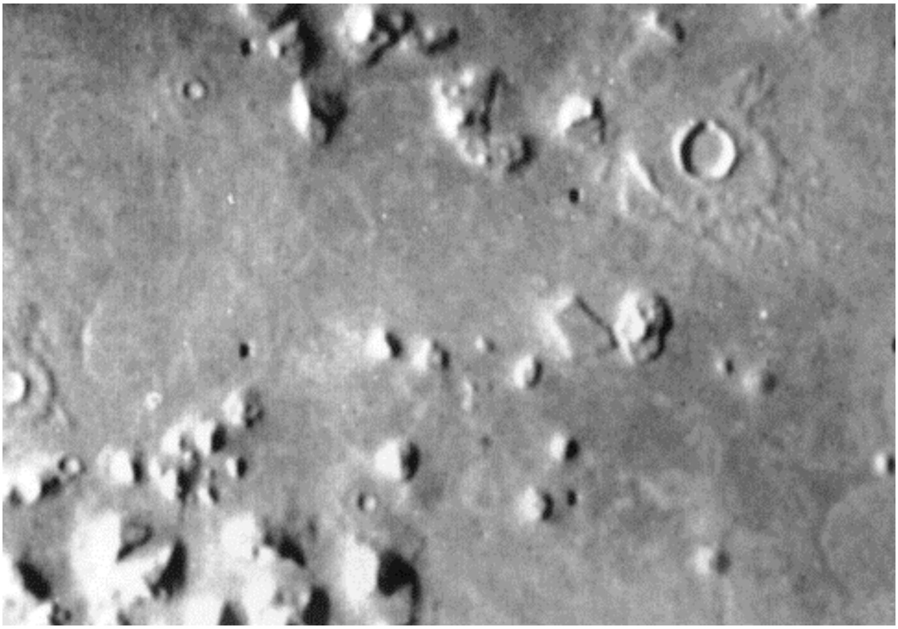

Figure 9 Portion of 673B56. This image was taken several years later. At this point in the mission, The orbiter passed over the Face near apoapsis so the resolution (about 1 km per pixel) is considerably less than in the previous images. The City and Face are in the lower part of the photograph, left of center.

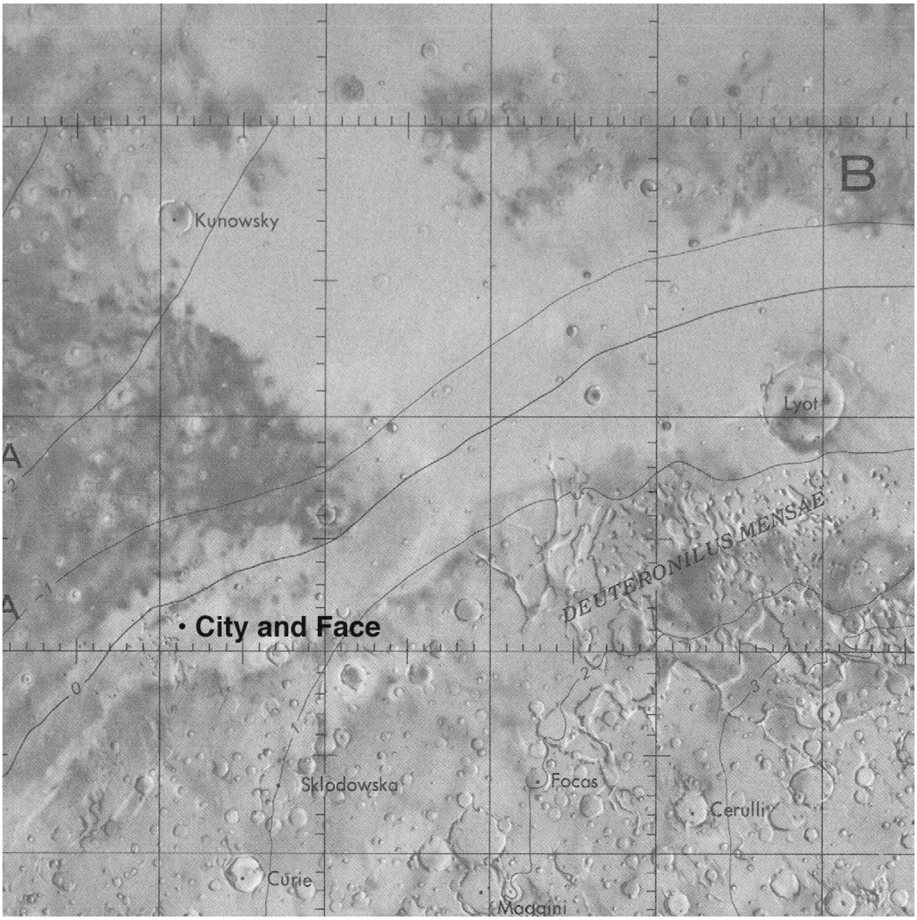

Figure 10 Portion of topographic map [5] showing the approximate location of the City and Face. These features are located in the region of Mars known as Cydonia Mensae near the end of a chain of eroded mountains bordering Acidalia Planitia and the northern plains. It is a region containing a variety of flat-topped prominences with cliff-like walls (mesas) and conical hills or knobs [6]. Mesas are 5–10 km wide and are thought to be remnants of cratered plateau material that was later stripped back by erosional processes. Knobs are smaller, about 2 km across, and might be isolated hills with a shallow apron around the base or be on the tops of mesas. No single mechanism has been suggested for their origin. Geologically, the formation on which the Face appears is considered to be a knob. Brandenburg [2] has suggested that the City and Face would have been near the shoreline of an ancient ocean during earlier watery epochs on Mars. Such speculation is based on the proximity of these objects to the 0 km mean elevation contour and signs of water channels nearby.

Image Restoration

Each picture captured by the Viking cameras is composed of an array of 1182 by 1056 dots or pixels (picture elements). The value of a pixel represents the brightness at that point in the image. Viking's imaging systems converted the value of each pixel into a sequence of seven binary digits (zeroes or ones), usually called bits, that were transmitted to earth one at a time. On earth, these sequences of bits were translated back into the original value for each pixel, and the pixels then reassembled into a picture.

Due to radio noise, errors can occur in the transmission of data from Mars to Earth. For example, if a pixel's brightness value is 100 it will be represented by the seven bits 1100100. If an error occurs and the first bit is received as a zero instead of a one, the value will change to 0100100 which in binary (base 2) mathematics equals only 36 and will therefore appear much darker than it really is. If enough errors occur, the net result in the reassembled picture will be "salt-and-pepper" dots scattered randomly over the image (Figure 2).

Since these errors are caused by random noise, it is not possible to recover the true pixel values. The missing values may, however, be inferred from the values of adjacent pixels since brightness values usually change slowly enough across an image. This is accomplished by means of an image restoration algorithm that detects pixels that may be in error and replaces their value by some combination of the values of surrounding pixels (Figure 11).

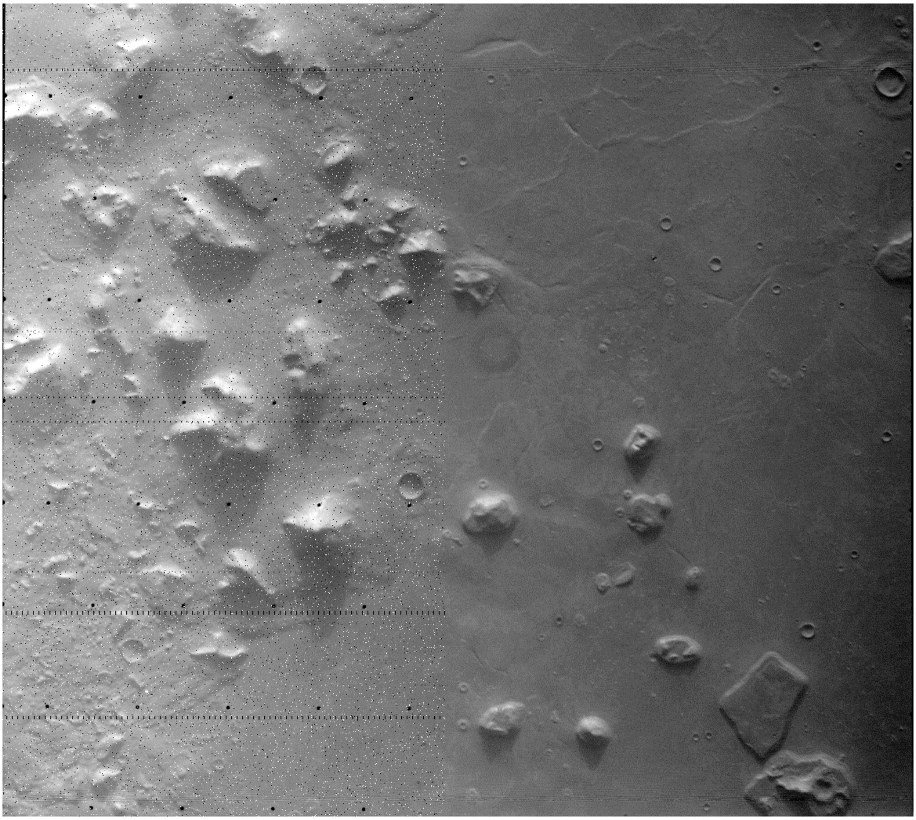

Figure 11 Frame 35A72 is shown here partially processed by an image restoration algorithm. The left side contains the raw data, in which transmission errors have created the impression of "salt-and-pepper" noise. The right side of the image has been "cleaned up" by the algorithm.

Image Magnification

The ground resolution of a satellite imaging system depends on the resolution of its imaging sensor, the focal length of the camera lens (whether it is relatively "wide angle" or "telephoto") and the altitude of the spacecraft above the surface. When the Viking Orbiter acquired frames 35A72 and 70A13 its altitude was approximately 1500 kilometers and its ground resolution was about 50 meters per pixel. In other words, objects 50 meters across would have been just visible but completely lacking in detail. At this resolution, the Face occupied a very small portion of the image (about 64 by 64 pixels) and had to be magnified for detailed analysis.

In order to magnify digital images, additional pixels must be added and their values determined (Figure 12). The simplest way to do this is by repeating pixel values. For example, to magnify an image to twice its original size, every pixel value can be repeated once in the horizontal and vertical directions. The result, however, is simply a larger image composed of larger pixels, which looks "blocky" and is not very appealing. A better method is to calculate intermediate pixel values, once again using some combination of their surrounding values. For example, bilinear interpolation uses a pixel's four nearest neighbors and produces results that are smoother than pixel replication but tend to be blurry. Cubic spline interpolation, which uses the values of twelve neighboring pixels, produces somewhat sharper results and was used to enlarge most of the images in this book.

While the visual quality of one interpolation technique may appear to be better than that of another, none of these methods can actually increase the amount of information over that in the original image. In fact, using too high an order interpolating polynomial can lead to the introduction of spurious features.

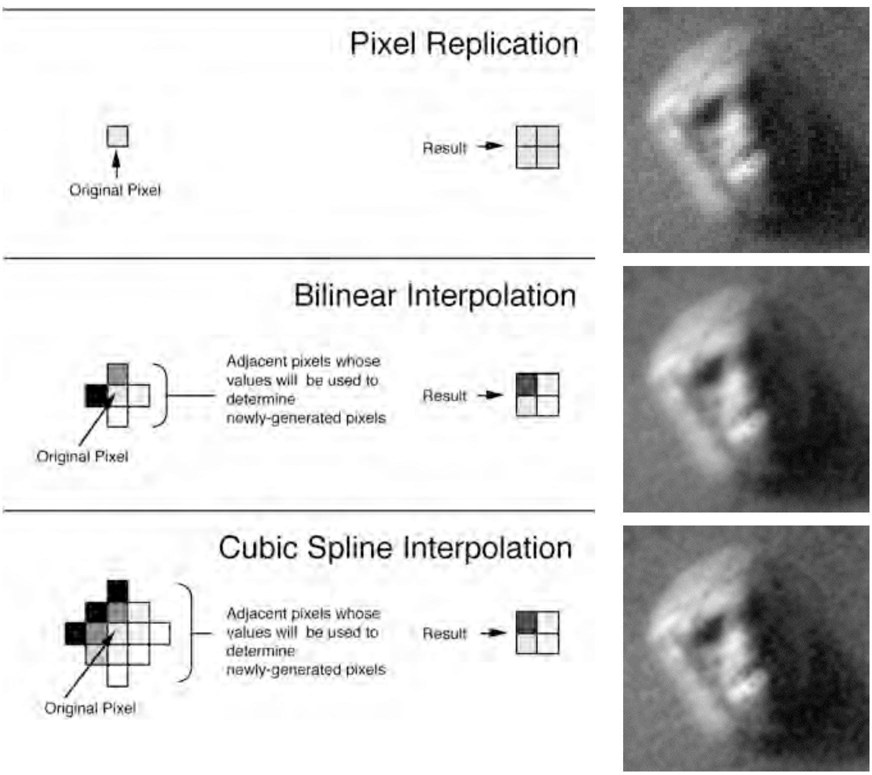

Figure 12 Digital image interpolation techniques (left). Comparison of pixel replication (nearest neighbor), bilinear, and cubic interpolation techniques (right).

Image Contrast

Next to resolution, contrast is perhaps the most critical factor determining the intelligibility of an image (Figure 13). It is also often the most poorly understood by the general public and even by many otherwise well-informed and well-intentioned researchers. Over the past decade, numerous misunderstandings of the Martian anomalies have been traced to high contrast reproductions of the Viking photos in newspapers, magazines and books. For example, a number of spurious "faces" and "pyramids" have been "discovered" only to prove, upon closer examination, to be artifacts of excessive contrast (Figure 14).

The actual contrast of any scene is determined by many factors including the size, distance, direction and number of light sources, and the reflectance and texture of objects in the scene. For example, "space-walk" pictures taken on manned space missions away from the earth's sunlit side tend to have high contrast because there is only one narrow light source (the sun), little or no light coming from other directions to fill in the harsh shadows, and subjects with highly reflective — usually white — surfaces. As a result the overall shapes of objects stand out in bold relief, but frequently at the sacrifice of fine detail. Often the bright sides may be too bright, and the dark sides too dark, to be encompassed by the dynamic range (the acceptable ratio of dark-to-light, also called the gamma range) of the imaging or photographic system and may therefore appear as broad, featureless areas. At the other extreme would be a snapshot taken on an overcast day. The lack of surface shading and cast shadows would now tend to make objects seem unnaturally "flat" — lacking in depth and definition. However, all elements of such a scene would fall well within the dynamic range of any imaging or photographic system.

Figure 13 These prints illustrate five grades of contrast. The highest contrast represented here approximates that of NASA's print of Viking frame 35A72 in which the Face originally appeared.

Viking's cameras had a dynamic range of 128 to 1; however, paper photographic prints cannot encompass that great a range. To translate Viking's digital transmissions into printable negatives the extreme values must be brought toward the middle. At the same time, the relative values in low contrast areas must be made somewhat more extreme so that small surface details can be more easily distinguished. Ideally, the end result is a single print that has drawn together all the important information contained in the bright highlights, dark shadows and middle-tones of the original scene.

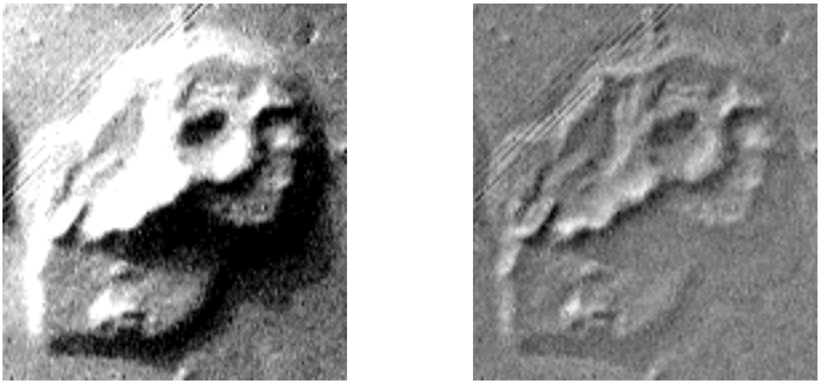

Figure 14 The "Key," an eroded mesa southeast of the Face. Due to excessive contrast in NASA's reproductions (left), this formation has often been erroneously identified as another "face." Careful control of contrast (right) can minimize the possibility of such misidentification.

Digital Contrast Control

Contrast control of Viking's images begins with the digital readjustment of pixel values. Where overall contrast is, for example, too low, the simplest method of improving it is to "stretch" the range of brightness values. This is known as a global contrast stretch because all pixels, regardless of their location in the image, are treated the same way (Figure 15). Where particular regions require different adjustments, a local contrast stretch enhances the image adaptively; in other words, regions where the contrast is already high are not affected as much as regions (such as those within shadows) where the contrast is low. One way to adjust contrast locally is 1) to blur the original image — this provides a local measure of average brightness, 2) to subtract a portion of the blurred image from the original image — this equalizes the average local brightness, and 3) to multiply the difference by a constant scale factor — this increases the local contrast.

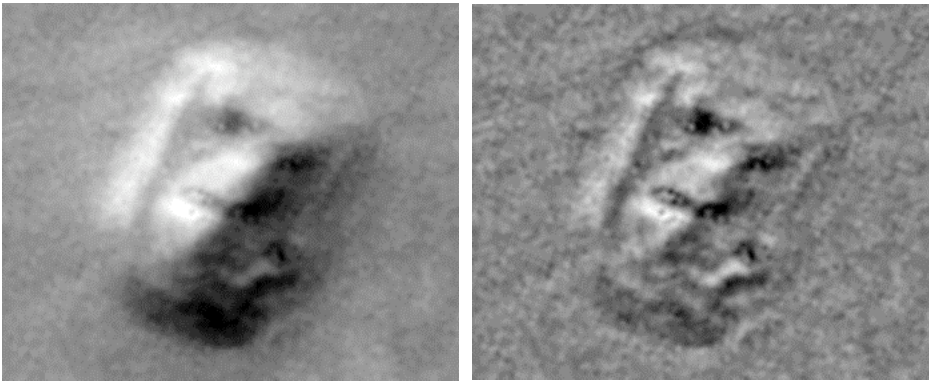

Figure 15 Global digital contrast control (left) and local digital contrast control (right).

Figure 16 Printing contrast: To reveal highlight details in the negative, the print must be overexposed (left). To reveal shadow details it must be underexposed (right). To reveal the full tonal range, the printing paper must be exposed selectively, with lighter areas receiving greater exposure and darker areas less (middle). General and local contrast control may also be applied by various means. It should be pointed out that when a photograph is itself rephotographed or photocopied the contrast of the copy is always higher than that of the original. Copies of copies are yet more contrasty, and so forth, so that a progressive loss of detail in the highlights and shadows is experienced with each succeeding "generation." This is one reason why photographic enlargements intended for study or analysis must be made exclusively from original ("first generation") negatives.

Analog Contrast Control

In preparing the photographs for this book, the greatest possible care was taken to ensure optimal contrast control in the analog photographic domain after the digital processing was completed. The digital imagery was first displayed on a high-resolution video monitor and photographed onto fine-grain 35mm Plus-X and T-Max films. Several exposures were made of each image, and after careful development the best exposure was chosen for printing (Figure 16). Since photographic printing paper has a much narrower dynamic range than negative film, conventional darkroom techniques were employed to ensure a minimal loss of highlight and shadow information in the definitive master prints. The technology and economics of book printing provide further challenges to maintaining good contrast control; reproductions in previous publications on this subject have been qualitatively inconsistent and even the present volume cannot do complete justice to the master prints. Had it been economically feasible, some actual photographic prints (or, ideally, transparencies, which have a greater dynamic range than prints), would have been included in this book.

Image Processing Results

The enhancements performed on the images of the Face from 35A72 and 70A13 reveal subtle features not obvious in NASA's original photographs: bilaterally-crossed lines above the eyes, fine structure in the mouth that some have referred to as "teeth," and regularly-spaced lateral stripes on the "headpiece" or "helmet" that have suggested to others a style found in the Pharaonic art of ancient Egypt. It is noted that these features appear in both of the Viking images and so could not have been caused by random noise or by artifacts of the image restoration and enhancement process [7].

It is apparent in these enhancements that the right side of the Face is either incomplete or degraded and is not a mirror image of the left. Those who support the intelligence hypothesis argue that the distortion could be due to meteorite impact, erosion over time, outright abandonment of the project or its intentional discontinuation upon achieving adequate recognizability as a face. Opponents are not surprised at the roughness in the symmetry of what they believe simply to be a naturally-formed mesa. It should be understood by all concerned that the original Viking data from the shadowed side of the Face contains very little information and therefore represents the weakest link in the chain of image reconstruction. Final judgments about the symmetry of the ridgeline and the nature of any fine detail in the shadowed side should be suspended until the Face can be photographed under more revealing illumination.

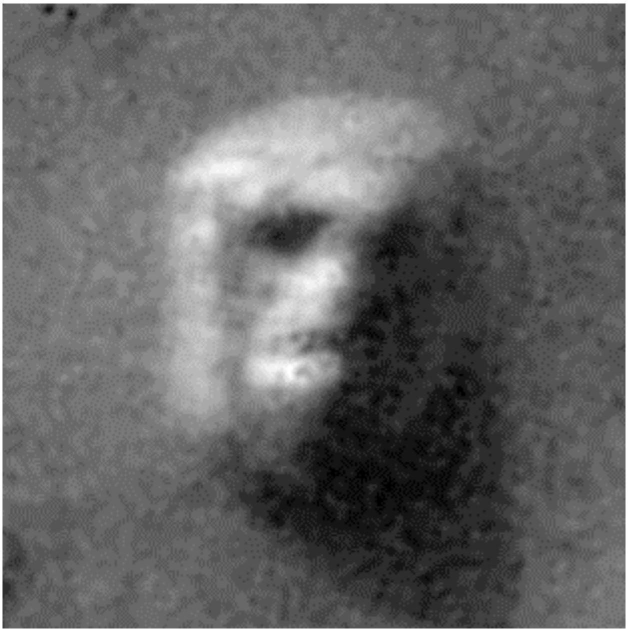

Figure 17 Face from 35A72 digitally magnified by a factor of nine and enhanced to clarify the more obvious details.

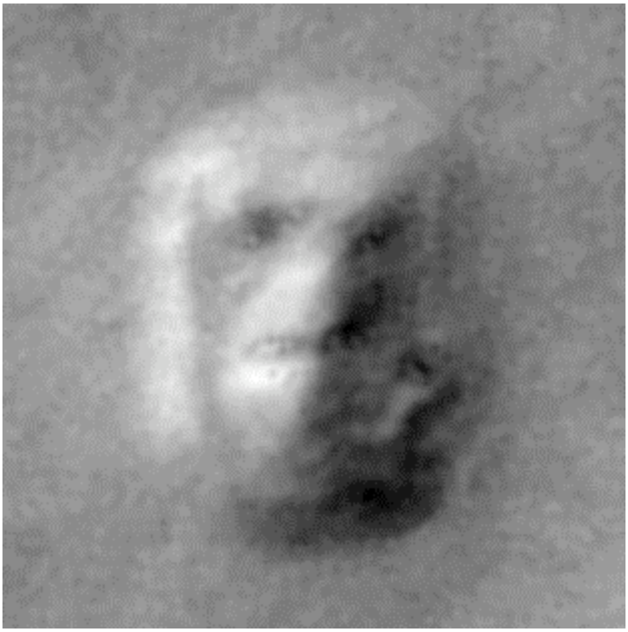

Figure 18 Similarly magnified and enhanced portion of Viking frame 70A13. The dark spot below and to the right of the mouth is a camera registration mark that was not completely removed by the image-restoration algorithm.

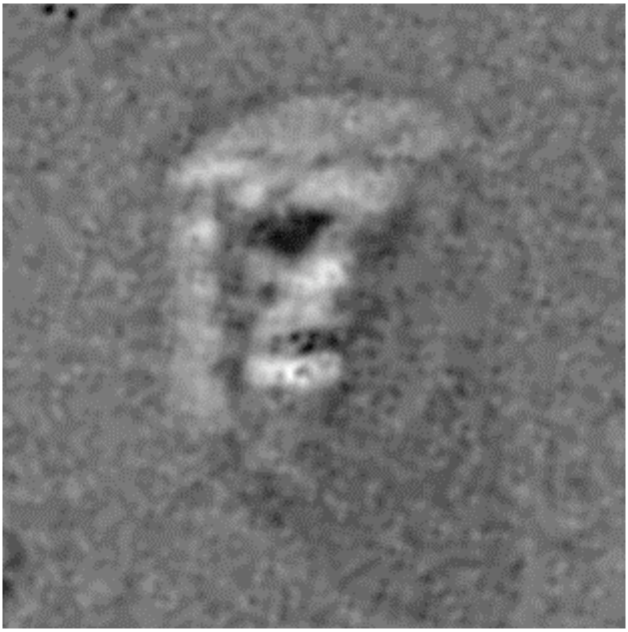

Figure 19 Linear features in 35A72 are emphasized here to better show the bilaterally-crossed lines above the eyes and wide lateral stripes across the side of the "helmet."

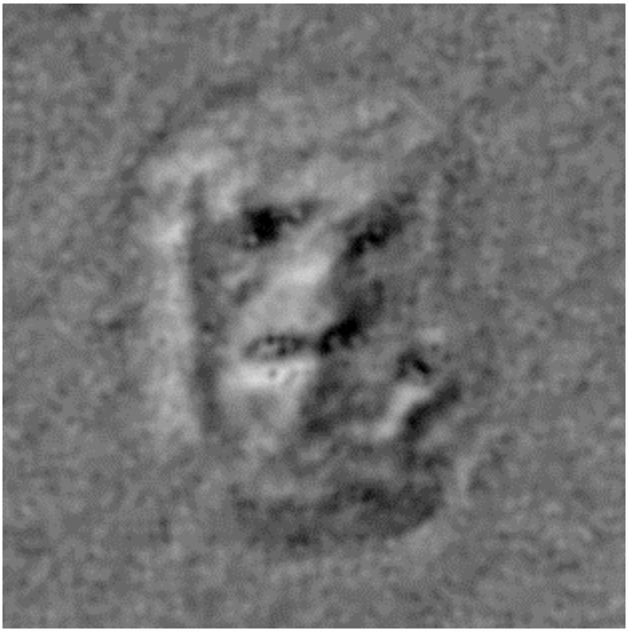

Figure 20 Contrast equalization performed on 70A13 shows subtle detail on the shadowed side of the Face that includes an apparent second eye socket and an extension to the mouth.

The Face and Nearby Objects

Soon after rediscovering the Face, DiPietro and Molenaar found other unusual objects nearby. Further discoveries by Hoagland and others followed later. Hoagland has argued that the proximity of such features to the Face increases the likelihood that this collection of objects is not natural. Moreover, he and Torun [8] have sought to strengthen the case for extraterrestrial intelligence based on the statistical improbability of certain observed relationships. For example, that direct alignments with the summer solstice sunrise (as found in prehistoric complexes on Earth) are satisfied among key objects in the Cydonia complex every million years; also that certain mathematical constants are redundantly encoded in the observed angular relations within and between certain objects, as well as in relation to their planetary coordinates (see Appendices A and B). Others, however, argue that such analysis is based on circular reasoning that assumes the intelligence hypothesis is true and searches until interesting relationships are found [9].

Figure 21 The "Fortress" from 35A72. In some ways more intriguing than the Face is this unusual trapezoidal object measuring about 2 kilometers across, dubbed the "Fortress." The object appears to include several wall-like sections including two straight sides enclosing an inner space. Two of the "walls" appear to contain regularly-spaced markings or indentations. The black mark to the right of the northeastern wall is the remnant of a camera registration mark.

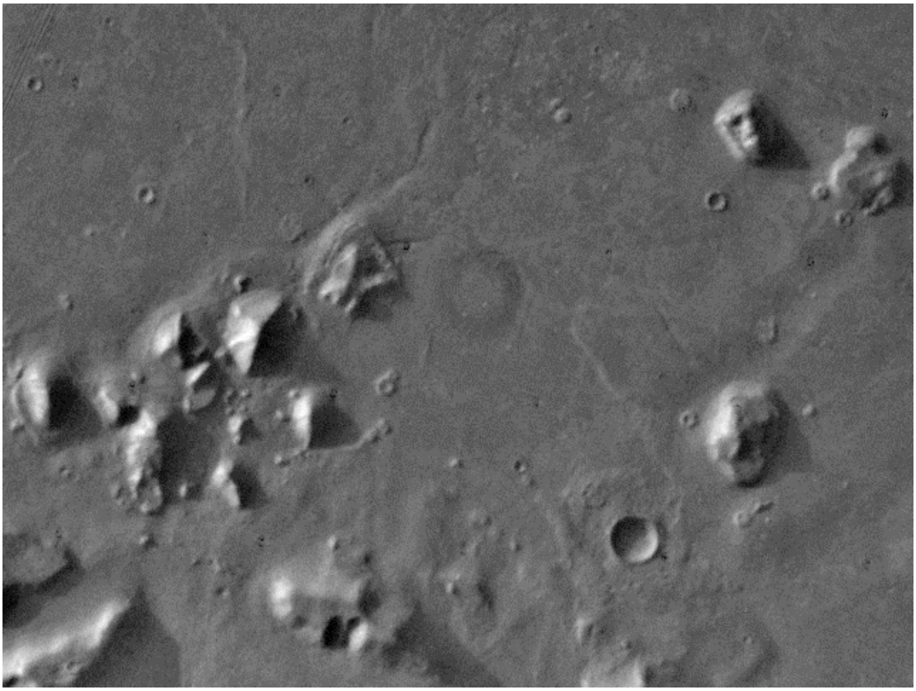

Figure 22 Digitally restored and contrast enhanced subscene from 35A72. The image is about 33 by 27 km in area and is oriented so that north is up. This view shows the Face along with a collection of polyhedral objects to the southwest known as the "City." Objects and their shadows, as well as subtle variations in the surrounding terrain, have been enhanced. The circular ring in the center of the photograph is caused by a water spot on the faceplate of the camera and does not represent a feature on the Martian suffice. Remnants of camera registration marks (a grid-like pattern of dots) that were not completely removed by the restoration algorithm can also be seen.

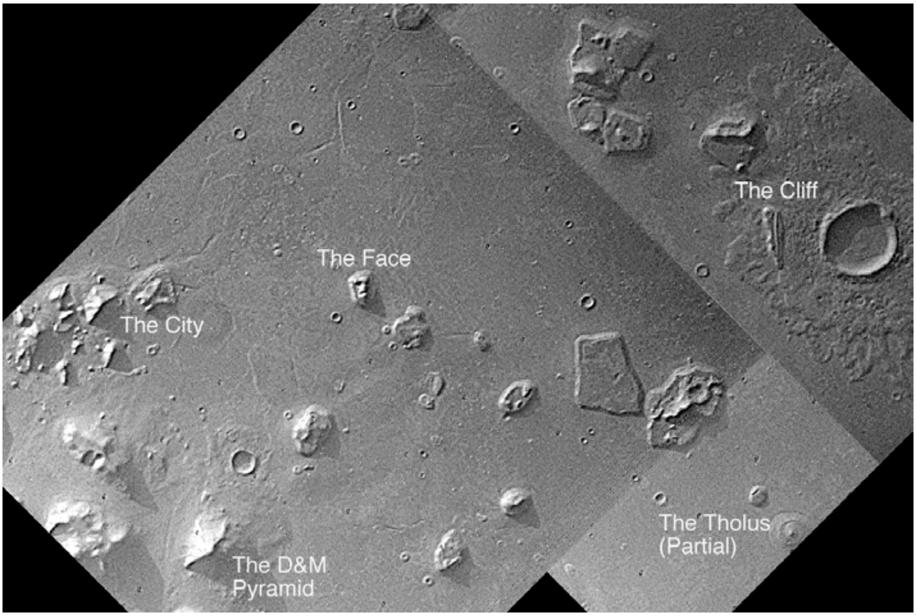

Figure 23 Overview of the Cydonia complex constructed from Viking frames 35A72, 73 and 74. The area shown is about four times that of the previous image and shows the principal objects of interest in the Cydonia region. In this image, high pass filtering reduces tonal variations across the image while emphasizing fine detail.

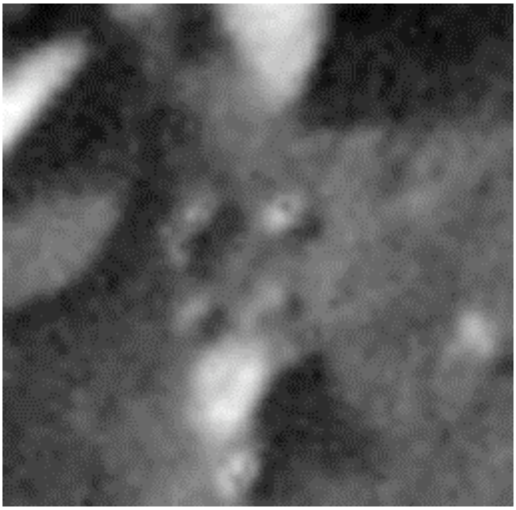

Figure 24 Enlargement of the "City Square," a grouping of four small mound-like features. The configuration is suggestive of a "crosshairs," and appears to be located at the exact lateral center of the City. An observer at this point would view the Face in perfect profile. This point has also been used as a key reference by Hoagland and Torun for their observations of the geometry of the Cydonia complex. The City Square is the point used by Hoagland to measure the summer solstice alignment.

Figure 25 The "Tholus" is geomorphological anomaly bears a striking resemblance to prehistoric earthworks found in the British Isles, particularly in its proportions and in details such as the distinctive peripheral ditch or "moat." Hoagland and Torun have argued that it constitutes a key point in the apparent geometric relationships observed in the Cydonia complex.

Figure 26 The "Cliff" is a peculiar mesa that rises 25-30 meters above a pancake-like "crater pedestal" (the surrounding ejecta blanket formed when the Martian permafrost was melted and ejected by the original cratering impact). Hoagland has demonstrated that the Cliff participates with the Face in solstice alignments and in several other angular and positional relationships. The Cliff's overall shape, surface texture and internal structure appear to differ markedly from that of the surrounding crater ejecta, which suggest that its formation post-dates the intense cratering impact. Supporters of the intelligence hypothesis theorize that if the object had pre-dated the impact, ejecta material would have piled up on the east side of the Cliff, displayed peripheral splash patterns and formed a "blast shadow" on the opposite side. However, the adjacent terrain on the crater side, rather than being piled-up. appears instead to have been hollowed-out — the opposite result to that expected from natural forces. This, and the striated or "plowed-field" effect between the Cliff and the crater, have fueled speculations about the quarrying of material for the Cliff's construction.

Figure 27 There appears to be a continuous groove or path originating in the hollowed-out area that rises ramp-like to the northeast end of the Cliff, turns and proceeds southward, then makes a final hairpin turn and terminates at the northwest end. This feature is made more obvious here by artificial foreshortening that simulates a view from the south at an angle of about 70° from nadir.

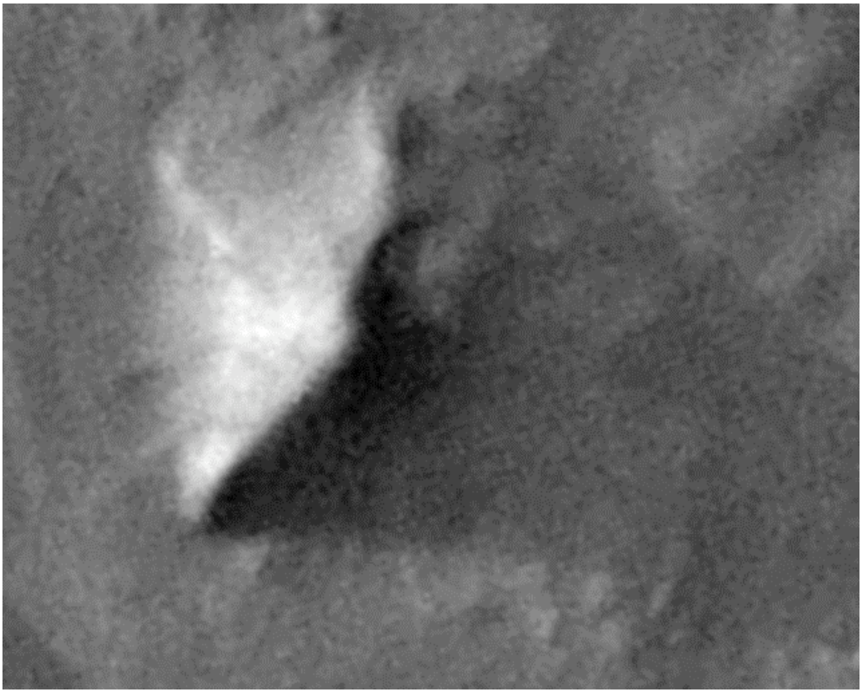

Figure 28 The D&M Pyramid as it initially appeared in frame 35A72. In this frame the deep shadow cast by the low sun contains almost no pixel value information. The result, even after the best digital processing, is a radical distortion of the object's shape and the near disappearance of the adjacent crater. It was not until the later discovery of frame 70A13 by DiPietro and Molenaar, and its subsequent study by Hoagland, that the structure's actual form became evident.

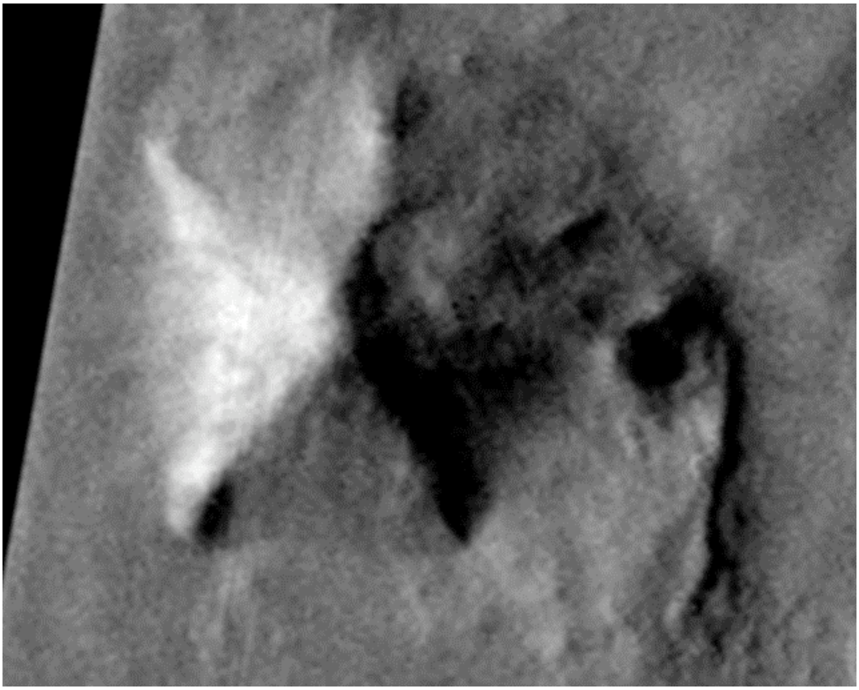

Figure 29 The D&M Pyramid from 70A13. Among the other objects first noticed by DiPietro and Molenaar was a pyramidal object south of the Face, subsequently christened by Hoagland the "D&M Pyramid" after its discoverers. Hoagland first observed that it appears to be a five-sided, essentially bisymmetrical structure that may have sustained some considerable impact damage, and that its apparent axis of symmetry points directly at the Face. More recently Torun [8] has studied the geomorphology of this object in detail and has argued that it could not have been formed by any known geological process.

Visible just to the east of the structure is a deep hole whose bottom, unlike that of most craters, cannot be seen. This feature has given rise to speculations involving explosive penetration — as if something had entered there and exploded inside the structure, creating the large domed uplift observable to the right of center, the apparent dislocation of the surrounding material, the debris flow around the structure on the eastern and southern sides, and the exfoliation of a semicircular area on the southernmost facet. Another noteworthy feature is a "cellular" structure or pattern (observable on the master photographic prints, though less obvious in these reproductions) through an apparent rectilinear breach in the Pyramid's northeast quadrant.

The similarity of the D&M's shape, when viewed from directly overhead, to that of a human figure with upraised arms has not gone unnoticed by those who favor the intelligence hypothesis, while others argue that humanoid forms, like faces, may be found wherever the human imagination is free to roam. Those who argue that the structure was originally bisymmetrical point out possible specific causes for its present shape; for example, that the apparent shortness of the right "leg" can be attributed to the deep debris flow around its base.

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III. 3-D ANALYSIS OF THE FACE ON MARS

"Isn't it peculiar what tricks of lighting and shadows can do. When we took the picture a few hours later it all went away..." — Viking project scientist, Gerry Soffen, July 1976.

From the beginning the planetary science community had dismissed the Face on Mars as a "trick of light and shadow," partly due to the apparent lack of corroborating imagery. Although DiPietro and Molenaar did find another picture of the Face, it was acquired under conditions generally similar to the first with the sun near the western horizon. Even though Mars was viewed by Viking under a variety of imaging conditions, no useful images of the Face other than 35A72 and 70A13 seemed to exist. Several lower resolution images (753A33, 34) of Cydonia and the Face acquired in the morning were found but contained too little detail for them to be of much use except in reconfirming the essential symmetry of the mesa on which the Face appears.

Early in 1986 I began an analysis of the three-dimensional shape of the Face on Mars. The plan was to use the imagery that was available to derive and reconstruct the underlying 3-D structure of the Face. Once the shape was modeled digitally, computer graphics techniques could then be used to create synthetic views by varying the positions of the light source and the observer. This would allow a number of questions to be answered. For example, what does the object look like when viewed from different perspectives? Would the object still look like a face if it were illuminated from the east? Does the underlying 3-D structure also resemble a face or is the impression of a face indeed a "trick of light and shadow?"

Shape-From-Shading

The best way to determine the 3-D shapes of landforms from aerial photographs is to begin with stereo pairs; in other words, two images taken from slightly different perspectives. The relative position of surface features in each photograph indicates their elevation. As stereo pairs were not available for the part of the Cydonia region containing the Face, an alternative technique known as photoclinometry or shape-from-shading [1] was used instead to compute elevation surfaces from a single image.

In computer graphics, images are rendered from surfaces. Shape-from-shading is, in effect, the reverse of computer graphics, producing surfaces from images. Shape-from-shading derives surface heights from the slope angles of the surface, which are themselves derived from brightness or shading in the image. For a surface of constant color or albedo, the brightness at a point in the image is a function of the component of slope in the direction of the sun (Figure 30 and Figure 31). Key to shape-from-shading is the inversion of this function, that is, in determining slope as a function of brightness.

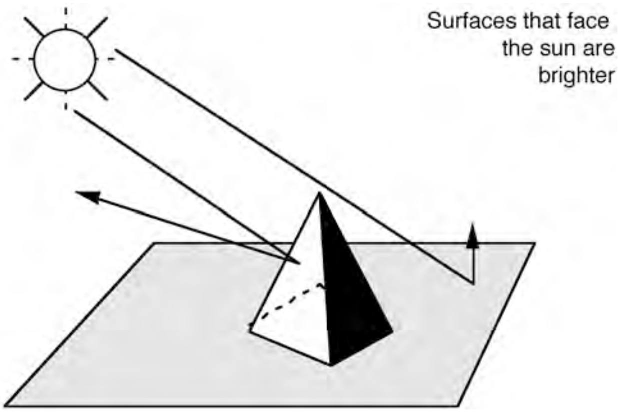

Figure 30 In one model that is often used in shape-from-shading, image brightness is proportional to the cosine of the angle between the local surface normal (a line perpendicular to the local slope of the terrain) and the direction of the light source, and does not depend on the position of the viewer. Surfaces that face the light source are the brightest, while those that face away from or are shadowed by other surfaces are the darkest. More complex models such as those that model specularity (shininess) depend on the position of the observer as well.

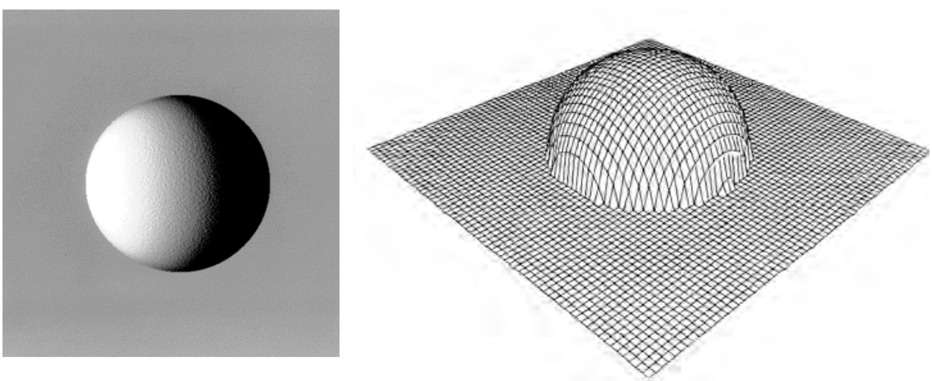

Figure 31 Image of an oblate hemisphere on a flat surface (illuminant is to the left) and a perspective plot of the corresponding elevation surface.

A variety of shape-from-shading algorithms have been developed in the astrogeology and computer-vision communities and have been successfully applied to images of arid areas on Earth, and of the Moon, Mars, and most recently Venus. A particularly simple version can be used when the sun is near the horizon, the scene is being viewed from directly overhead, and the slope angle is much less than the solar zenith angle [2]. Under these conditions the slope of the surface in the direction of the light source is related in a simple way to image brightness. A map of surface heights (elevation image) can be computed as follows:

1) Rotate the brightness image so that the sun is to the left;

2) For each row in the brightness image compute the average value of all pixels in the row and subtract that value from each pixel in the row;

3) Set the left-most pixel in each row of the elevation image to zero;

4) Moving left to right one pixel at a time, compute the elevation at each pixel by adding the values computed in Step 2) to the elevation value of the previous pixel to the left;

5) Repeat Step 4) for all rows;

6) For each row in the image compute the average elevation value of all pixels in the row and subtract that value from each pixel in the elevation image.

The elevation image produced by this algorithm (Figure 32) is an approximation to the true surface topography, and is reasonably accurate to within a constant scale factor and offset.

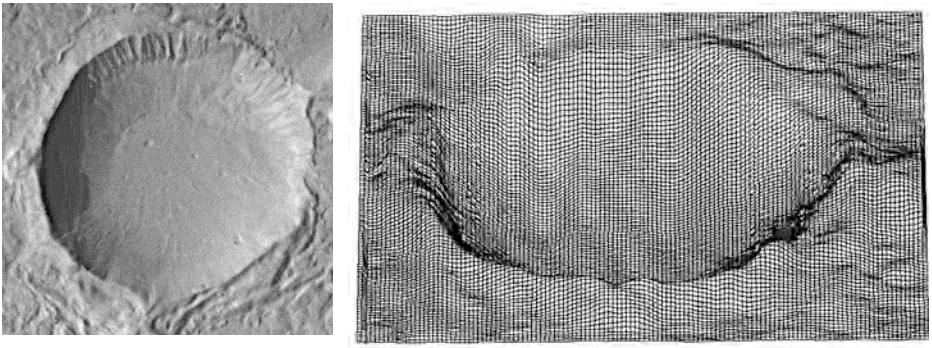

Figure 32 Image of crater on Mars from 70A10 and computed surface using shape-from-shading.

3-D Reconstructions of the Face

3-D representations of the Face have been computed from frames 35A72 and 70A13 using several techniques (Figure 33 and Figure 34). Both are ideal images for shape-from-shading, with the sun low in the sky and the view from almost directly overhead. Initial results were obtained with an iterative multi-resolution algorithm that computed consistent but somewhat blurry surfaces from the two images [3]. Later, a statistical algorithm based on simulated annealing was developed [4] that generated a sharper but somewhat noisier result. Both algorithms are computation-intensive and so could only be used for small images. For larger images, the strip integration algorithm, described earlier, was used.

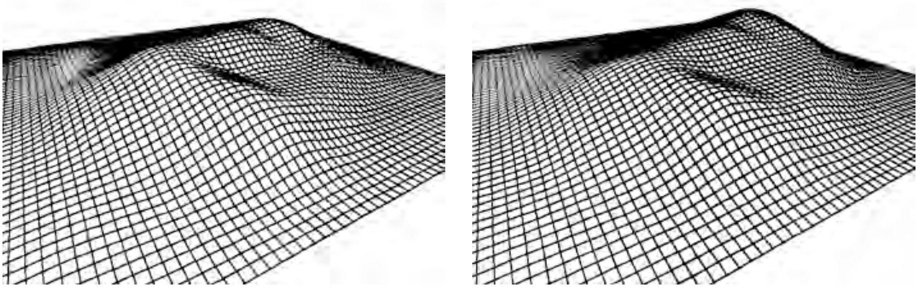

Figure 33 Perspective plots of the elevations computed from 35A72 and 70A13 using the multi-resolution algorithm. The view is from the northwest, above and to the left of the Face.

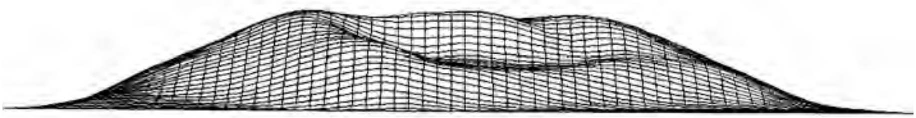

Figure 34 View of the elevation surface from the City looking toward the Face using the simulated annealing algorithm.

Verification of the Results

Since we lack ground truth for Mars, the reconstructed surfaces of the Face were checked by several methods (Figure 35). First, shaded renditions computed from the derived elevation surface were compared to the original image. Second, since there are two principal images of the Face, the computed elevations from one were used to compute a shaded rendition to match the other; in other words, elevations derived from 35A72 were used to create a synthetic 70A13 image, and vice-versa [5]. Third, a shaded rendition under simulated morning light was generated and compared with the lower-resolution image, 753A34. Results from all three tests indicate that the computed surfaces are accurate 3-D representations. The cross-checks between the 35A72 and 70A13 results justify the assumption of uniform albedo (surface reflectance) over this area. The measurement of shadows cast at known sun angles provided additional verification of the shapes and vertical dimensions of certain features (it should be noted that shadow-length computation is also included in the shape-from-shading algorithm).

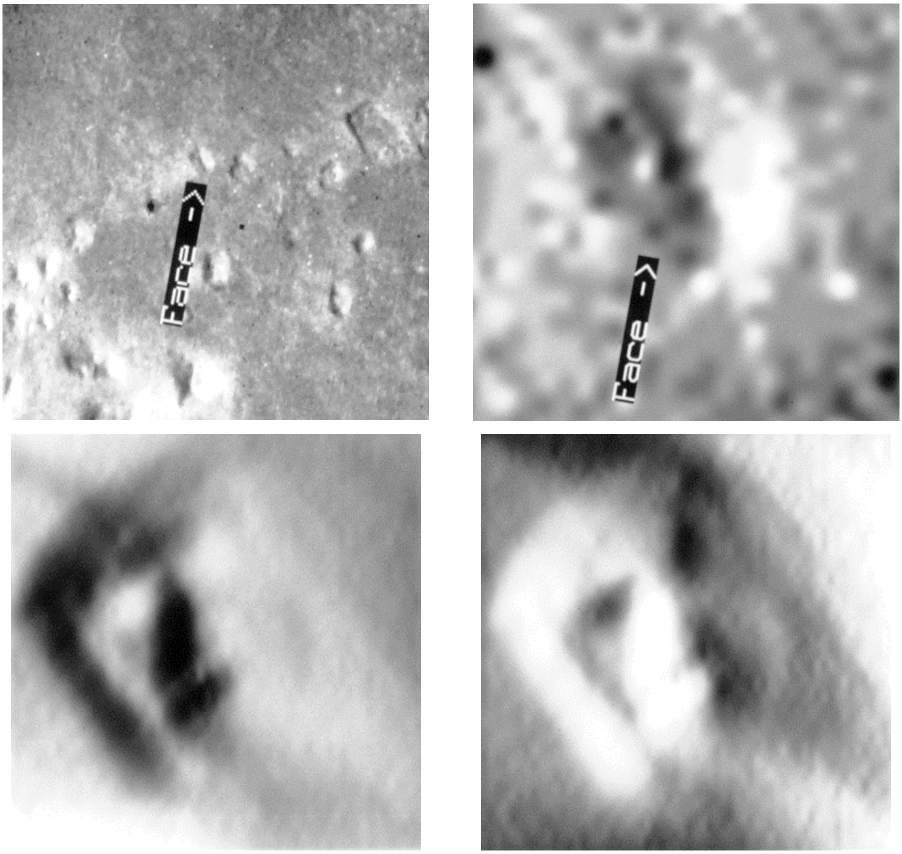

Figure 35 (Upper left) Portion of 753A34 image acquired over Cydonia region. (Upper right) Magnified morning image of the Face from 753A34. (Lower left) Synthetic morning image derived from 70A13 surface. Shaded renditions of the reconstructed surface under different lighting conditions can be computed by changing the position of the light source. This figure suggests how the Face might look when lit from the opposite side. It is noted that the detail on the right side of the face is reduced as this portion of the original image was in shadow (in practice, shape-from-shading techniques have some difficulty in recovering the shape of those portions of the surface); also, the process of computing shaded renditions does not compute shadows cast by the object, so the image appears somewhat like a photographic reversal of the original. (Lower right) Predicted image of 35A72 derived from 70A13 surface.

Perspective Views

Once the 3-D surface of an object has been modeled in the computer, synthetic views from any perspective can be generated using computer graphics rendering techniques. In a series of perspective views from around the Face, features evident in the original down-looking view persist even when the object is viewed from radically different perspectives (Figure 36). Critics of the intelligence hypothesis often cite New Hampshire's Old Man of the Mountain as a terrestrial analog for the Face on Mars; therefore we reproduce it for comparison (Figure 38). As in the case of all naturally-occurring silhouettes, its "facial" features disappear as the viewer's position changes.

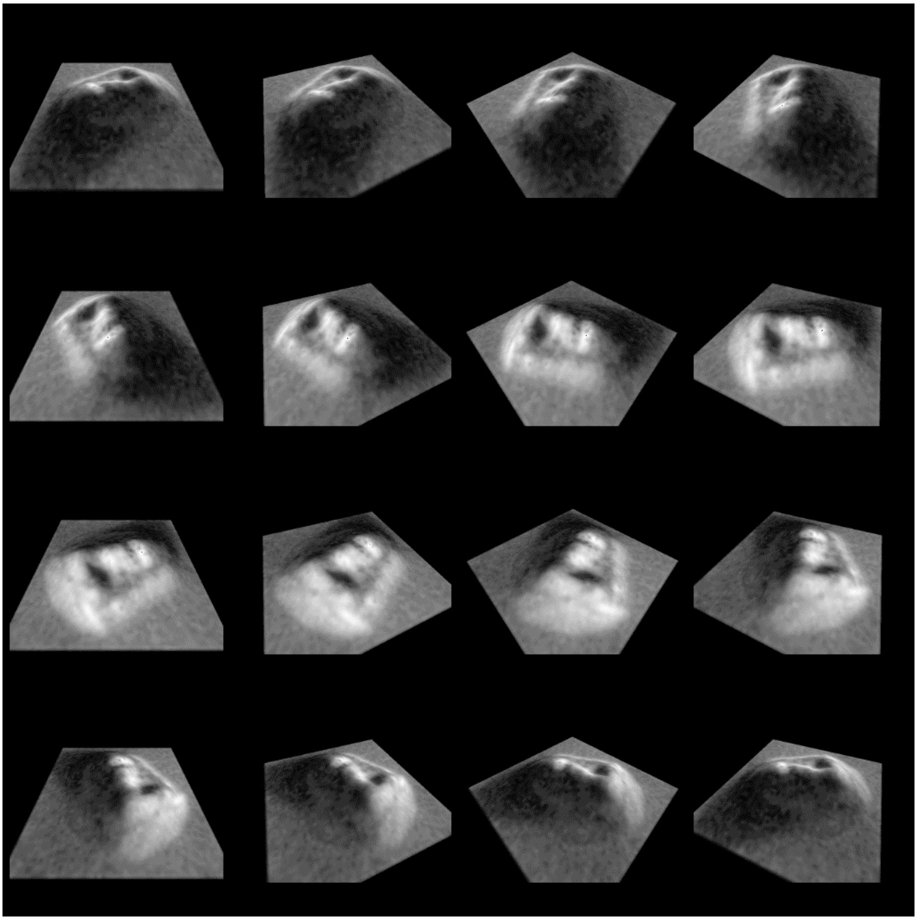

Figure 36 Perspective views from around the Face.

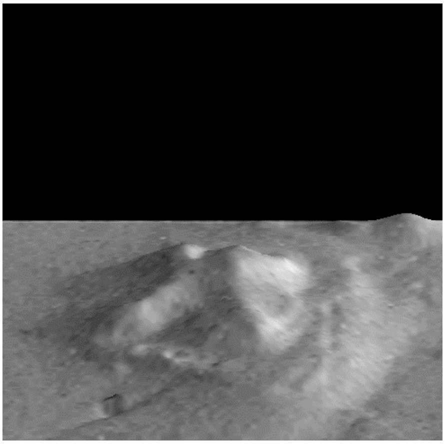 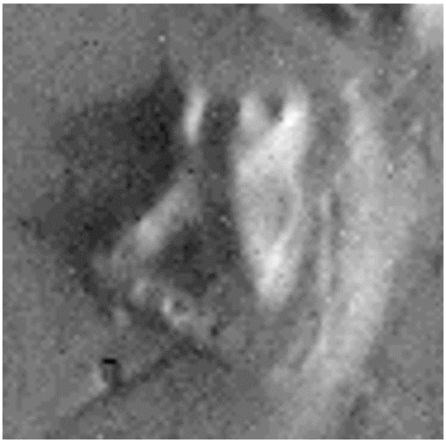

Figure 37 Perspective view of the Fortress, left. Compare with overhead view, right.

 

Figure 38 View of Old Man of the Mountain from the tourist area (left). The illusion disappears in a view taken a short distance away (right).

Artificial Stereo

Another way to present the results of the 3-D analysis is in the form of artificial stereo pairs (Figure 39), i.e., two images computed from slightly different perspectives. When these are viewed stereoscopically (the left image viewed only with the left eye and the right image only with the right eye), the result conveys an accurate impression of depth. Stereo pairs may sometimes be produced with increased parallax (as if with the eyes further apart than normal) to provide an exaggerated depth dimension that allows surfaces and spatial features to be studied in greater detail.

Using the following approach the reader may view the pairs of images presented here stereoscopically to experience a coherent 3-D view (Figure 40 to Figure 42).

1) Holding this book level and at arm's length, look just over the top of the book at a distant object.

2) Without actually lowering your gaze onto the page notice that the image pairs now seem to overlap to form a third image between them.

3) Keeping your eyes relaxed and still focused in the distance, slowly and carefully shift your attention (but not your eyes) to that third, middle image.

4) Finally, keeping the book as level as possible, raise it slightly so that the middle image is now at the center of your field of vision.

After some practice you should be able to focus clearly on the stereo image and then to draw the book toward you for a closer look.

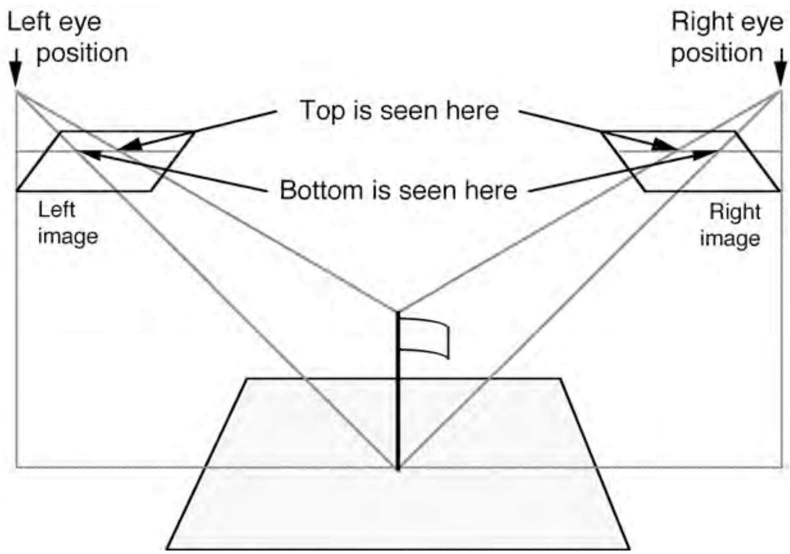

Figure 39 How a stereo image is formed. Note the different positions of the top and bottom of the object in each image.

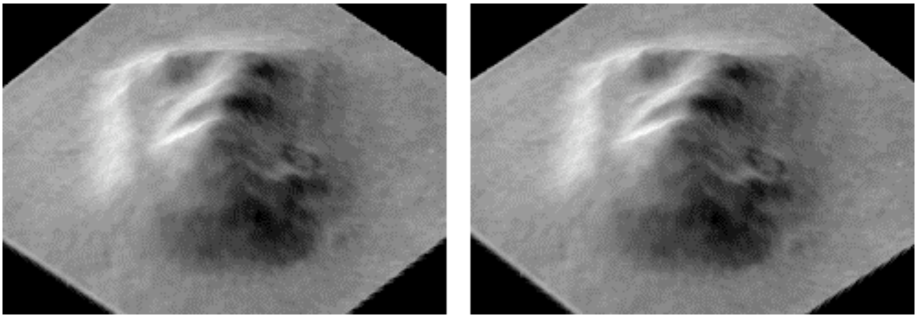

Figure 40 Left and right stereo-pair of a view directly in front of the Face.

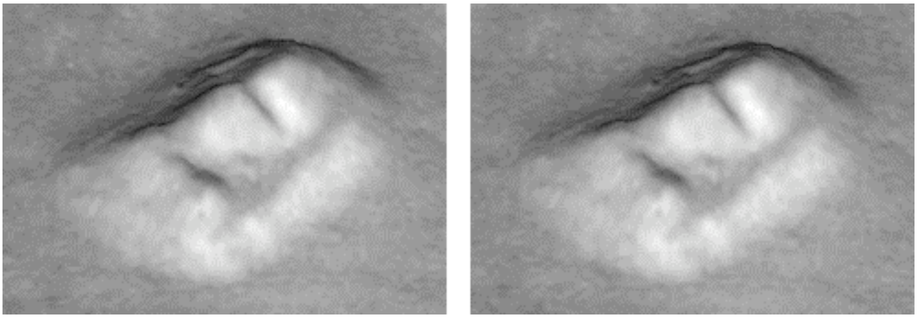

Figure 41 Left and right stereo-pair of a view from the northwest, above and to the left of the Face.

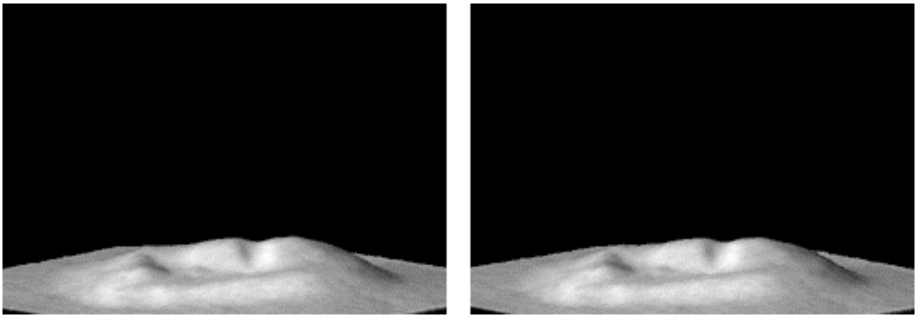

Figure 42 Left and right stereo-pair of the Face in 70A13 near ground level from the direction of the City. It has been argued that this rendition supports Hoagland's theory that if the Face is artificial its "finished" (western) side was meant to be viewed from the City.

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IV. MARS AND THE SEARCH FOR EXTRATERRESTRIAL INTELLIGENCE

"Let's say that each of these civilizations sends out one interstellar expedition per year. That means that every star, such as our sun, would be visited at least once every million years. In some systems where these beings found life, they would make more frequent visits. There's a strong probability, then, that they visited earth every few thousand years. It is not out of the question that artifacts of these visits still exist or even that some kind of base is maintained, possibly automatically, within the solar system, to provide continuity for successive expeditions." — Carl Sagan, from a speech to the *American Rocket Society*, 1962.

The Search for Extra-Terrestrial Intelligence (SETI) began in the early 1960s, using radiotelescopes to systematically scan the sky for radio transmissions of intelligent origin from likely sources in deep space [1]. After thirty years, however, no ET radio transmissions are known to have been received. This raises some questions about the basic assumptions behind SETI: Have we looked in all the right directions or listened at all the right radio frequencies? Do we really have the technology to detect and decipher ET communications? Is radio the ET communications technology of choice? Or are we listening for a signal that is simply not there [2]?

Lack of success in contacting ETs has even caused some to wonder whether the Earth might be under some kind of cosmic quarantine [3]! Others argue that wedding the SETI concept to an exclusively deep-space approach may be "setting heaven and earth infinitely apart," distracting us from noticing and examining evidence closer to home. If, as is generally assumed, life as we know it could not have evolved on the other planets in our solar system, it would indeed seem that our only hope of contacting beings like ourselves is by radio or something like it. But on what basis can we rule out the possibility that ETs or their probes may already have reached this solar system? Can we say with absolute certainty that they have not left behind artifacts or altered planetary surfaces in ways that are detectable by our own planetary probes [4]? Is it not permissible to consider the possibility that Viking, whose mission included a search for life, might have imaged alien artifacts on Mars? Since the search for extraterrestrial intelligence is a search for the unknown, must we not, at the very least, remain open to the unexpected?

The Need for Objective Criteria

Whatever our approach to acquiring data, we must develop objective criteria and methods for testing the intelligence hypothesis whenever provocative evidence presents itself. Within the SETI community several criteria and methods have already been proposed. For example, Sagan [5] has suggested that deviations from the natural spectrum of black-body radiation may be indicative of intelligence at interstellar distances. SETI itself has long rested on the assumption that radio-wave modulations displaying certain mathematical characteristics may be regarded as evidence of intelligent origin.

In the fields of aerial and satellite reconnaissance another mathematical approach known as fractal modeling may be employed to distinguish artificial objects embedded in natural landscapes. There is no reason to assume that this technique would work less effectively on other planets; indeed, the results to date using the Viking data have been most provocative [6]. In particular the Face and other nearby objects in Cydonia do seem share objectively measurable qualities that set them apart from the surrounding terrain. By standards already deemed acceptable in terrestrial applications, it can be demonstrated that the anomalies in Cydonia lack the kind of structure that is characteristic of naturally-shaped landforms.

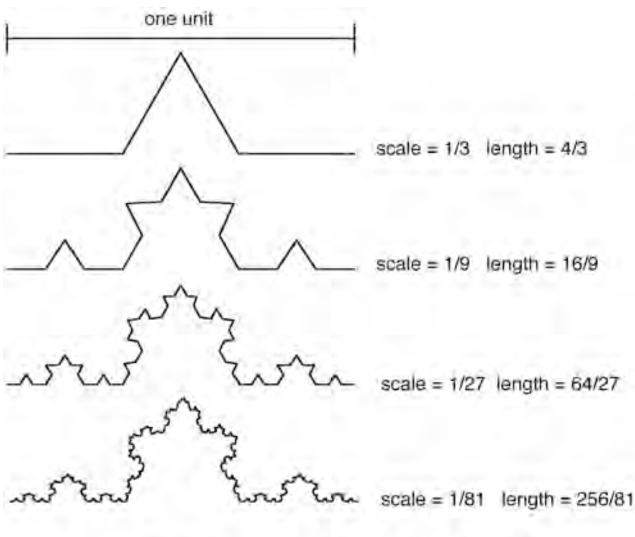
Fractal Modeling

In a photograph it is often impossible to estimate the size and distance of natural features (trees, rocks, hills, lakes, etc.) unless a familiar object is also present to provide a scale reference. This is because natural features tend to exhibit the same kinds of substructure at different scales. For example, a set of branching limbs on a miniature tree may appear virtually indistinguishable from that on a giant tree; one may find the same pattern of fractures and indentations on a small rock as on a boulder; the twists and turns in the shoreline of a pond may mimic precisely those taken by a much larger stretch of lakefront, and so forth. Generally speaking, nature tends to create structures having “self-similar” substructures; as one examines them in greater and greater detail the same kinds of patterns keep appearing. Objects that exhibit this kind of behavior are known as fractals.

Artificial structures, by contrast, are essentially non-fractal. The only exceptions are those deliberately designed to imitate nature’s fractal forms; for example, artistic representations of nature and mathematically-generated fractals such as the von Koch "snowflake" curve. The science of fractal geometry has been used with great success to better understand, through modeling, a wide variety of natural phenomena [7] including electrical discharges, clouds, the distribution of craters on the moon, fluctuations in the stock market, and the shapes of natural terrain and coastlines, to name just a few. In recent years an entire branch of mathematics has grown up around the concept of fractals. Since digital imaging and image processing are essentially mathematical, fractal analysis may be used in computer image analysis to pinpoint non-fractal objects in a fractal environment.

An Example of a Fractal

A straight line may be transformed into a fractal pattern by adding additional sections that increase its complexity and therefore its length. The rate at which its overall length grows, relative to the rate at which it is subdivided, is its fractal dimension. We think of most objects as having integer dimension, e.g., lines have dimension one, surfaces two, and volumes three. If an object is divided into N parts such that each part is scaled down by a ratio of r from the whole, the dimension D satisfies the relation NrD = 1. For example, a unit square (1 x 1) can be divided into four smaller squares, each 1/2 x 1/2 in size; thus, 4(1/2)2 = 1 so D = 2. For fractals, the dimension is not an integer. As an example, consider the von Koch curve. The process of generating a von Koch curve is as follows: Start with the unit interval, remove the middle third and replace it with two segments, each of length 1/3. So if at the initial resolution its length is one, at resolution r=1/3, there are N = 4 segments each 1/3 long for total length L = 4/3. If the procedure is repeated for each of the four intervals, 16 segments each of length r = 1/9 are produced for a total length of L = 16/9. Repeating this k times yields a curve with length (4/3)k. As the curve is repeatedly subdivided, i.e., as k increases, its length approaches infinity but its area is zero! The dimension of the von Koch curve is equal to log N / log (1/r) = log 4k/ log 3k = log 4/log 3 = 1.26, approximately. Since the dimension is strictly greater than its topological dimension, it is a fractal. The von Koch curve thus fills more space than a straight line.



Example of a Fractal: The von Koch Snowflake

Fractal Terrain

By extending a similar process into the third dimension, one may create fractal models of natural terrain (Figure 43 and Figure 44). An important class of fractals known as 1/f noises or fractional Brownian motion have been shown to be good models for natural terrain surfaces at scales less than 0.6 km [8]. The roughness of the terrain is related to the fractal dimension D. Smooth terrain such as rolling hills has a dimension near 2.0 while rugged mountain ranges are closer to 2.5. Like the Von Koch curve, fractal surfaces exhibit several interesting scaling properties. For one, the standard deviation of the difference in height between two points a distance r apart is proportional to r^{3-D}. In other words a plot of the standard deviation of the difference between points spaced r apart as a function of r on log-log graph paper is a straight line with slope equal to 3-D. Another interesting property of fractal surfaces is that the spatial frequency content varies as f^{5-2D} where f is the spatial frequency in cycles/meter. This property has been exploited by Voss [9] for generating fractals by filtering white noise. Still another property of fractal surfaces is that the surface area decreases as r^{2-D} where r is the scale of measurement.

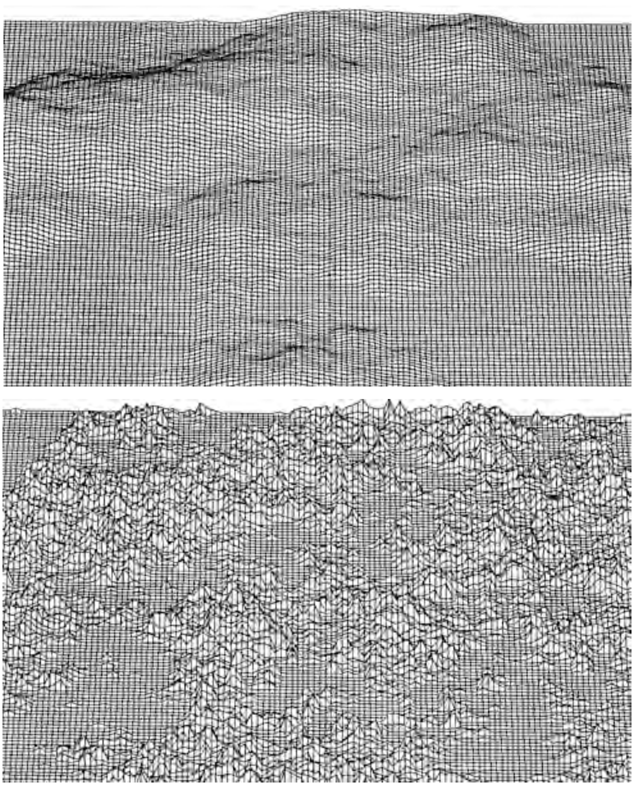


Figure 43 Portion of fractal surface with dimension D = 2.1 (left) and with dimension D = 2.3 (right).

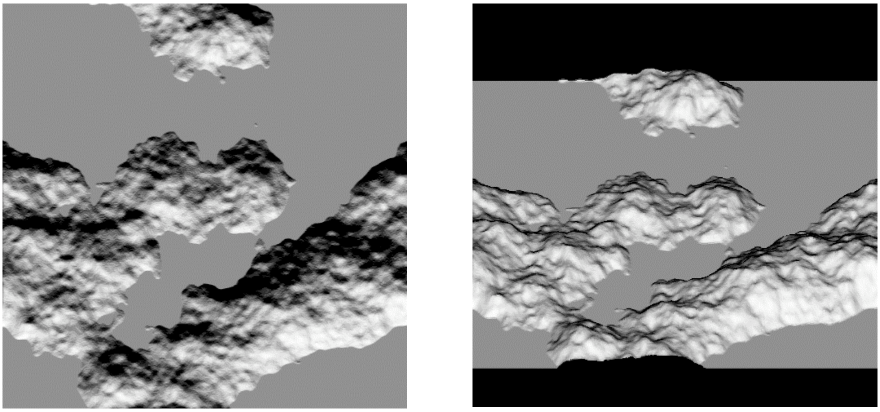


Figure 44 (Left) Shaded rendition of a fractal surface (D = 2.1). Heights less than a certain value are set to a constant, somewhat like filling the fractal terrain with water up to a certain level. The sun is to the south 45° above the horizon with the observer directly overhead. (Right) Perspective view with the observer 30° above the horizon and south, with the sun directly behind.

Detecting Artificial Objects in Images

Since specific properties of man-made objects (size, shape, texture, etc.) are often not known in advance, an algorithm [10] has been developed that detects man-made objects indirectly — by modeling and then removing, the natural background (Figure 45). As noted earlier, the metric properties of fractals scale by power laws so we can regard the straight line in log-log space as a signature for fractal objects. On the other hand, signatures of non-fractal surfaces are not straight lines (Figure 46).

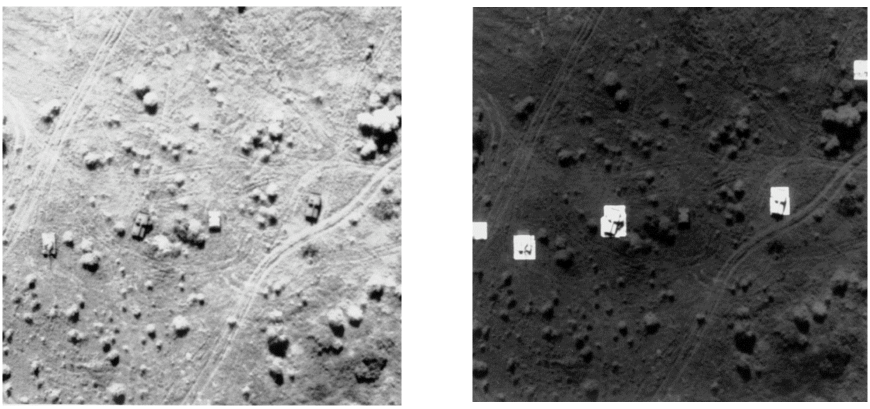


Figure 45 (Left) Image of military vehicles arrayed on a battlefield. (Right) Detection result obtained by combining areas that are outside the dimension range of natural objects (2.0-2.5) with those areas that are not fractal, and "growing" the results by an amount equal to the size of the analysis window. Three of the four vehicles were detected, one was missed, and there were two "false alarms."

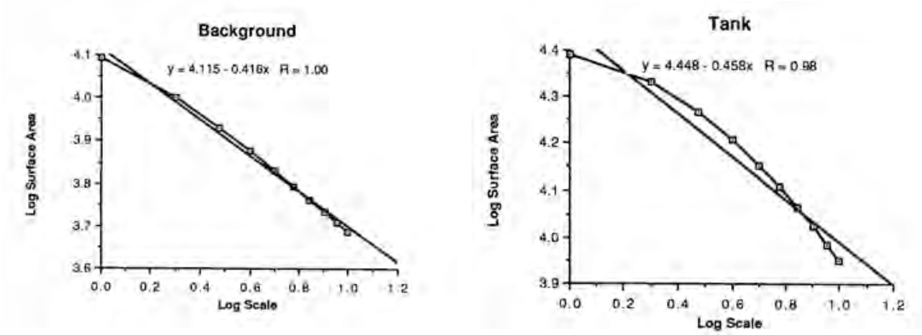


Figure 46 (Left) Signature of the natural background. (Right) Signature of a military vehicle.

Fractal Analysis of the Face

When the above technique is applied to the two key Viking images of Cydonia, the result is plain: in both images the Face is the most non-fractal object (Figure 47 and Figure 48). Parts of the two images, 35A72 and 70A13, that contain the Face are shown here along with their fractal model-fit error images that represent the deviation from fractal behavior on a local basis. Bright areas in these images indicate a high degree of error, and therefore show where the image is not locally fractal. In 70A13 where the sun is about 17° higher in the sky than in 35A72 there are considerably more "false alarms." This is due to the fact that as the sun approaches the zenith the texture of the terrain is less distinct, therefore it becomes more difficult to distinguish between fractal and non-fractal objects [6].

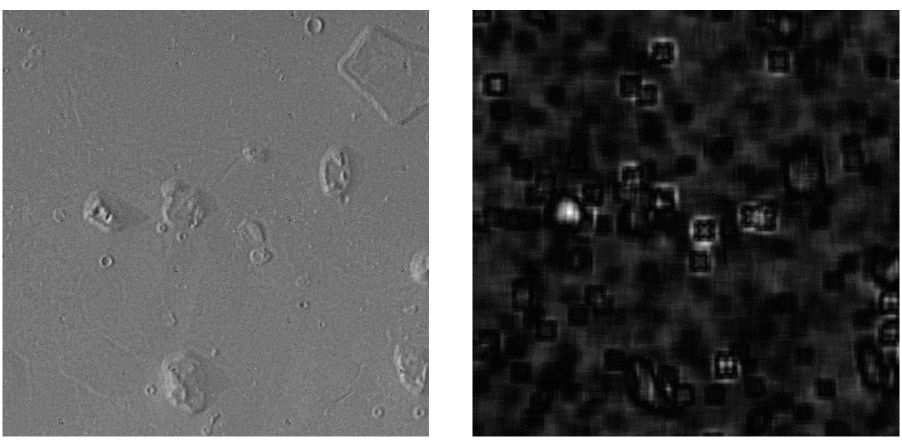


Figure 47 (Left) Image from 35A72 containing the Face. (Right) Fractal model-fit error for 35A72. Bright areas are less fractal than dark areas. Square rings are artifacts caused by residual "salt-and-pepper" noise in the image.

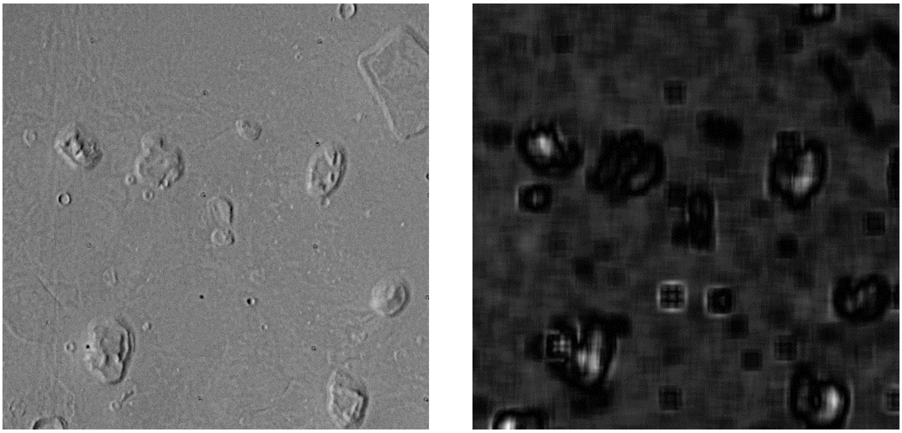


Figure 48 (Left) Image from 70A13 containing the Face. (Right) Fractal model-fit error for 70A13. Note reduction in ability to distinguish the Face from the background.

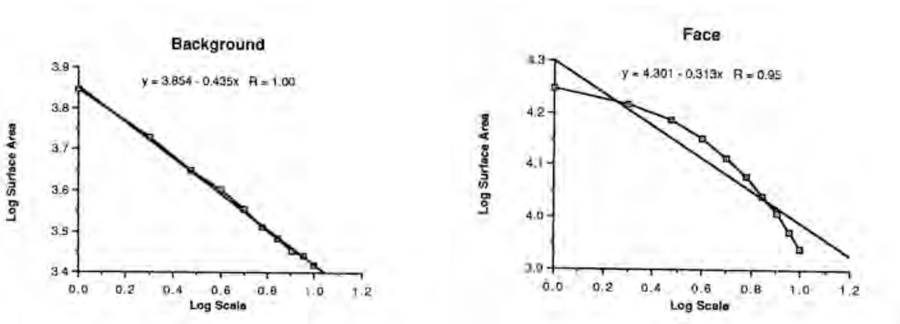


Figure 49 (Left) Example background signature (Compare with signature of natural terrain on Earth.) (Right) Signature of the Face (Compare with the signature of a military vehicle.)

Analysis of the Cydonia Complex

The analysis just described was extended to neighboring Viking frames (Figure 50). While the Face was found to have the largest fractal model-fit error, a number of objects in the City also have very high fractal model-fit errors, including the Fortress. A 1280 by 1024 pixel mosaic of parts of Viking Orbiter frames 35A72, 35A73, and 35A74 shows the results within the Cydonia complex consisting of the City, Face, D&M pyramid and other objects. Each pixel represents about 50 by 50 meters. The total area is approximately 3,000 sq. km.

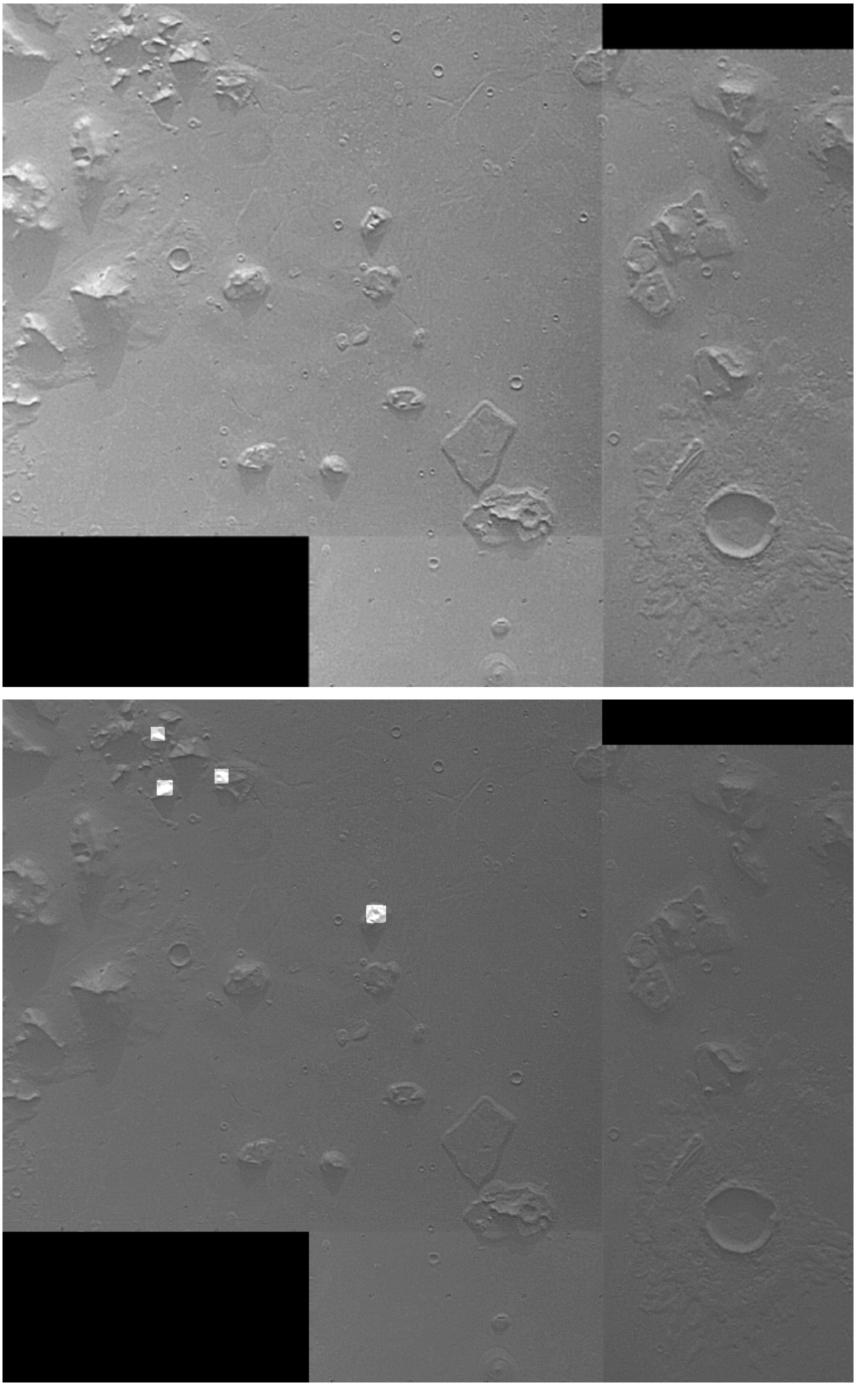


Figure 50 (Top) Mosaic assembled from parts of three Viking frames. (Bottom) Mosaic of corresponding model-fit images processed to show the strongest anomalies.

Other Anomalous Objects in the Cydonia Area

Here is a result from Viking frame 70A10 that suggests there may be other objects in the general vicinity worth investigating. The area shown is 512 by 512 pixels in size and is over 100 kilometers away from the Cydonia complex. Ignoring the bright areas caused by non-fractal periodic noise in the image, one can detect a strong anomaly (Figure 51) in the form of an unusual circular formation (called the "Bowl") that appears to lack some of the essential morphological features of typical impact craters. It is located at the center of a structure having, among other intriguing details, a tapered "ramp" that suggests to some observers the stairway of a Mesoamerican pyramid.

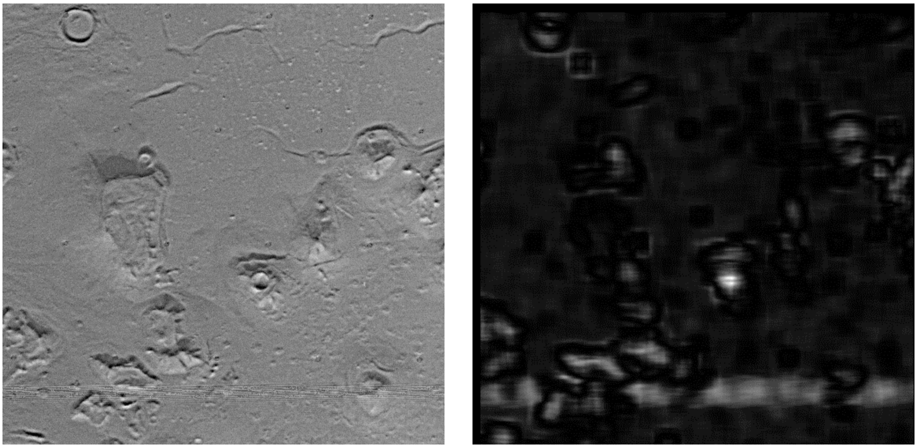


Figure 51 (Left) Image from 70A10. (Right) Fractal model-fit error image.

Figure 52 Left and right synthetic stereo-pair of Bowl, pyramidal object and rectilinear cuts.

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V. GEOLOGICAL ANALYSIS OF ENIGMATIC LANDFORMS IN CYDONIA†

"Despite our shortness of breath and beating of our hearts, the Martian sphinx looks natural — not artificial, not a dead ringer for a human face... But I might be wrong." — Carl Sagan, *Demon Haunted World*, 1996.

We are told by NASA that the Cydonia features are nothing more than exhumed, eroded remnants of a prior terrain. To the contrary, there is much evidence to show that the features in evidence at Cydonia are the products of more than simple denudation. Regardless of their origin, the features and their relationship to one another spatially and temporally are sufficiently complex to warrant closer scrutiny. Only through continued serious evaluation can we come to understand the Cydonia features and perhaps more importantly, translate a heightened understanding to a reevaluation of some of earth's geomorphic processes.

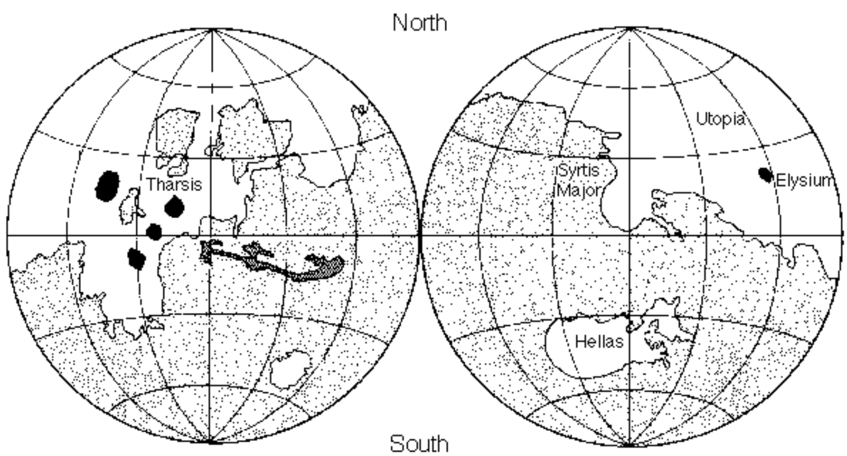

Figure 53 The topography of Mars is asymmetric with the majority of the southern hemisphere rising above the reference datum and the northern hemisphere falling below it. The southern hemisphere is more heavily cratered and thus thought to be older than the northern plains. (Lunar and Planetary Institute.)

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† The text of this chapter was contributed by James Erjavec and Ronald Nicks.

The Cydonia Region of Mars

Broad generalizations by NASA, which have been based in part on previous geologic studies of the Cydonia region of Mars, have been inadequate to definitively explain the origins of the varied surface features of Cydonia. During the development of a geomorphic feature map of Cydonia (Figure 55), a preliminary study of the landforms was conducted, including both anomalous and "ordinary" forms.

The arguments that NASA has relied on to debate the anomalous nature of the morphologies of the Face and other enigmatic Cydonian landforms are based on suggestions that the Martian northern lowland plains (Figure 53) were at one time covered with a kilometer or more of erodible sediment [1]. Cattermole [2] cites research that suggests the lowland plains were covered with as much as 2 to 3 km of sediment.

The origin of the landforms in Cydonia Mensae has been attributed to a differential erosion process that removed an overlying cratered plateau material, leaving a knobby terrain that is a combination of exhumed remnants of cratered terrain, igneous intrusives or cratered plateau material [3]. Inasmuch as popular scientific literature appears to have accepted this view without reservation, it is not uncommon to find references to Cydonian landforms that typically cite their origins as the exclusive result of wind erosion [4] without considering the validity of the data and assumptions that support such claims.

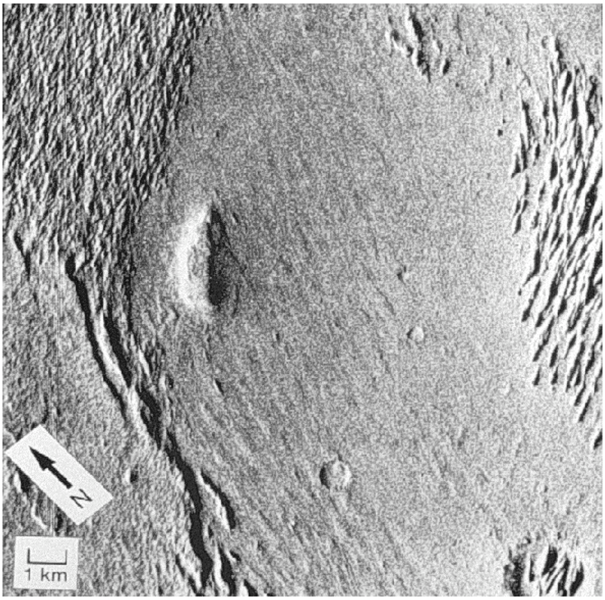

Figure 54 Yardangs are wind-shaped hills that range in size from a few meters to tens of kilometers and form in arid areas. They occur when erodible rocks and sediments are exposed to a strong unidirectional wind. (Lunar and Planetary Institute.)

But more recent evidence [5] has been provided that refutes claims that over a kilometer of sediment was eroded from the Martian northern lowland plains. McGill has used crater dimensional equations to conclude that only a slight to modest erosion of the northern lowland plains could have occurred since Noachian times and that at best, 200 meters of material may have been stripped off the plains. This is corroborated by Maxwell [6] who shows that there is little correlation between the Martian landform dichotomy (northern lowland plains and southern cratered uplands) and the trends of scarps and ridges of the landforms. Cattermole states that because a series of closely related geologic events have affected the northern plains [7-10] and because there is a lack of evidence for where the 2 to 3 kilometers of eroded sediment has been transported, there is little probability that erosion was the driving mechanism for the lowering event. Instead he believes that the evidence suggests the lowering of the northern plains was a result of some (to-date) uncertain internal mechanisms.

Table 1 Mars Time-Scale Models

Ages in billions of years	According to Hartmann-Tanaka	According to Neukum-Wise
Late Amazonian	9.25-0	0.7-0
Middle Amazonian	0.7-0.25	2.5-0.7
Early Amazonian	1.8-0.7	3.55-2.5
Late Hesperian	3.10-1.8	3.7-3.55
Early Hesperian	3.5-3.1	3.8-3.7
Late Noachian	3.85-3.5	4.3-3.8
Middle Noachian	3.92-3.85	4.5-4.3
Early Noachian	4.6-3.92	4.6-4.5

Furthermore, in light of a gravity model developed by Smith and Zuber [11], it is possible that the dichotomy may not exist at all, at least not with the sharp elevation break that has been suggested. Analysis of orbital ground tracking data by Smith and Zuber of the Mariner 9 and Viking orbiters indicates that the Martian center of mass and center of shape are offset by approximately 3 kilometers. If these data are true, then the signature of the dichotomy might be little more than the product of that offset. The authors suggest that the dichotomy boundary is more gradual than previously ascertained, with the surface sloping gradually over thousands of kilometers.

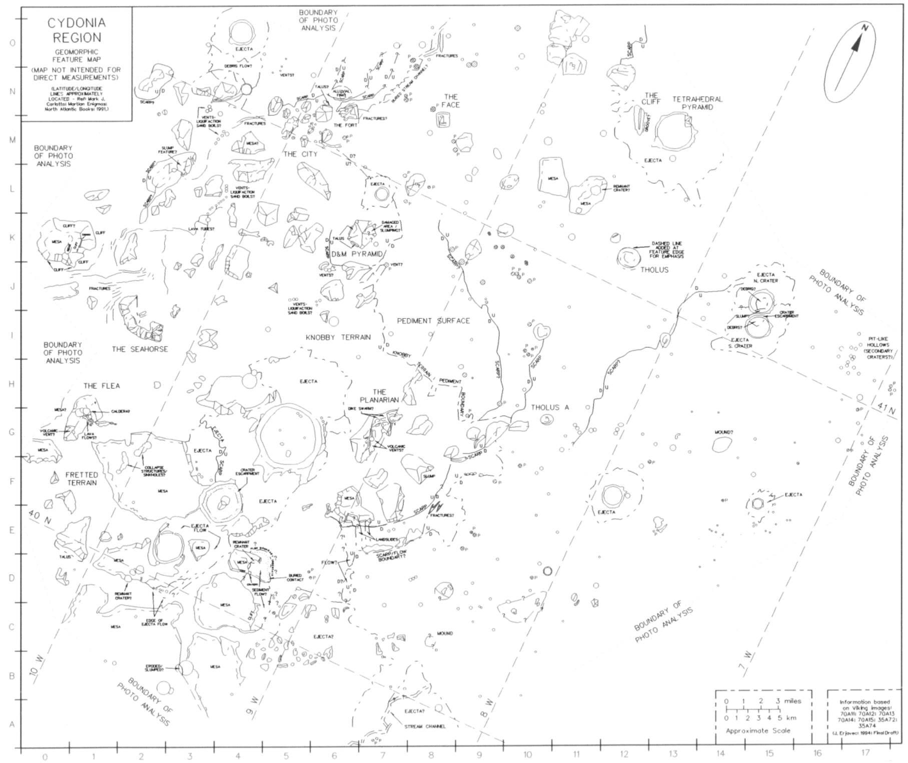

Figure 55 Geomorphic feature map of the area of Cydonia bounded approximately by the 40N to 41.5N degree latitude lines and the 11W to 7W longitude lines (an area covered by Viking Frames 70A11, 70A12, 70A13, 70A14, 70A15, 35A72 and 35A74). (Full resolution map available in high resolution content.)

Dimorphic Impact Crater Distribution

This study corroborates the findings of the above-mentioned authors on the basis of geomorphological and geological analysis of Cydonian landforms. An initial finding of the dimorphic distribution of impact craters between the knobby terrain (western area of the map) and cratered plain (eastern area) in this area of Cydonia weakens support for an extensive pre-plain overburden (Figure 55). The knobby terrain (approximately bounded by an outline running from map reference blocks H-0 to E-6; E-6 to G-9; G-9 to K-7 and K-7 to O-7) contains several large impacts greater than 1 km in diameter, but relatively few craters below this threshold (Figure 56). The pediment surface, situated mostly eastward of the knobby terrain, has a similar distribution of large impacts (> 1 km), but contains a significantly greater number of smaller craters (< 1 km). On its most basic level, this dimorphism suggests there is a distinct geomorphic difference between the cratered and knobby terrains that cannot be accounted for if exhumation by erosive forces has been the primary factor in this area's morphological development. If one rules out random impacts alone as a means of origin for this dimorphism (and statistically there is no reason to attribute it to random cratering because age determination for Martian surfaces have been based on impact crater rates and densities [12,13]) either different geologic/erosional processes have been at work in these two terrains, or the two surfaces had origins in markedly different morphologies, or more likely, a combination of the two have occurred.

To verify the authenticity of this apparent cratering dimorphism, impact crater counts (<1 km) were performed for the knobby and cratered terrains and the following results obtained:

Average for the cratered plain:	8800 craters/100,000 sq. km
Average for the knobby terrain:	2000 craters/100,000 sq. km
Ratio cratered/knobby:	4.4/1

After factoring in craters that appear to have suspect impact origin (i.e. pseudocraters or craters following distinct linear trends or fractures whose crater morphologies signify a possible origin from volcanic or liquefaction processes, etc.) the following results were obtained:

Average for the cratered plain:	9700 craters/100,000 sq. km
Average for the knobby terrain:	4900 craters/100,000 sq. km
Ratio cratered/knobby:	2.0/1

Since the area involved in the crater counts is rather small in extent in relation to the surface of Mars, definitive conclusions about the ratios cannot be made, but the apparent dimorphic trends appear to persist in the surface of Cydonia Mensae surrounding this study area. If the dimorphic signature of these impacts is authentic, then it poses the question: Could such a distribution have resulted under the influence of differential erosion as a primary geologic mechanism? In itself, the cratering bimodal distribution appears to cast doubt on claims that the area was subjected to a differential erosion of at least 1 kilometer of soft, overlying sediment and that the landform morphologies (knobs, hills, ridges, etc.) are primarily the result of that process.

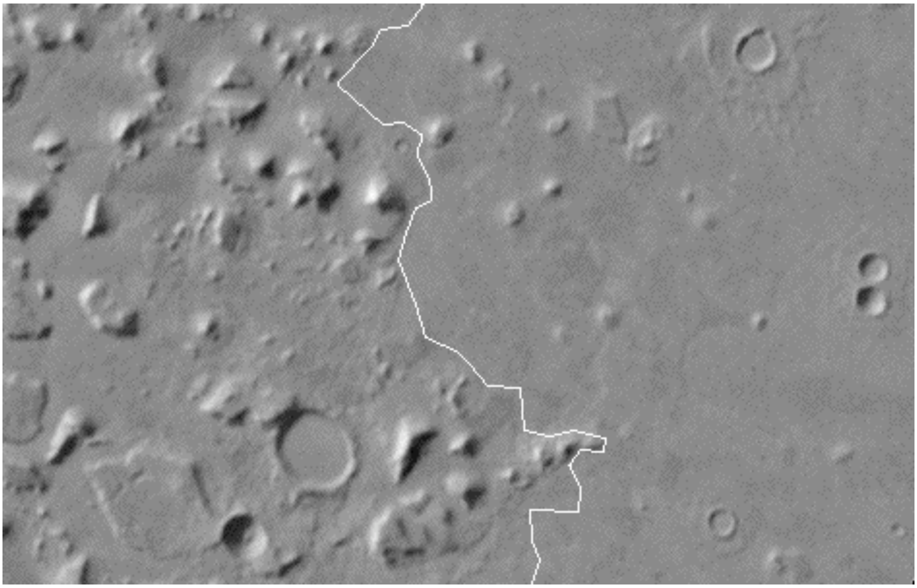

Figure 56 Boundary between higher knobby terrain (left) and lower cratered terrain (right).

Paleo-Lake Cydonia?

Consider the following interpretation. The surface expression of the crater groupings in the cratered plain and the cratering record in this area may be suggestive of erosional and depositional effects of a large standing body of water. Pedestal crater alignments and escarpments strongly suggest that certain craters were present in the littoral zone and may have been modified by wave action and longshore currents.

An escarpment and series of pedestal craters that trends from H-9 roughly northwest in a curvilinear fashion toward M-6 could be evidence of a paleo-shoreline. A continuation of this expression can be delineated toward the southwest from G-9 along a sinuous escarpment. A second curvilinear trend defined by pedestal and eroded impact craters as well as benches surrounding the bases of knobby landforms also implies another relict shoreline. This second signature (trending both northwest and south-southwest from I-10) roughly parallels the trend of the first expression. Moreover, there is sufficient evidence to support an interpretation of these trends as ancient shorelines, most notably the distinct elevation rise into the knobby terrain on the west as defined by a series of curvilinear ridges. From this interpretation it follows that the water of this paleo-lake deepened toward the east. In deeper waters, wave activity would have a minimal impact on the erosion of subaqueous landforms. Not surprisingly, the crater record reflects that as one moves eastward into the plain. Not only is there a marked decrease in small pedestal craters, but there is an increase in small non-eroded craters in general.

Conversely, since the terrain appears to deepen toward the east, it rises toward the west (the knobby terrain). If this is true, the knobby terrain may have remained aerially exposed during the times in which the lake existed and subsequently would have been subject to greater modification by eolian, fluvial and glacial processes as well as creep and mass wasting. Though this interpretation of the geology of this area is still unfinished because of the difficulty in obtaining reliable stratigraphic relationships which is compounded by the limits of image resolution, it is still a plausible scenario, and furthermore, it more adequately explains the differences evident in the knobby terrain and cratered plain than does differential erosion. Evidence that further supports the knobby terrain as a boundary on the edge of a large lake would include possible strandline deposits (E-7, E-8, E-9) and a number of landslides that are readily discernible in the area of E-6 and E-7. These landslides could have been formed by the action of wave cutting into the knobs with a consequent undermining of strata and sediment flow toward the south and into the lake. The fretted terrain to the south (bisected by a line drawn from F-0 to B-4) could have been formed by transgressions of the lake in combination with coastal erosion, mass wasting and creep as suggested by Parker and others [14].

Differential Erosion

Using NASA's view [1], one would have to accept that differential erosion selectively eliminated nearly all evidence of small impacts on the knobby terrain while leaving the cratered plain nearly untouched. A more likely answer (as suggested by the above evidence) is that landform development was the result of a geologically interrelated set of processes of both constructive and destructive nature which provided the present character of the Cydonian surface.

In support of this more dynamic geologic history, the following will discuss some of the enigmatic landforms in Cydonia in a geologic/geomorphic framework. Naming conventions will adhere to those previously used for these landforms (for clarity) with the addition of a few descriptive names that were "coined" to identify specific landforms during the mapping process. This discussion will not attempt to explain the enigmatic Cydonia landforms in an extraterrestrial context. Its aim is to point out weaknesses in NASA arguments that have been used to discredit the hypothesis that certain objects in Cydonia are artificial by showing that NASA's geological interpretation of Cydonia is even inadequate to explain the definitive "natural features" and that despite NASA's approach, the Cydonian landforms in question have retained their anomalous character.

Figure 57 Mesa in 35A72(left) and 70A13 (right)

The Face — Image Or Illusion?

The Face (M-8) has been argued by Malin and Mr. Q as nothing more than an optical illusion or a trick of shadows [1]. Those arguments appear to be based more on conjecture than on substantive geomorphic or geologic evidence. As stated by McDaniel, since the two images containing the Face were taken under a 17 degree difference in solar lighting angle (Viking image 70A13 — solar angle 27 degrees; and 35A72 — solar angle 10 degrees), the persistence of internal features in the Face precludes the latter possibility. Thus the questions remaining are the authenticity of the morphology of the Face and its possible origin.

After considerable review of the Face and other Cydonia landforms, the conclusion can be drawn that the morphology of the Face is not a result of an optical illusion. To the contrary, under the variation in illumination angles between images 70A13 and 35A72, the features of the Face change little, indicating that the origins of the "eyes," "mouth" and other features are likely the result of a variation in surface morphology rather than shadows cast by as of yet indeterminate protruding surfaces. A comparison of the Face in frames 70A13 and 35A72 to some nearby mesas also depicted in those frames corroborates the validity of the Face's morphology. Using one mesa (L-11) approximately 13 km due east of the Face (Figure 57) as an example, NASA's argument that the Face's morphology is an illusion is further contradicted.

This mesa has a steep-walled ridge trending lengthwise through its center and appears to contain a remnant impact crater (1 km diameter) in its northern half. Because of the low solar angle in 35A72 the shadows are heavy, obscuring some of the central features on the eastern slope of the landform. In 70A13, the greater solar angle allows for more of the shadowed eastern side in 35A72 to be discerned. Though it is apparent that the two images of this mesa are slightly different due to shadowing effects, the general trends within the mesa are persistent. Not only does the definition of the sunward side of the mesa appear to change little between images 35A72 and 70A13, the definition of the ridge becomes more pronounced, revealing the ruggedness of its eastern slope.

It is obvious that in viewing the images of this mesa, its general morphology is authentic despite slight definition changes between the images. Similar observations of the definition changes in the Face between those images indicates that the same logic can be applied. Thus to conclude that the morphology of the mesa is authentic (and it is difficult to dispute that) after inspection of the images, it follows that the morphology of the Face must be authentic as well. In fact, there are less visual changes in the morphology of the Face between images 35A72 and 70A13 than are noted in the mesa. Using NASA's arguments of light and shadow or optical illusion, one might be predisposed to conclude that the features of the mesa are more suspicious than those of the Face.

An analysis of other landforms in this area supports the above conclusions, but could the morphology of the Face be the result of a random series of geologic events? Undoubtedly that is a possibility, but the landform's obvious human-like characteristics and societal implications, in combination with other enigmatic landforms at Cydonia, requires that a more thorough geologic evaluation of Cydonia be pursued to acquire a resolution to this problem.

The Cliff

The Cliff (N,M-12) is an elongate mesa 18 km northeast of the Face (Figure 58), apparently overlaying an ejecta blanket of a 3 km impact crater (M-13). The Cliff contains a thin, almost linear central ridge running the length of it. NASA has relied on the Cliff's relation to the nearby impact crater (M-13) in an attempt to explain its origins. Mr. Q has stated the adjacent crater to be a tuff ring or similar volcanic feature [1]. This statement is erroneous on even the most basic level. Cursory observation of this crater immediately indicates its formation from impact. The impact is surrounded by rampart-style ejecta ("Yuty-type") and displays all of the features of a rampart crater, including characteristic overlapping sheets of ejecta with lobate margins, raised rims along the ejectamenta's outer edges and the extension of ejecta about two crater diameters away from the impact. Though it has been determined to date in this analysis of Cydonia that there is more geomorphic evidence suggesting (at least isolated) volcanic activity than recognized in previous studies, this crater is of unquestionable impact origin.

Malin [1] indicates that the Cliff is a product of stratigraphic superposition and differential erosion. In this current study, the detailed analysis of the variety of geomorphic features in Cydonia does not support a primary reliance on differential erosion as a means of landform development. Evidence of differential erosion is present in Cydonia, but not to the degree that Malin suggests. Additionally, if the Cliff is a relic mesa derived from an extensive preexisting surface, there is no supporting evidence for that, either in the crater or on its ejectamenta.

Also, no evidence has been found for the remnants of this preexisting surface in association with any of the other ejecta blankets of significant impact craters (> 1 km) in this area. To date, the Cliff appears to be an isolated event. Another argument might be that only this impact (M-13) had any of the preexisting surface deposited on it, but without sediment deposition in the impact crater itself. Is such a restrictive solution geologically plausible or provable? And what questions would that pose for the feasibility of the depositional process?

A third possibility is that the Cliff existed before the impact, but there is no evidence of the ejecta having overlain the Cliff, though the ejecta flow extends beyond the Cliff for at least a kilometer. There is also no evidence to imply that the Cliff is associated with the impact event itself. If the Cliff predated the impact, it would seem logical for some of the impact's ejecta to have overlain the Cliff or at least to have flowed around the base of the Cliff as is known to have occurred in other landforms/impact associations in Cydonia, but there is no evidence for that either. Since ejecta appears to resist erosion as shown by the numerous pedestal craters on Mars, if ejecta had been thrown on the Cliff, trace evidence of that event might be expected to be found. Again, nothing. Because of the general lack of evidence for any definitive explanation for the Cliff's origin and its timing in relation to that of the adjacent impact, the Cliff and associated cratering event remains enigmatic.

Other evidence that undermines the Cliff's origin as a differential erosion product are the trends within the various groupings of small pedestal craters (< 1 km) that dot the cratered plain. These groupings suggest that this area was not buried with soft sediment to the degree that Malin claims. The alignments and groupings of pedestal craters moreover provides evidence of a preexisting topographical surface that was much thinner than that suggested by Malin. Furthermore, the disposition and elevation of the pedestal crater rims in conjunction with eroded benches around some of the other landforms implies that there may have been at least two distinct surfaces present in the past or perhaps two or more significant episodes of erosion. As noted previously, features that appear to have been the result of shoreline processes in the cratered plain also suggest this area may have seen activity of a large, possibly recurrent body of water at some time in the Martian past similar to ancient paleo-lakes known to have occurred on Earth. Evidence supporting such a scenario is provided by Parker and others [14], who from geomorphic evidence have implied that a sea or ocean was at least intermittently present in the northern lowland plains during the early history of Mars.

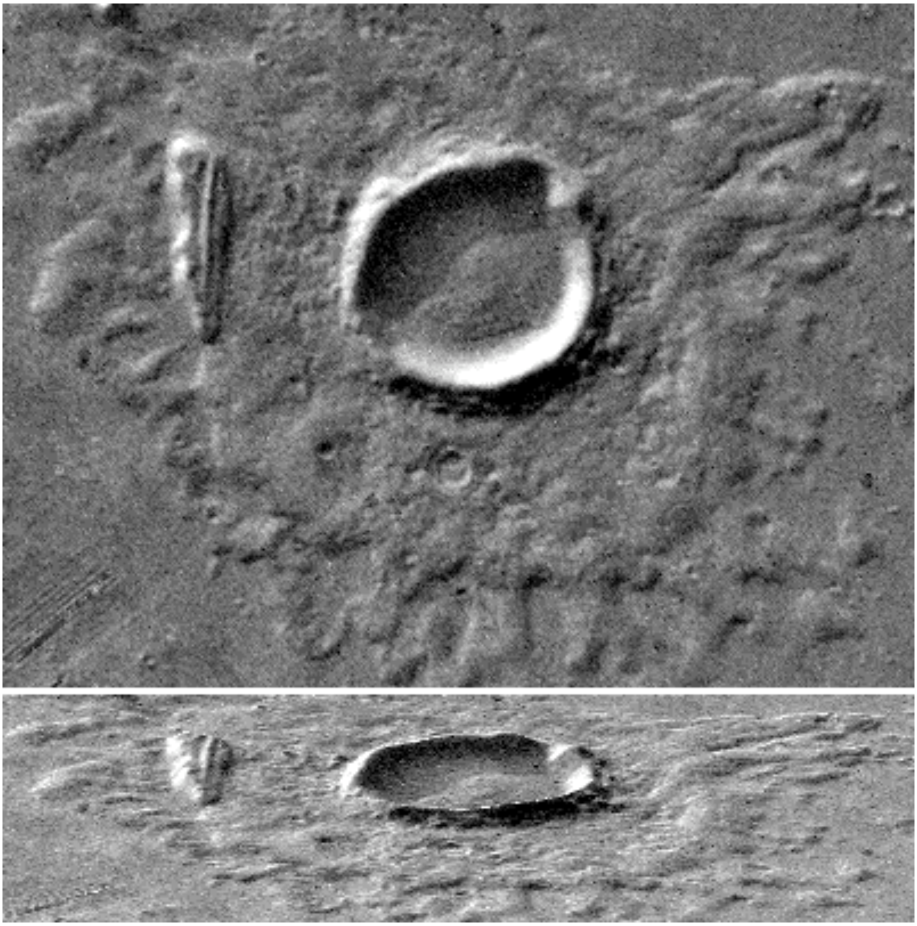

Figure 58 Overhead view of Cliff and adjacent impact crater from 35A74 (top). Perspective view (bottom) generated by projecting overhead view onto elevation surface computed by shape-from-shading and viewing from below at zenith angle of 60 degrees.

More Arguments Against Differential Erosion

Two large adjacent, 2 km diameter craters (J,I-15) approximately 30 kilometers east of the Face (Figure 59) provide further evidence against the existence of the extensive eolian capability necessary for the removal of a kilometer or more of overlying sediment. (To provide a reference frame, the northernmost crater of the doublet will be designated Crater N and the southernmost Crater S.)

Detailed inspection of these craters in images 70A15 and 35A74 shows that there is a sizable debris slump in Crater N that fills roughly two-thirds of the crater bottom. This sediment appears to have flowed down from the elevated crust between the two craters. There is a similar slump of debris in Crater S, but it is not as extensive as in Crater N, covering at maximum about one-fifth of the crater bottom. The sediment flow in Crater S appears to originate from a steep crater scarp that is present on the northern edge of Crater S, rather than from between the raised surface between the two craters. There is no evidence of a similar scarp in Crater N.

Two other primary features provide evidence for the timing of these two impacts. First, the internal morphology of Crater N shows walls and a bottom that are smoother and more rounded than those of Crater S. This points to a greater degradation of Crater N in reference to S. Second, the ejecta blanket of Crater S clearly overlies the ejecta blanket of Crater N as evidenced by an ejecta scarp, and additionally the ejecta from S has a both a higher and more rugged relief than that of Crater N. From this evidence, it is not difficult to conclude that Crater N predated Crater S and that there was an time-indeterminate (but suggestive of long) hiatus between the two impacts as indicated by the degradation of Crater N's ejectamenta and internal features in relation to those of Crater S.

The ability to discern the sequence of impact events as those between Crater N and Crater S, shows that generalized differential erosion of Cydonia is not likely a means of landform development. Since it is possible to determine (at least locally) the relative sequence of geologic events in this area by the analysis of landforms, features and their geomorphic relationships, it is rather simplistic to believe that Cydonian landforms were buried to the degree that Malin states. Could they have been exhumed to their current disposition with the removal of most of the evidence for the preexisting surface, but still leave intact pristine signs of superposition and timing that have no relation to that depositional event? Moreover, since the largest impacts are believed to have occurred in the earlier history of Mars, a problem with sequencing of events becomes evident. If extensive burial or deposition had occurred and then been eroded, it should be expected for at least some of the impact craters to show signs of sediment burial or remnants of sediment on their ejecta blankets, especially on leeward slopes. Conversely, the lack of a prominent pedestal nature for these impacts lends little support for their occurrence prior to the suggested extensive erosion.

One large crater in Cydonia to date does show evidence of sediment fill that might lend credence to Malin's observations, but upon scrutiny, another origin of the sediment becomes evident. This crater lies approximately 45 kilometers south of the Face on the edge of a small, low-relief mesa (D-4). The crater is approximately one kilometer in diameter and is partially filled with sediment that appears to be the result of a debris (ejecta?) flow which may have originated from a 5 km impact crater its north, called Big-3 for this report, (G-5). Relief lines of the mesa's eastward edge are evident beneath the flow and the flow's material transitions northerly into surface material. There are debris flows emanating from Big-3 and Med-3 (a 3 km impact southwest of Big-3; E,F-3,4) that have lapped up onto some small landforms and been diverted around larger mesas. Because of this evidence, it is not inconceivable that a lobe of southerly flowing material with sufficient momentum was "washed up" onto the low-relief mesa (D-4) and under one-third gravity, spread across it and into the crater.

The flattening of Big-3's westerly wall against a rugged knob, also suggests that the knob was present at the time of the Big-3 impact. The flat floor of Big-3 and the spattering of small impacts within its crater also imply that this impact may predate most other large impacts in this area. Furthermore, the debris flow extending south from Med-3 shows that its flows were channeled between some of the surrounding mesas, but were strong enough to breach a shallow, older, 2 km impact crater, Little-3 (E,D-2,3), perhaps modifying its crater rim.

Another example of an impact-initiated debris flow that depicts cratering/landform timing occurs about 20 km west of the Face (O,N-4), where a 2 km impact crater's ejecta flow has overlain and buried a preexisting landform whose definition is still observable beneath the ejecta. This event, along with Big-3 and Med-3, suggests that some of the large impacts postdated at least some (if not many) of the landforms in this area and that it is implausible to use widespread differential erosion as a method to explain the current landform/crater relationships.

Figure 59 Doublet Crater N (top) and Crater S (bottom). Back dots are remnant camera registration marks.

Other Cydonia Enigmas

Briefly, a few other enigmatic Cydonia landforms will be described in an attempt to show the need for further detailed geologic analysis of this area. The Tholus (name not to be confused with other "Tholus" names designating volcanic vents on Mars) is an isolated, semi-circular, mound-like landform (Figure 60) that lies in the cratered plain (J,K-12). The mound is of relatively low relief in relation to the knobby terrain to the west. The Tholus appears to contain a thin depression or groove that circles the landform at its base and spirals up toward the landform's peak in a clockwise fashion cutting through the mound.

Another similar mound, Tholus-A (G-10), lies approximately 20 km to the south of the Tholus and is about one-third the size of the Tholus. It too contains a groove that spirals from its base to the peak, but the spiral is counterclockwise. The smooth gradation in elevation present in the Tholus is less evident in Tholus-A. The spiral almost appears to be the result of a low escarpment which winds up the feature.

A third elliptical hill (I-13) lying about 8 km of the Tholus sits on the edge of what appears to be a meandering scarp line that trends southwest/northeast. Though the general shape is similar to the Tholus and Tholus-A, this landform has a steeper gradient. A fourth low-relief mound (G-14) is located about 25 kilometers southeast of the Tholus in a line with the above mentioned landform. This mound appears to be eroded remnants of a larger landform and does not exhibit any of the symmetry of the Tholus.

These features are surrounded by a number of small impact craters in various stages of degradation. Some are fresh, others eroded into pedestal craters and others eroded to remnants of their original form. The Tholus, and to a lesser degree Tholus-A, stand in stark contrast to the surrounding landforms. They display no evidence of volcanism, are not impact-related and are difficult to explain as remnants of larger non-distinct landforms because of their symmetrical shapes and uniform, low gradients. Their lack of ruggedness or mesa-like appearance makes both landforms enigmatic and problematic to other landforms in this area.

The Tetrahedral Pyramid (M-13) is an angular knob on the edge of the raised rim of the impact crater (M-13) adjacent to the Cliff. Evidence that the Tetrahedral Pyramid rises above the rim of the crater is shown by the definitive shadow it casts toward the east, plus the abrupt truncation of the internal shadow of the crater at the point the Tetrahedral Pyramid rises above the crater. The length of the Tetrahedral Pyramid's shadow indicates that this feature is perhaps one-third as tall above the crater rim as the crater is deep from the top of its rim. The origin of this knob remains enigmatic in light of understood Martian geologic processes.

The D&M Pyramid (K-6,7) has been shown by Torun [15] to remain enigmatic after known geologic processes were considered in an attempt to define its origin. Torun used arguments for liquid and wind erosion, gravity, volcanism and crystal growth and determined each process to lack in its ability to develop a landform with the symmetries and angular nature of the D&M Pyramid. Furthermore, a review of earth glacial processes seems to supply an insufficient explanation for glacial activity as a mechanism of obtaining the apparent symmetry within the D&M landform. Though artes cols and other angular landforms are observed on earth and have resulted from glacial activity, none of these forms can definitively be used to explain the D&M's appearance.

Figure 60 Three views of the Tholus from 70A13 (left), 70A15 (middle), and 35A74 (right).

Conclusion

The above-discussed Cydonia landforms are but a few of the problematic landforms in this area. To lessen their possible significance by explaining them as erosional remnants of a preexisting surface, without supporting evidence, is clearly not a rigorous scientific approach. To the contrary, what exactly is needed are more rigorous geologic evaluations to determine the origins of these controversial landforms.

This review has pointed out inconsistencies in previous geologic arguments and indicates, at the very least, that geologic generalizations are not an acceptable method to explain surface features in Cydonia, enigmatic or not. Such "ballpark" solutions are adding little knowledge to the understanding of the landforms under study. The Cydonia landforms may ultimately turn out to be no more than an odd assortment of enigmatic natural features, formed by random geologic processes, but they may as well turn out to have significant implications for humanity. An unbiased approach assumes neither, but strives for the truth.

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VI. OTHER INTRIGUING OBJECTS ON MARS

"... I feel other examples of interesting landforms on Mars should be gathered and studied prior to formulation of theories about their apparent origin. The more evidence gathered the better the case. If formulation of explanations is delayed, one is usually less likely to be biased by a special theory explaining the features and their associated intelligent life-forms..." — Lambert Dolphin, 1984

The scientific method is based on two kinds of thought: deductive reasoning which is the process of generalizing from a large number of facts, and inductive reasoning which moves from a limited number of facts to broad generalizations. Hoagland reasoned inductively that if the Face is an artificial object, someone had to build it. And that the builders probably resided nearby. The City provided a justification for the Face. That the City and Face are artificial was further supported by an alignment — one that seemed to suggest the objects were built at a time when Mars was more habitable than today.

The above quote by physicist Lambert Dolphin, a member of the Independent Mars Investigation, stressed the need for balance between inductive and deductive reasoning. Simply put, Dolphin felt that Hoagland's hypotheses were premature. He believed that more data were needed before any definite hypothesis about these structures could be developed. As a result, the group expanded their search for other unusual landforms beyond the City and Face, both within the immediate area as well as to other parts of Mars. The objective was to try to find more anomalies in order to build a stronger case for artificiality.

The continuation of a line from the City through the Face led Hoagland to an unusual object known as the "Cliff" located next to an impact crater. He conjectured that the Cliff could have served as a backdrop for the viewing of the Face from the City. Although this idea was later dropped, the Cliff remained an anomaly due to its location next to an obvious impact crater and the lack of any debris flow over or around it suggesting the possibility that the formation or construction of the Cliff post-dated the impact. Hoagland and Brandenburg also noticed other unusual features nearby including a low relief feature, later called the "Tholus."

Hoagland observed that the City and Face are located near the "0 km datum" — what would, in effect, be sea level if Mars had water. He thus suggested that a search for other objects be conducted along this hypothetical shoreline. Several other unusual objects were subsequently found to the southwest including a large pyramidal landform oriented almost north-south in frame 219S16, and several very small objects ("Gate Pyramid" and "Pentagon") in 72A14. Being isolated features, and not particularly unusual in comparison with the City and Face, they received little attention.

The Crater Pyramid

Moving toward the northeast, the research team found an unusual pyramidal object (Figure 61) located on the ejecta blanket of a large impact crater in the Deuteronilus region (Viking frames 43A01-04). The "Crater Pyramid" [2], oriented 45 degrees relative to the compass directions, is located almost half way between the equator and the north pole at 46.3° N, 353° W (Figure 64). It is also the highest point for more than 100 km in all directions. What is intriguing about this object is that it abuts the wall of the impact crater and yet lacks the expected impact damage or surrounding ejecta flows, implying that its formation post-dates that of the crater.

Curiously, the Viking orbiter took a unique series of four exposures of this structure from different angles. Since the distance (and therefore the radio-transmission delay) between Mars and Earth precluded real-time control, NASA must have had advance knowledge of this object's precise planetary coordinates in order to successfully pre-program Viking's camera orientation. What stimulated the agency's interest in this object, and how it acquired the necessary targeting information, remain a mystery.

Figure 61 The Crater Pyramid from a portion of 43A01 taken over Deuteronilius Mensae. This area is about 800 km northeast of Cydonia along the southern edge of Acidalia Planitia. Note that the ejecta blanket near the large crater at the bottom of the frame displays a unique arrangement of furrows. Unlike natural erosional channels, these do not branch out in a fractal fashion but seem to originate in a straight line running tangent to, rather than radially from, the crater's bowl. Supporters of the intelligence hypothesis have speculated that these features may represent some kind of mining operation, a field of collapsed tunnels or an arrangement of large storage structures. No conventional geomorphological explanation has been proposed to account for their origin.

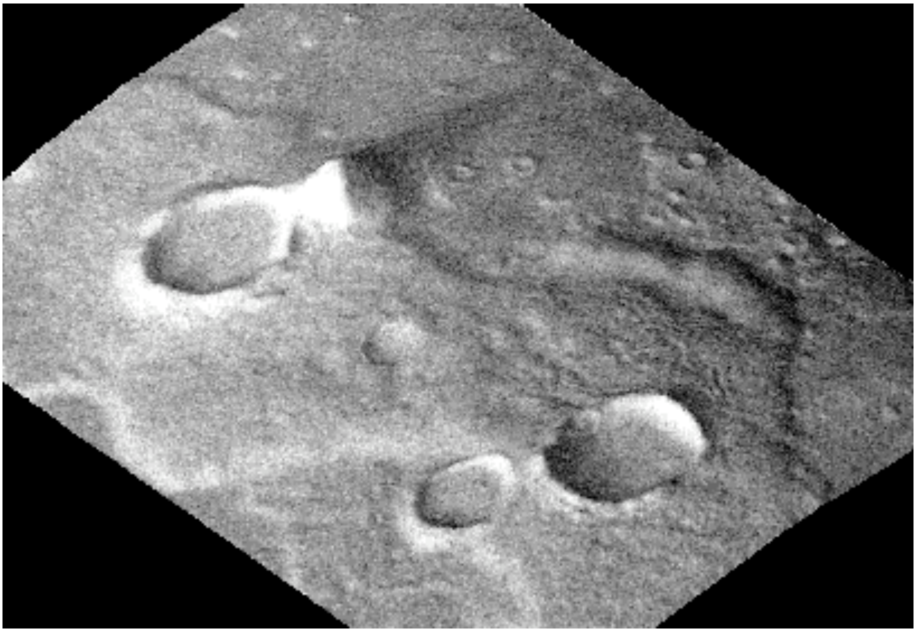

Figure 62 Computer generated perspective view of Crater Pyramid and surrounding area

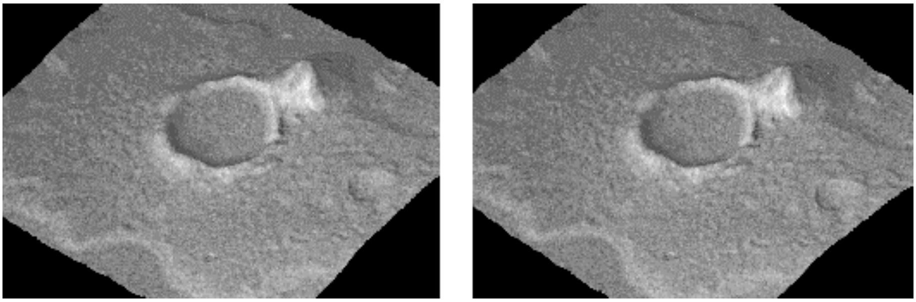

Figure 63 Artificial stereo image of the Crater Pyramid at Deuteronilius. The pyramid is about 600 meters in height and is the tallest object for at least 100 km in any direction.

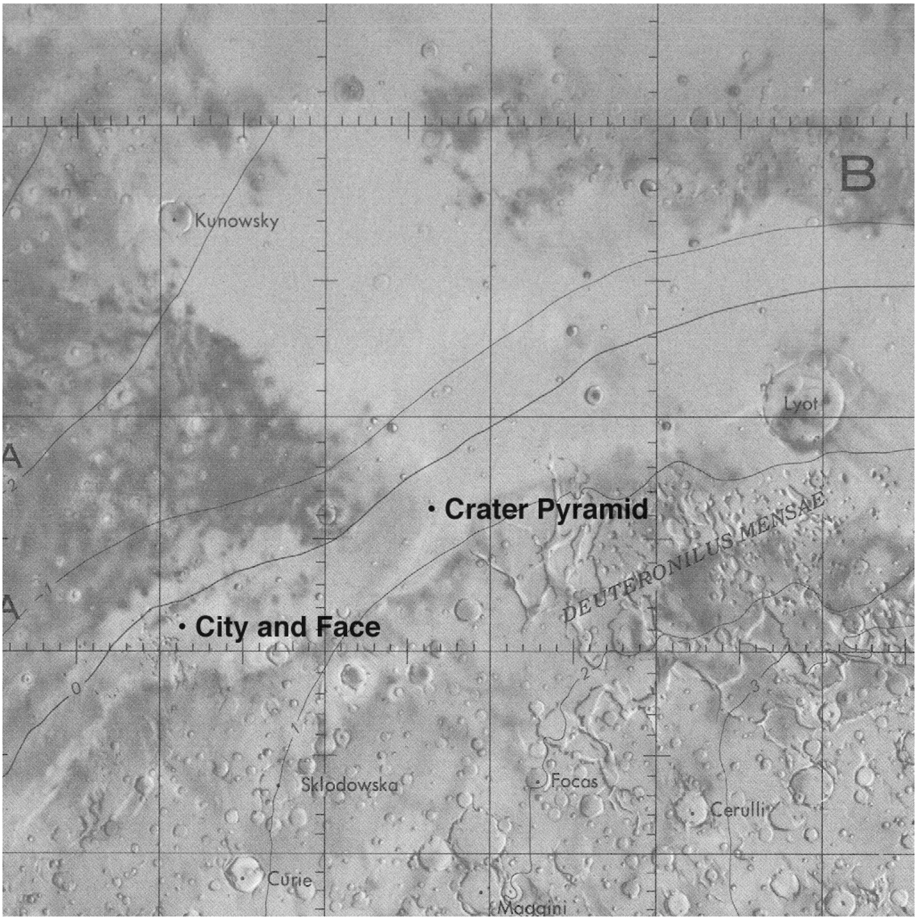

Figure 64 Portion of topographic map showing approximate location of the Crater Pyramid at Deuteronilius.

The Runway

Perhaps the most interesting feature outside of Cydonia was found on the other side of the planet, 3-4 km above the mean datum, on the slopes of Hecates Tholus (frame 86A08). Termed the "Runway" (Figure 65) it consists of a series of bumps, each about 300 meters tall, spaced 300 meters apart in a line about 4 km long. One member of the Independent Mars Investigation research team, geologist Bill Beatty interpreted it to be a natural feature. Physicist Lambert Dolphin offered another interpretation:

> "This feature certainly looks like an east-west runway with adjacent taxiway. The regular 'knobs' along the runway suggest an accelerator structure, and the bumps on the mesa [located nearby] suggests large buildings. This is how I visualize the 'runway' area, assuming it is non-

natural. I find a natural explanation for this artifact more difficult [to conclude, than Beatty does].” [3]

Hoagland measured the orientation of the Runway (within the accuracy of the data) to be exactly east-west. This led him to speculate:

> “One purpose for such a specifically aligned structure, with ‘regular knobs’ along its length, might be as some kind of accelerator to launch spacecraft from the planetary surface...” [4].

What Hoagland is referring to here is similar to "rail guns" that were being developed under the "Star Wars" Strategic Defense Initiative (SDI) at the time.

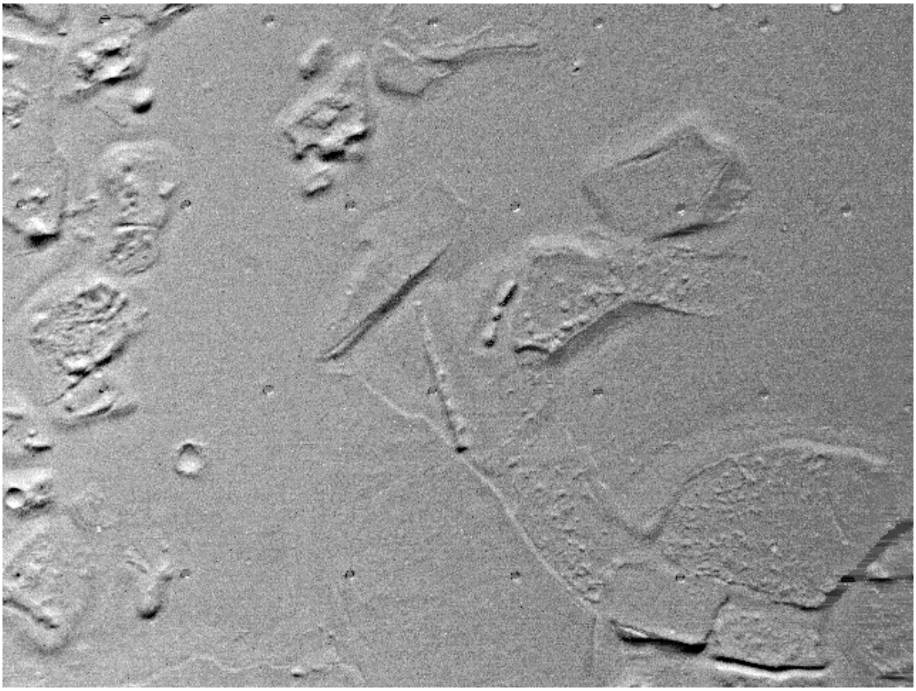

Figure 65 Portion of 86A08 from the Utopia region of Mars on the northwest slope of the volcano Hecates Tholus. The Runway appears just left of center.

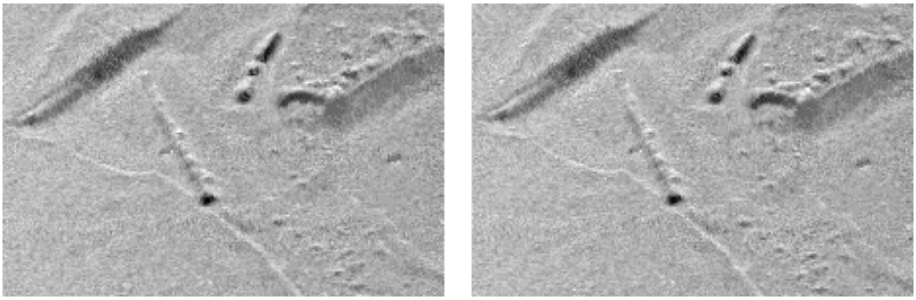

Figure 66 Left and right artificial stereo pair of the Runway in the Utopia region. The Runway is the linear structure near the center of the image, consisting of a 4 km row of conical or pyramidal forms that appears to emerge from the ground at one end and is nestled in a shallow, basin-like depression. A similar but more well-defined depression surrounds a nearby collection of three mounds forming a rough "bow-tie" shape. The Runway itself is 3-4 km above the mean elevation datum and is oriented east-west. Some investigators have likened this structure to a linear particle accelerator, or to a "mass-driver" (a proposed device for propelling objects into orbit) partly due to the easterly orientation of its more exposed end. The irregularity visible near the Runway's mid-section is a remnant of a camera registration mark and not part of the object itself.

Figure 67 Magnified view of Runway and surrounding area.

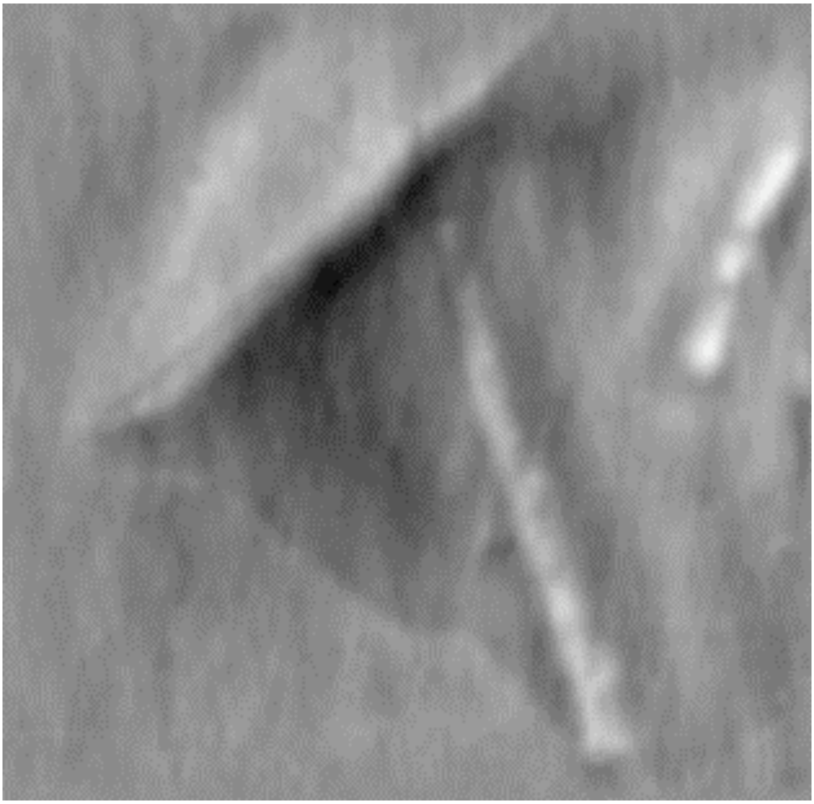

Figure 68 Height map of region around Runway derived by single image shape-from-shading algorithm.

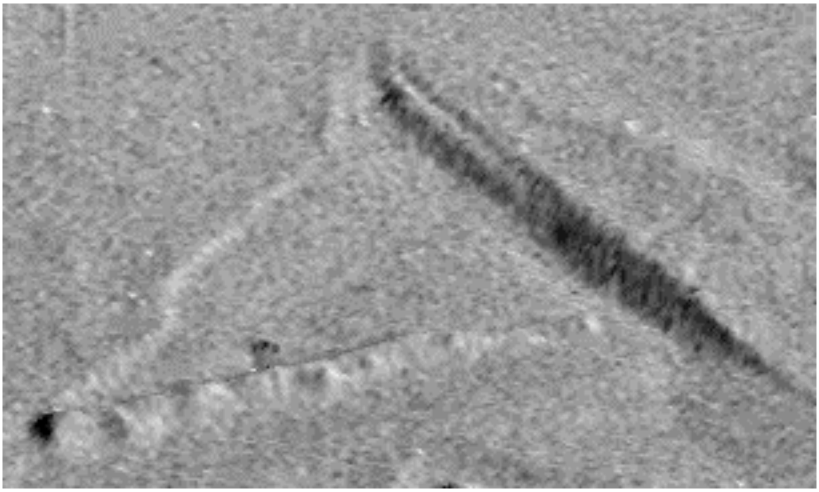

Figure 69 Computer generated perspective view of the Runway from the side. Structure appears to emerge from slightly depressed area just in front of escarpment to the right.

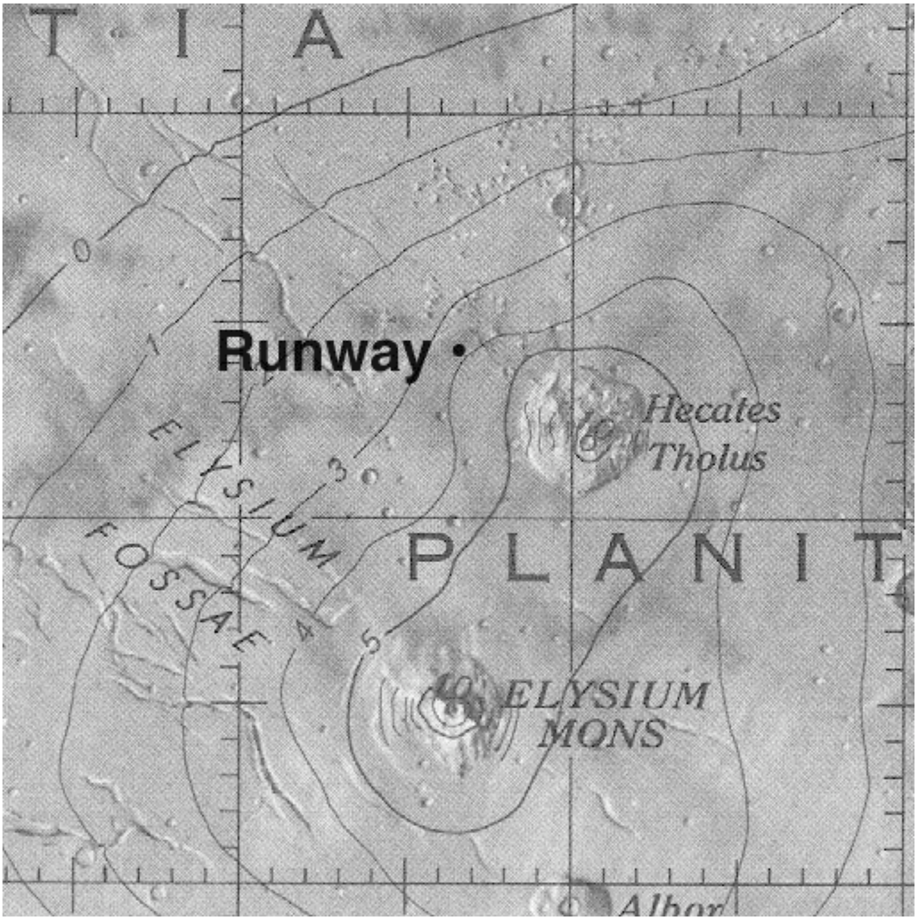

Figure 70 Portion of topographic map showing approximate location of the Runway, near Hecates Tholus.

Other Anomalies in Cydonia

As a result of analyzing additional Viking images (Figure 71) using the fractal technique, an unusual formation known as the "Bowl" (Figure 52) was detected in frame 70A10. This feature located about 110 km south, southwest of the Face is next to a four-sided pyramidal object, ("B pyramid"). This pyramid, like the D&M, appears to have its southern face oriented, to within measurement accuracy, exactly due south. In addition there are a number of sharp linear features etched into the surrounding terrain. Two appear to meet at a 45° angle.

Somewhat closer to the Face is another four-sided pyramidal object (Figure 72). Discovered by a group of students at the North Kelvinside Secondary School in Glasgow, Scotland led by researcher Chris O'Kane, this object is about 50 km southwest of the Face and is oriented roughly in line with the City and Face.

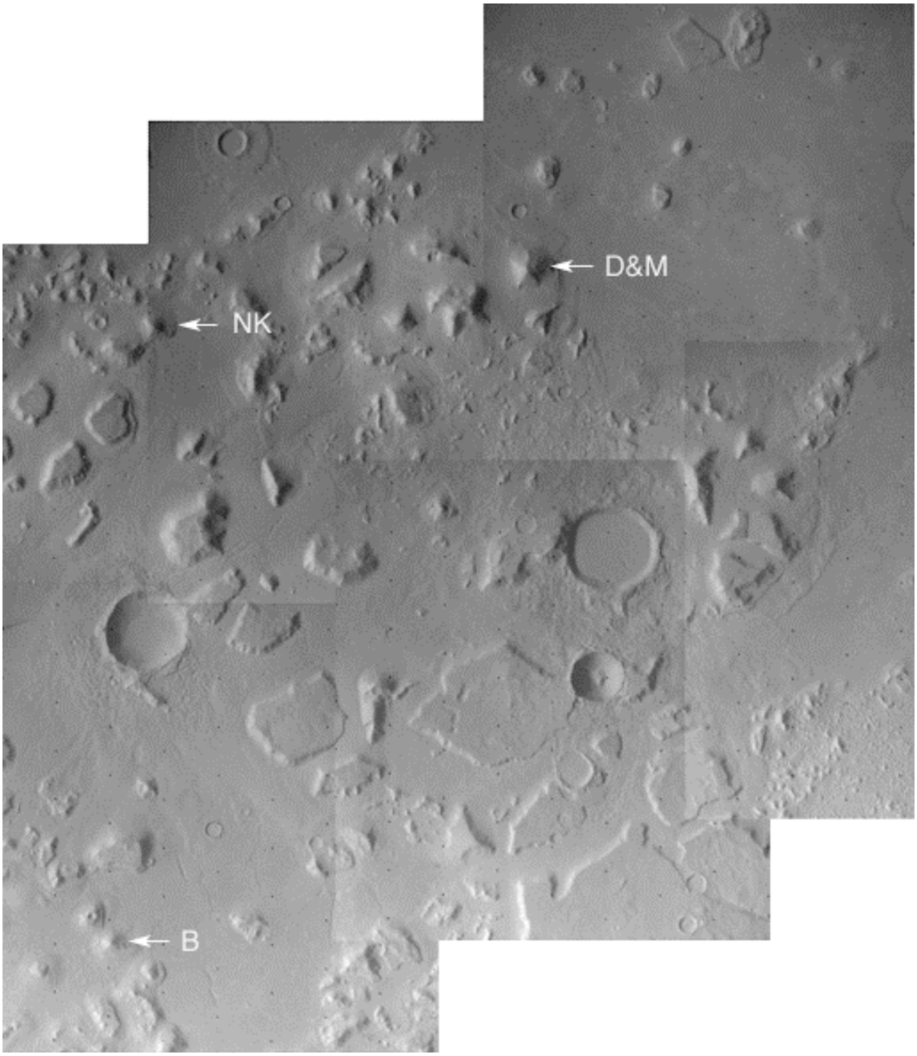

Figure 71 Overview of region southwest of face showing location of B and NK pyramids relative to that of the D&M.

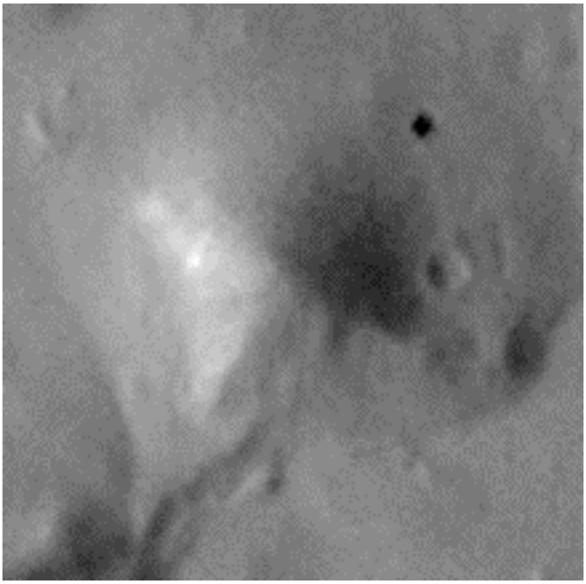

Figure 72 NK Pyramid located about 50 km southwest of the Face

Fort Aetherius and King Pyramid

No where else on Mars does one find the extraordinary collection of objects seen in Cydonia. However, as part of a more recent systematic search for other anomalies on the Martian surface, British researcher Ananda Sirisena has found several additional objects of interest [5]. Two are seen in Viking frame 70A01 (approximate location 40° N, 14.4° W). One looks like the letter "A" and has been named Fort Aetherius (Figure 73) after the region in Mars' northern hemisphere between Utopia and Elysium. It is a raised circular formation similar to the Bowl in 70A10. To the south lies a four-sided pyramidal object dubbed the "King Pyramid" which appears to have at least two buttresses similar to those in the D&M pyramid. A similar pyramidal structure lies roughly south of the Bowl in 70A10. It is also noted that like the southern face of the D&M, the southern faces of these pyramids appear to be oriented exactly due south.

Figure 73 (Top) Fort Aetherius (top middle) and King pyramid (just below and to the right of center). (Bottom) Simulated perspective view from the south at a zenith angle of 60 degrees.

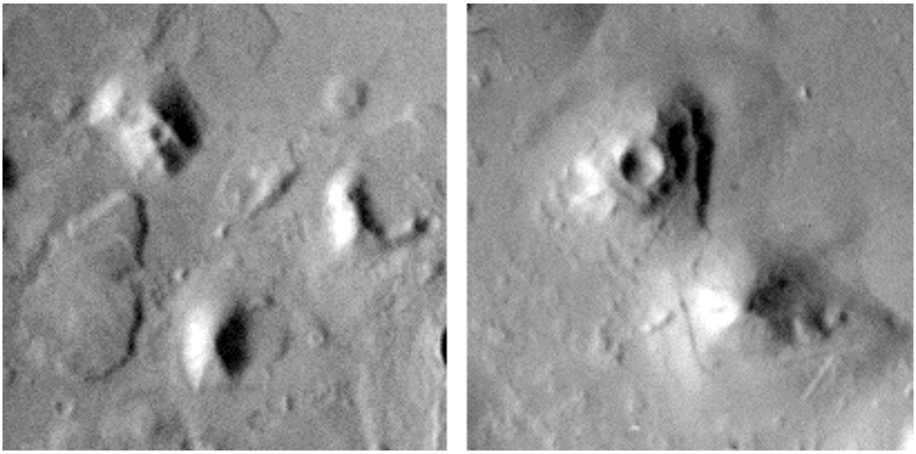

Figure 74 Fort Aetherius and King pyramid in 70A01 (left) and Bowl and pyramidal object in 70A10 (right)

References

[1] Randolfo Pozos, *The Face on Mars: Evidence for a Lost Civilization*?, Chicago Review Press, 1987, pg. 36.

[2] Richard C. Hoagland, *The Monuments of Mars*, North Atlantic Books, 1987., pp. 318-320.

[3] Ibid, pg. 321.

[4] Ibid, pg. 321.

[5] Ananda Sirisena, "Cydonia: The City on Mars," *Amateur Astronomy and Earth Sciences*, Vol. 1, Issue 9, 1996.

VII. THE CASE FOR ARTIFICIALITY

"Extraordinary claims require extraordinary evidence"
— Carl Sagan, 1985.

That certain objects on Mars may be artificial in origin is certainly an extraordinary claim. And for many years, Carl Sagan's demand for extraordinary evidence to support this claim seemed an unrealistic demand and an insurmountable obstacle to scientific legitimacy. We had no "smoking gun," no single piece of extraordinary evidence. Only a lot of weak evidence, all seeming to point in the same general direction.

But then it occurred to me that a method used for mapping terrain and land cover from satellite imagery (as well as other applications) could also be applied to the study of the Mars anomalies. In land cover mapping each map category is a hypothesis about what is on the ground at a particular location. But a satellite cannot directly sense the land cover. Instead it measures some observable quantity such as optical or microwave reflectance, temperature, etc. From these measurements a person or machine decides or infers what is likely to be present on the ground. A method known as Bayesian inference provides a way to combine information from multiple sources of information (in this case, images) as evidence to determine the probabilities for each hypothesis (land cover category). After combining the information, one can then make an informed decision, e.g., the most likely land cover type, based on all of the evidence.

For example, in an optical image acquired by a satellite, water (aside from glint), asphalt, and trees appear dark relative to other land cover types. It is difficult to discriminate between these three land cover types using just the optical image. In a radar image, water and asphalt again appear dark because they are smooth relative to the wavelength of the radar. On the other hand, trees are rougher and reflect more radiation thus appearing brighter than water and asphalt. So by using the optical and radar image together, one can now discriminate trees from water and asphalt. Now if we add in a thermal infrared image, we find that the temperature of asphalt and water will almost always be different. For example in the summertime, during the day asphalt will be much warmer than water (at night the situation will typically be reversed). Now with all three images and a method like Bayesian inference to combine them, we can reliably identify water, trees, and asphalt.

Back to Mars. Previously, four hypotheses have been put forth concerning these objects:

1. Cydonian Hypothesis [1] — Conditions necessary to support life on Mars existed long enough for an indigenous race of Martians to evolve and build the objects in question.
2. Previous Technological Civilization Hypothesis [2] — The objects were constructed by a previous technological civilization from Earth.
3. Prior Colonization Hypothesis [2,3,4] — The objects were constructed by visitors from outside of our solar system.
4. The Null Hypothesis — All of the objects are natural occurring geological formations.

Recently Lammer [5] has argued that the Cydonian Hypothesis is not consistent with what we currently know about Mars' geological and climatic history. We believe that there is insufficient information at this time to differentiate between the second and third hypotheses. However estimates of extraterrestrial (ET) visitation in our solar system [3] derived from a variation of the Drake Equation used to justify the search for extraterrestrial intelligence (SETI) by radio does suggest that ETs have may have visited our solar system in the last ten million years. If ETs did construct large artificial structures on Mars over this period (for whatever purpose) it is likely that they have been fairly well preserved by the Martian environment and are detectable by remote sensing [3,4]. This in itself provides a plausible justification for our hypothesis which, simply stated, is that the Face and other nearby objects in the Cydonia region may be artificial in origin. The Null Hypothesis that none of the objects are artificial represents the view of many in the planetary science community [6].

Simply stated, our hypothesis is that the Face and other nearby objects in the Cydonia region of Mars may be artificial (whatever their origin). After presenting the evidence to date (Exhibits 1-17), using a Bayesian argument we will assess just how strongly it supports this hypothesis.

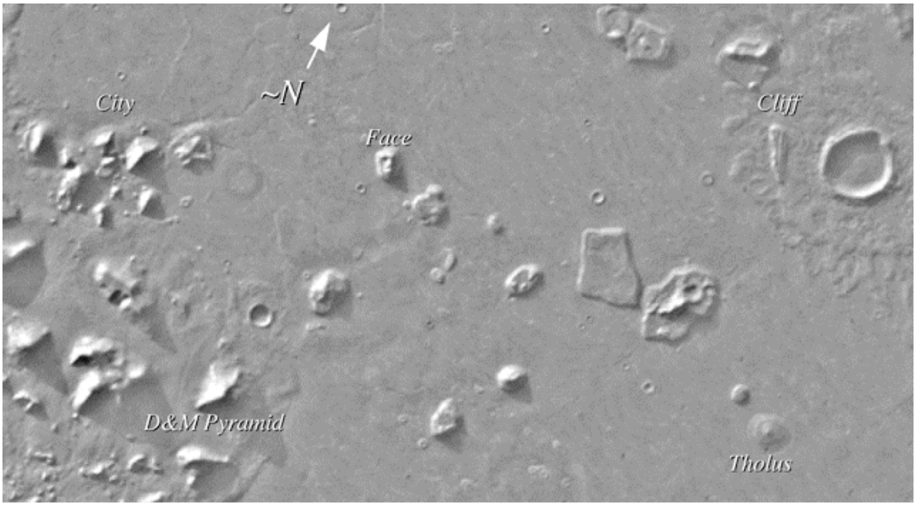

Figure 75 Mosaic of several Viking Orbiter frames from orbit 35 showing the Face and other objects of interest on the surface of Mars. The image covers an area roughly 70 x 40 km in size. The Face, near the center of the picture, is located at approximately at 41° N latitude and 9.5° E longitude.

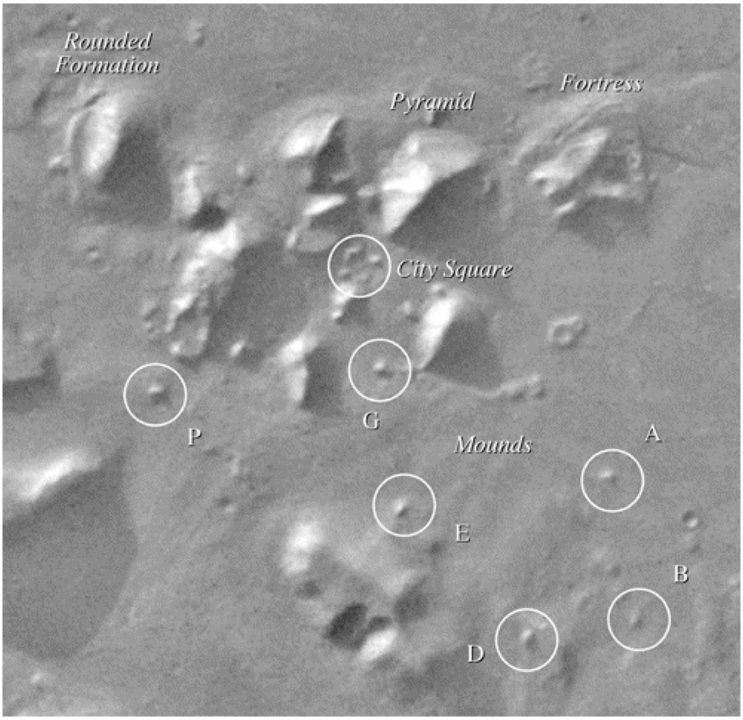

Figure 76 The City is a collection of formations located about 20 km southwest of the Face originally identified by Hoagland. Three objects comparable in size to the Face and a number of smaller mound-like objects shown above (from 35A72) are considered here.

Exhibit 1: The Face — General Features

Most accept that the Face looks likes a face. It possess all of the necessary features: head, eyes, ridge-like noise, and mouth. Even NASA acknowledges this fact. In July 1976, shortly after it was first photographed, JPL issued the following statement as part of a press release:

> "The picture [35A72] shows eroded mesa-like landforms. The huge rock formation in the center, which resembles a human head, is formed by shadows giving the illusion of eyes, nose and mouth."

When asked about this picture, they stated that in a second photograph taken over the area several hours later, the formation was no longer recognizable as a face — grounds to dismiss the Face on Mars as an optical illusion. But, as it turns out, there is no such photograph [7].

DiPietro and Molenaar did find a second image (70A13) of the Face taken, not several hours later as stated by NASA, but 35 days later [8]. In 35A72 the sun angle is only 10 degrees above the horizon and so most of the right side of the Face is in shadow. But in 70A13 the sun is 15 degrees higher and reveals more of the Face's right side. Instead of an ordinary rock formation, this second image not only confirms the facial features first seen in 35A72, but also reveals the overall symmetry of the head, the extension of the mouth, and a matching eye on the right side — features not visible in 35A72 because they were in shadow.

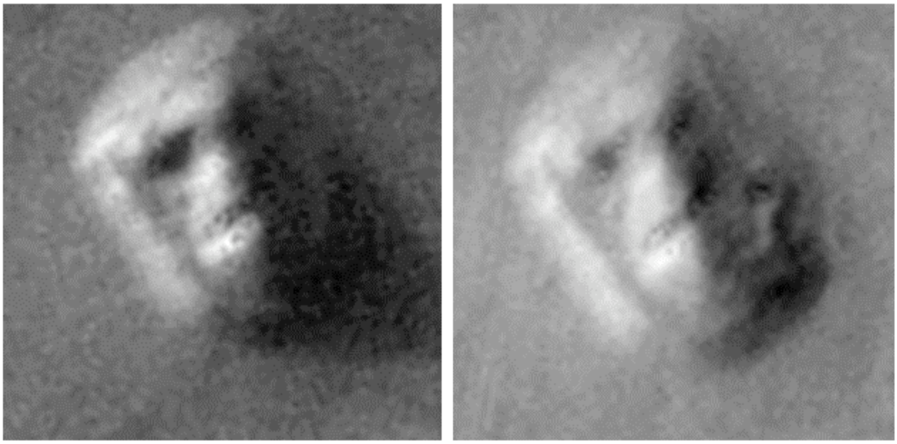

Figure 77 Two images of the Face from 35A72 (left) and 70A13 (right). The second image of the Face (right) provides corroborating evidence for facial features, overall symmetry, and fine scale details.

Exhibits 2 and 3: The Face — Facial Proportions and Architectural Symmetry

Several years after DiPietro and Molenaar's discovery, an independent Mars investigation group was organized to study the Face and surrounding landforms [9]. Artist James Channon, a member of that group, evaluated the Face in terms of its proportions, supporting structure, and expression. Concerning the facial proportions he writes:

> "The artist uses classical proportions and relationships when constructing the human face... The physical anthropologist recognizes a set of classic proportions, that relate facial features in predictable ways. The features on this Face on Mars fall within conventions established by these two disciplines."

Then, taking a step back he comments on the head itself:

> "The platform supporting the Face has its own set of classical proportions as well. Were the Face not present, we would still see four sets of parallel lines circumscribing four sloped areas of equal size. Having these four equally proportioned sides at right angles to each other creates a symmetric geometric rectangle."

In addition to being impressed by the facial proportions and architectural symmetry, Channon found the Face to have a strong aesthetic appeal emphasizing that "the artistic attention required to generate the expression like the one studied [i.e., the expression of the Face in 35A72] is not trivial."

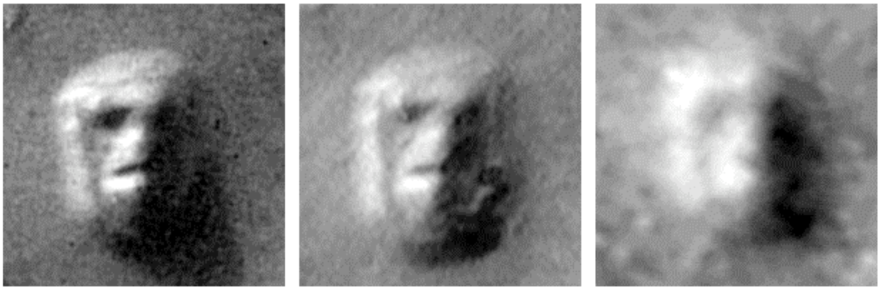

Figure 78 Three highest resolution views of the Face from 35A72 (left), 70A13 (middle), and 561A25 (right) at 47.1. 43.3, and 162.7 meters/pixel. The apparent symmetry of the Face is distorted somewhat in 35A72 and 70A13 since is illuminated from slightly above left. A better indication of its overall shape is seen in 561A25 where the illumination is almost perpendicular to the axis of symmetry.

NASA has stated repeatedly over the years that formations like the Face are neither remarkable nor uncommon on the Martian surface. And to support this position, they often cite two geological formations on Mars, one of which looks like a "Happy Face" (Figure 79). McDaniel puts these examples into the proper perspective when he writes [7]

"...NASA's 'Happy Face button' is so distorted that it impresses one as little more than a caricature of what was already a cartoon. ...The fact that all they could come up with were these two farcical exaggerations serves merely to underscore the point that the Face is, after all, quite a unique phenomena on Mars, whatever its origin."

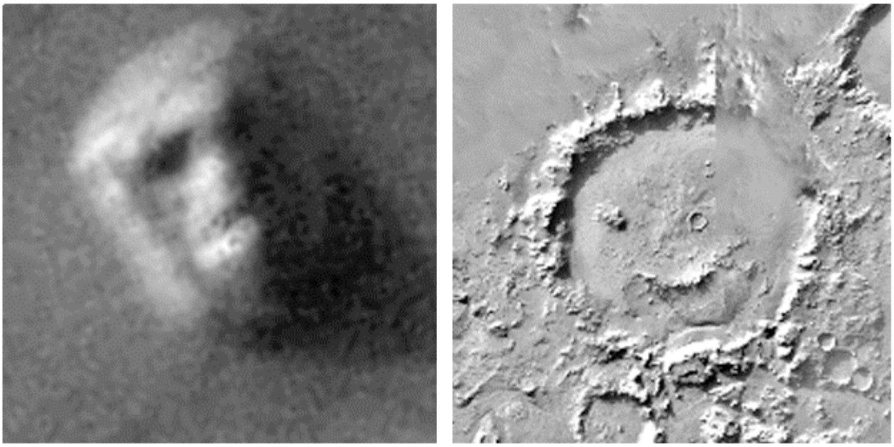

Figure 79 Comparison between the "Happy Face" and the Face on Mars. The "Happy Face" is used by NASA to illustrate the human tendency to see faces in nature.

Exhibit 4: The Face — Subtle Detail

In addition to the overall organization and symmetry of the formation a number of subtle features (Figure 80) or embellishments have also been observed. DiPietro and Molenaar first noticed a dark cavity within the eye socket that looks like an eyeball. Other early investigators observed broad stripes across the face. Later after image restoration, cubic spline interpolation, and contrast enhancement, thin lines that intersect above the eyes and fine structure in the mouth that appear as teeth were also found [10].

No specific geological mechanism has been proposed to explain the subtle detail in the Face. Instead, it has been argued that these features, in particular the "teeth" are nothing more than noise which has been emphasized through the improper use/interpretation of image enhancement techniques [11]. Malin shows that noise on the right shadowed side of the Face in 70A13, when enhanced, look like teeth, and uses this example to dismiss the teeth and other fine structure seen in the Face as processing artifacts (Figure 81). But as pointed out by McDaniel, Malin's "teeth" are not the ones on the left sunlit side of the Face that are under investigation. These teeth like the eyeball, the crossed lines in the forehead area, and to a lesser extent the broad strips across the Face, can be seen in both images. Because they are visible in both images it is very unlikely that they are due to noise in the imagery or artifacts of image processing.

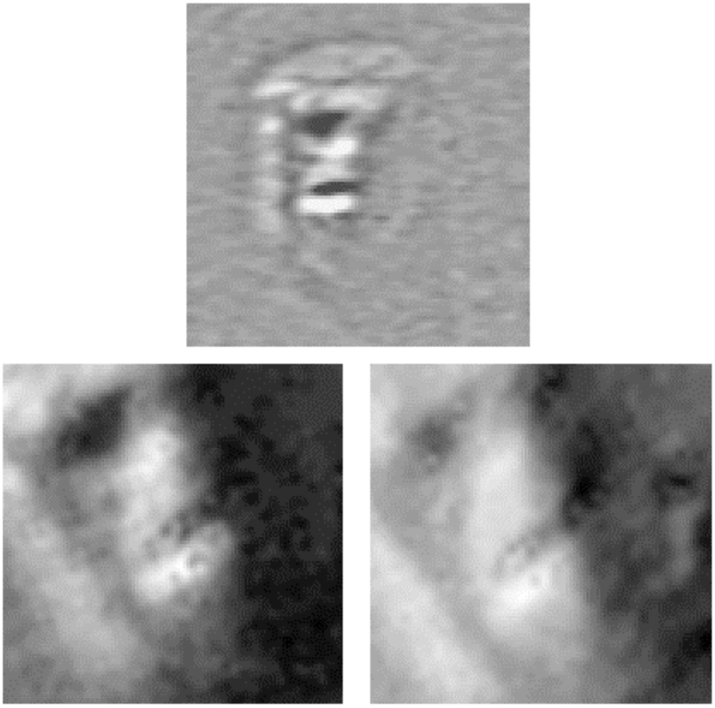

Figure 80 Portion of 35A72 enhanced to emphasize linear features (top). Note dark stripes or bands across the face and crossed lines above eyes. Fine structure in mouth (below). Since these features are present in two different images they are not likely to be noise or artifacts of digital image processing.

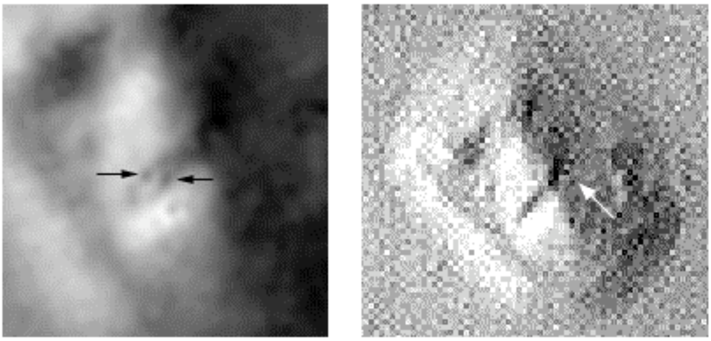

Figure 81 Malin's "teeth" (right) are not the features that we have been discussing (left)

Exhibit 5: The Face — Persistence of Facial Features over Variations in Sun Angle and Viewing Geometry

From the beginning NASA has maintained that the Face is "formed by shadows giving the illusion of eyes, nose and mouth”, in other words, an optical illusion. In order to test this claim, an image processing technique known as shape from shading was used to determine the 3-D structure of the Face from its image. Two images (35A72 and 70A13) were used to check the accuracy of the result by using the surface computed from one image to predict what the other should look like, and vice versa [10]. Computer graphics techniques were then used to predict how the surface would appear under different lighting conditions and from other perspectives. Results of this analysis showed that the impression of facial features is not a transient phenomena — that facial features seen in the image are also present in the underlying topography and produce the visual impression of a face over a wide range of illumination conditions (Figure 82-Figure 84) and perspectives [12]. The shape-from-shading results have been corroborated by the noted sculptress Kynthia who has created a model of the Face in clay that matches all available images under the corresponding light source/viewing conditions.

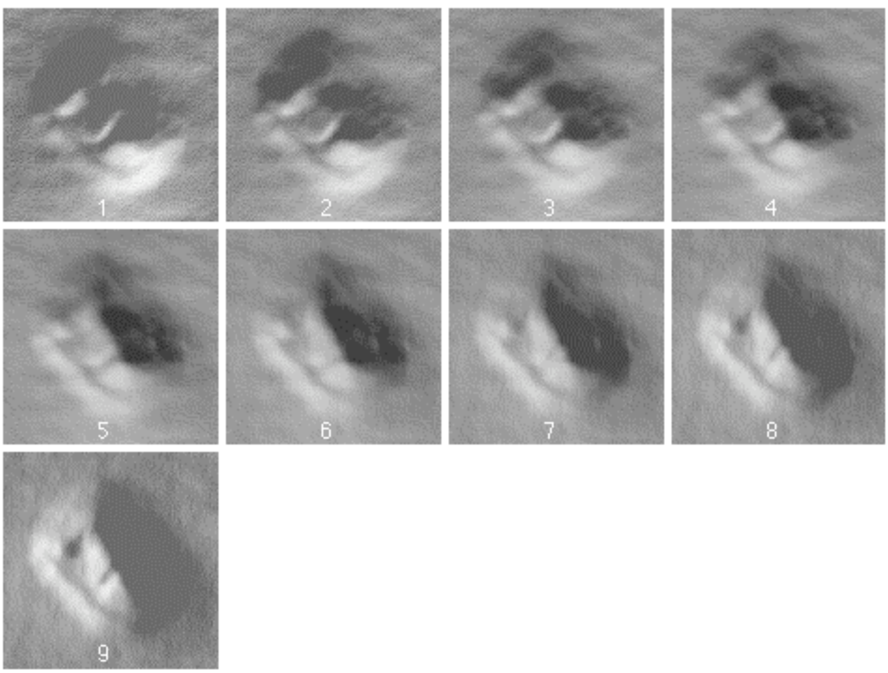

Figure 82 Simulated views of Face from above during the course of a winter day on Mars. Each frame is spaced one hour apart.

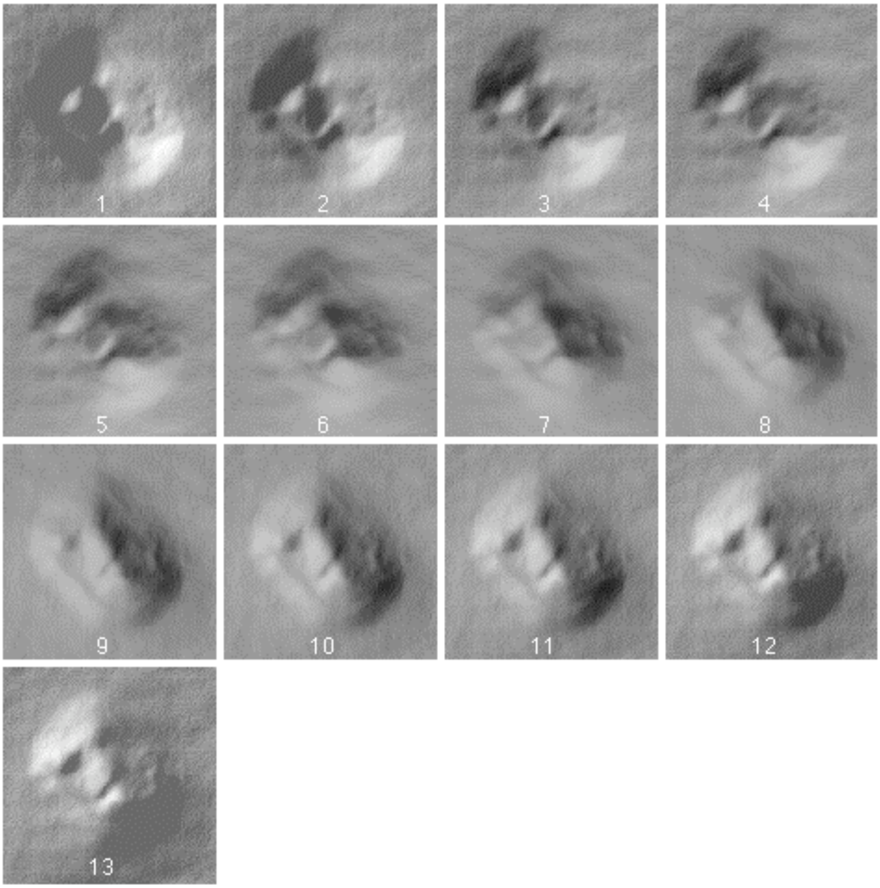

Figure 83 Simulated views of Face from above during the course of a spring day on Mars.

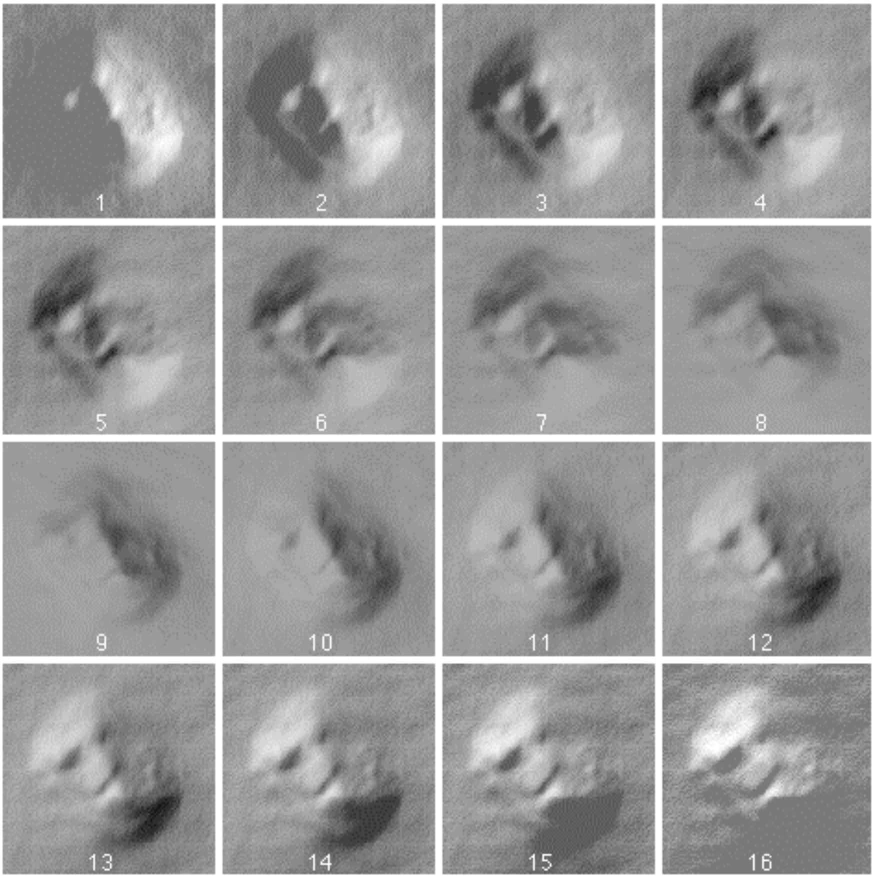

Figure 84 Simulated views of Face from above during the course of a summer day on Mars.

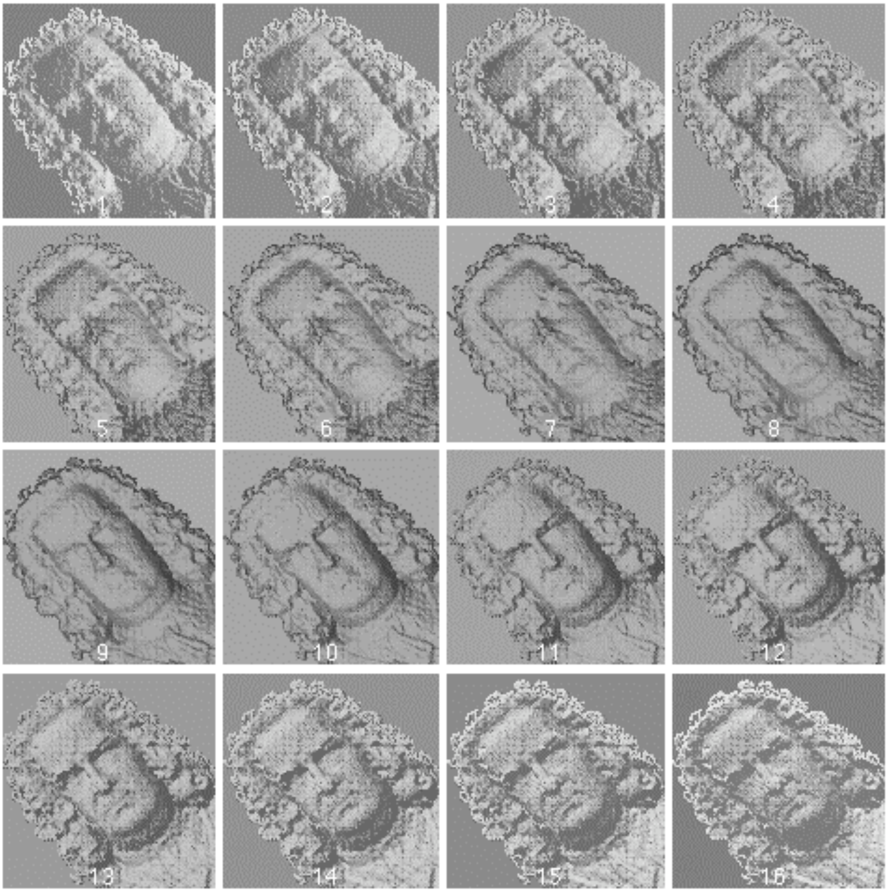

Figure 85 Comparative analysis. Simulated views of bust of Johann Sebastian Bach using same lighting conditions and Lambertian reflectance map as in previous sequence for Face on Mars. Note that Bach is difficult to recognize under midday lighting conditions similar to those where features in the Face are less distinct. (Range data courtesy F. Stein, USC Institute for Robotics and Intelligent Systems.)

Exhibit 6: The Face — Non-Fractal Structure

Where the previous five exhibits are somewhat qualitative in nature, the fifth piece of evidence to support the claim that the Face is an artificial object is based on a quantitative analysis of its structure using fractals. By using fractals to model images, areas that are least natural can be identified according to how well they fit the fractal model. This is the basis of an approach that has been used to detect man-made objects in overhead imagery [13]. In a study performed to analyze the structure of the Face and surrounding landforms, the Face was found to be the least fractal object in Viking frame 35A72 [4] It was also highly anomalous in frame 70A13. When the analysis was applied to four surrounding Viking frames, it remained the least fractal object over the entire area.

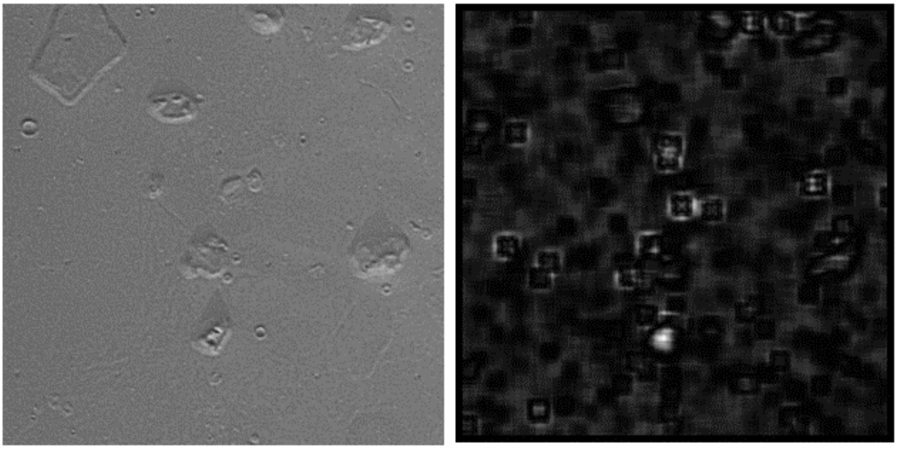

Figure 86 Fractal analysis results for Face and surrounding area from 35A72 (left). Bright areas in model-fit image (right) indicate where structure of the image intensity surface (which is related to the shape of the underlying terrain) does not fit a fractal model and thus is least natural by the fractal criterion.

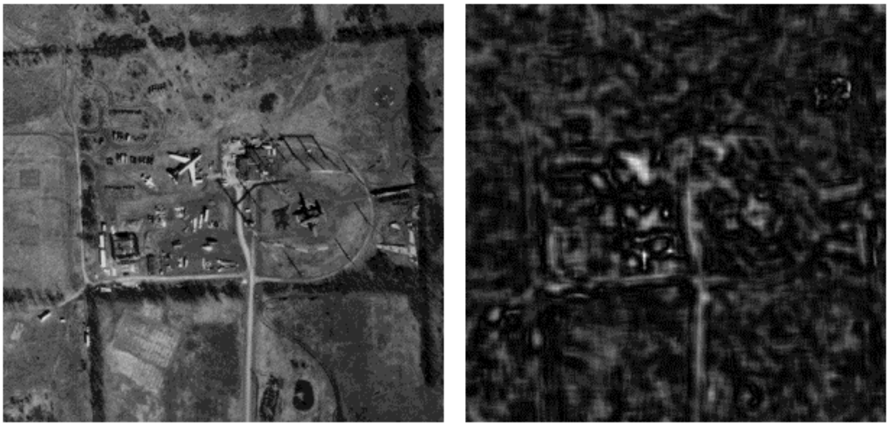

Figure 87 Image over U.S. military base (left) and fractal model-fit error image (right).

Exhibit 7: Similarity Between the Face and Rounded Formation in City

As noted earlier, Channon observed that the Face appears to rest on some type of platform and goes on to say that: "These support structures alone suggest a piece of consciously designed architecture" [9]. A rounded formation located at the extreme southwestern end of the City also seems to rest on a similar platform oriented in the same general direction. By overlaying the image of this formation over that of the Face a similarity in the gross morphology of the two formations is evident. The similarity can be seen by fading from the rounded formation to the Face. This transition from a featureless form to a face suggests the possibility that the Face could have been carved from such a formation. It also reminds us of the emergence, or release from imprisonment of the human form from stone as portrayed in Michelangelo's *The Prison* [14].

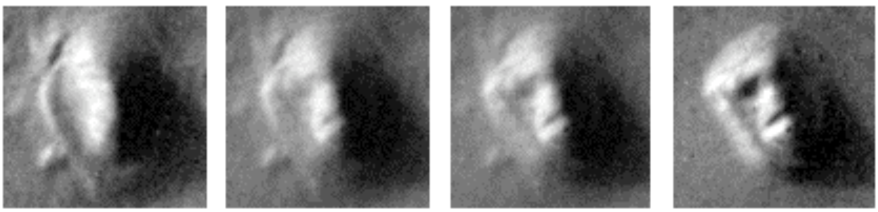

Figure 88 Similarity in structure between a rounded formation in the southwestern portion of the City and the Face. Note similar morphology and placement on platform-like structures. The images have not been rotated or scaled in size.

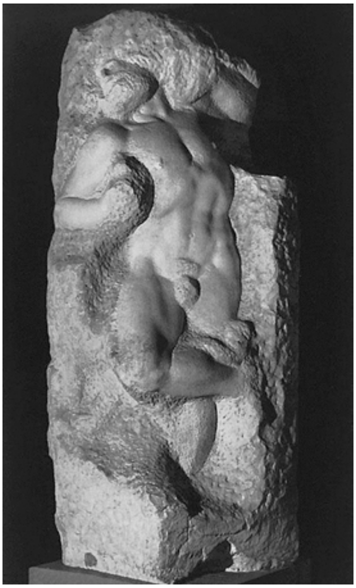

Figure 89 Michelangelo's *Il Prigione (The Prison)*

Exhibits 8 and 9: The Fortress — Geometric Shape and Fine-Scale Detail

In stark contrast to the sculpted appearance of the Face, the Fortress (Figure 90) is a geometrically shaped object in the northeastern portion of the City, closest to the Face. Four straight sides or walls are visible in the two available images (70A11 and 35A72) of this object. These walls enclose an inner space; i.e., an area that is lower in height than the surrounding walls.

Like the Face, the Fortress also contains subtle details that are at or slightly below the resolution of the imagery. In particular, two of the walls appear to contain regularly spaced indentations. Sagan remarks:

> "In the case (most unlikely in my view) that the nearby structures were really once a city, that fact should be obvious on closer examination. Are there broken streets? Crenellations in the 'fort'? Ziggurats, towers, columned temples, monumental statuary, immense frescoes? Or just rocks?" [6]

The indentations (Sagan's crenellations) are visible in both images and thus must be real surface features. But only with higher resolution images will we be able to determine if they are wrinkles or folds caused by natural geological processes or the fine scale details of an artificial structure.

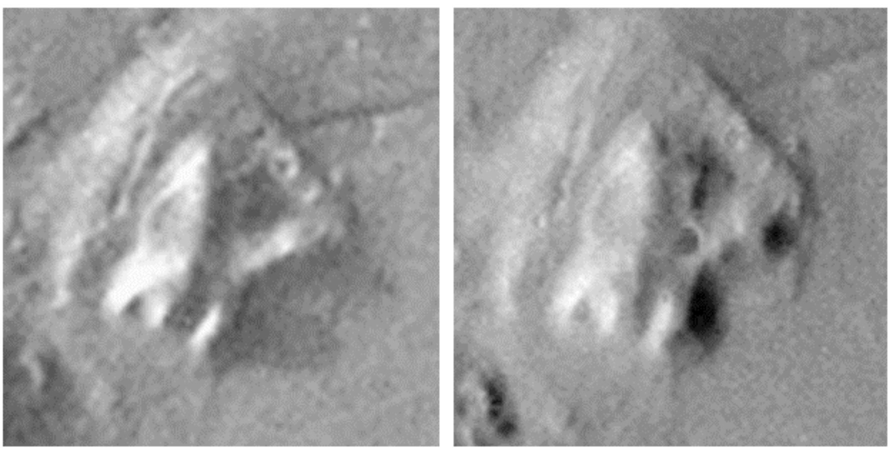

Figure 90 Two images of fortress from 35A72 (left) and 70A11 (right). As in the Face, fine scale details are seen in both images.

Exhibit 10: Similarity Between the Fortress and Adjacent Pyramidal Object

Another object of interest within the City is a pyramidal object next to the Fortress. This object appears to be aligned with the Fortress, and is similar to the Fortress in size and shape. It has been suggested that the Fortress might have been an enclosed structure that collapsed inward. To test this assertion, several points that appear to be common to the two structures were identified and used to align sub-images from 70A11. (It is noted that the images were only translated relative to one another and not scaled or rotated.) By fading from one object to the other it is then possible to visualize the similarity between the two objects (Figure 91). The impression of a collapse is particularly striking in the perspective view (Figure 92) where the apex of the pyramid appears to fall into the inner space of the Fortress. If the Fortress was enclosed pyramidal structure that collapsed inward, then the implication is that the adjacent pyramid may be hollow.

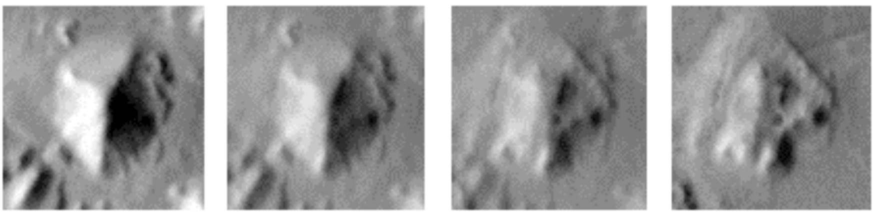

Figure 91 Similarity in structure between Fortress and adjacent pyramid from image 70A11. Sequence derived from coregistered images and fade from pyramid (left) to Fortress (right). (Movie available in animated content.)

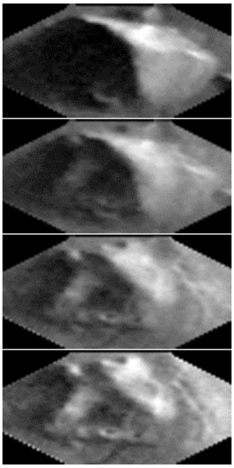

Figure 92 Visualizing the possible collapse of a pyramidal structure into that of the Fort. Perspective view from 60 degree zenith angle.

Exhibit 11: Similar Size and Orientation of Face and Larger Objects in City

Drasin [15] has noted that many of the objects of interest in Cydonia are about the same size. Comparison of the Face, rounded formation, Fort, and adjacent pyramid (Figure 93) reveal that in addition to their similarity in size, they also seem to be oriented in the same direction. This is particularly interesting because these objects are not all adjacent to one another and do not have the same morphology.

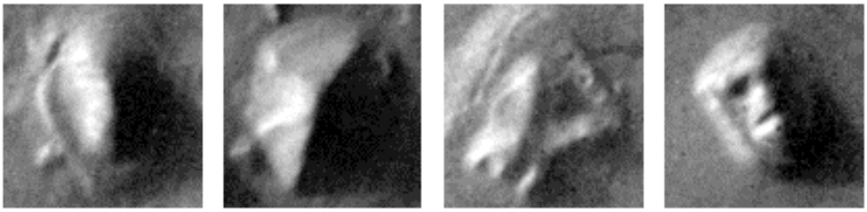

Figure 93 Similarity in orientation and scale of four objects (from 35A72). As in previous figures, these images have not been rotated or scaled in size.

Exhibit 12: Mounds — Grid Pattern

An important idea introduced in the beginning of the investigation was that if the objects in Cydonia are artificial then they should relate to one another within a broader context. Hoagland first observed that certain angles repeatedly occur between lines connecting the Face, D&M Pyramid, and other objects in this area. Later Torun found similarities between these angles and those internal to a five-sided reconstruction of the geometry of the D&M Pyramid [16]. It has been hypothesized that these angles are related to tetrahedral geometry. A criticism of the Hoagland-Torun findings is that they involve the selection of points on certain objects that seem in some cases to be somewhat arbitrary.

Hoagland also noticed a number of smaller mound-like features in the City (Figure 76). He conjectured that one group of four arranged in a square is positioned to allow one to view the sun rising over the Face on the first day of summer. Another group below seemed to lie at the vertices of an equilateral triangle. Recently an analysis of this later group of mounds was performed by Crater and McDaniel [17]. Since the mounds are relatively small well-defined features there is no methodological problem involved in selecting points for analysis. Among their findings:

- All 30 angles between the five mounds ABDEG can be expressed as $n(\pi/4)\pm m(t/2)$ where n and m are the integers 0, 1, 2, and 3, and t =

arcsin(1/3)≈19.5° is the tetrahedral latitude (the latitude where a tetrahedron, oriented apex down, contained within a sphere touches the sphere).

- All distances between the five mounds can be expressed as multiples of $\sqrt{2}$ and $\sqrt{3}$ times the distance between mounds B and D.
- The mounds appear to coincide with a rectilinear grid pattern with a long/short side interval ratio of $\sqrt{2}$.

Based on the preciseness of the fit they estimate the probability that the mounds were formed by natural geological processes at about one in 200 million.

Table 2 lists the orientations of lines between those mounds that lie on the Crater-McDaniel grid. Measurements were performed on map-projected Viking imagery. Each measured value in the table is the average of three separate measurements. Angles are measured counter-clockwise from the horizontal axis (due east). The average (standard deviation) of the first three measurements is 34.53 (0.91), and of the fourth and fifth measurements is 124.35 (1.15). The difference is close to 90° which would seem to confirm the presence of an underlying rectilinear grid pattern.

Table 2 Orientations of lines between mounds in City

Measurement	Orientation
Line from mound P to G	32.7
Line from mound E to A	35.9
Line from mound D to B	35.0
Line from mound E to G	123.2
Line from mound B to A	125.5

Exhibit 13: Alignment of Larger Objects in City and Face with Grid Pattern

The Face, Fortress, pyramid to the left of the Fortress, and rounded formation also appear to be oriented in the same general direction as the grid pattern suggested by the arrangement of the mounds. The orientations of the best defined edge on each of these objects are listed in Table 3. As above, each measured value in the table is the average of three separate measurements. The average (standard deviation) of the last four measurements is 121.8 (1.6). The similarity in orientation between these six mounds, three larger objects in the City and the Face suggests an underlying regularity or pattern of organization in this collection of objects — a regularity that is hard to explain in terms of random geological processes.

Table 3 Orientations of Face and larger objects in City

Measurement	Orientation
Left edge of Face	120.9
Right edge of Fortress	124.5
Left edge of pyramid in City	120.8
Left edge of rounded formation in City	120.8

Exhibit 14: Anomalous Geomorphology of D&M Pyramid

During their initial investigation of the Mars anomalies, DiPietro and Molenaar discovered a large pyramid-like landform (D&M Pyramid) south of the Face. Torun considered all possible geological mechanisms for the formation of the D&M Pyramid including fluvial deposition/erosion, aeolian deposition/erosion, mass wasting, volcanism, and crystal growth. He concluded that none could explain its formation. According to Torun [16]:

> "This object's five-sided shape and bilateral symmetry is unlike any landform seen to date in this solar system, and even small-scale phenomena such as crystal growth cannot explain its morphology."

It has been conjectured that the D&M Pyramid is in a state of collapse with a significant amount of slumping evident in several of its faces. The southern face is best defined with a straight base, symmetrical sides, and well-defined apex. It also appears to be facing very nearly due south (Figure 94).

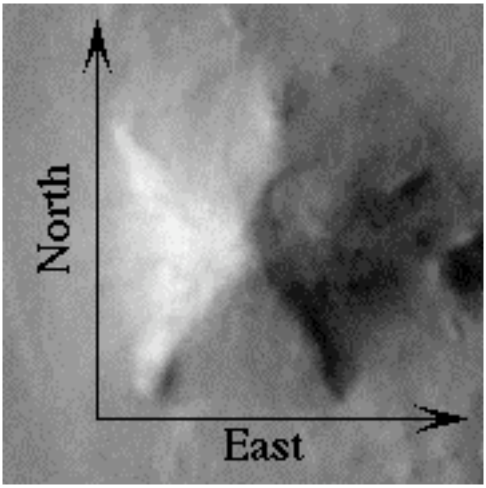

Figure 94 D&M pyramid in frame 70A13 mapped to a Mercator projection.

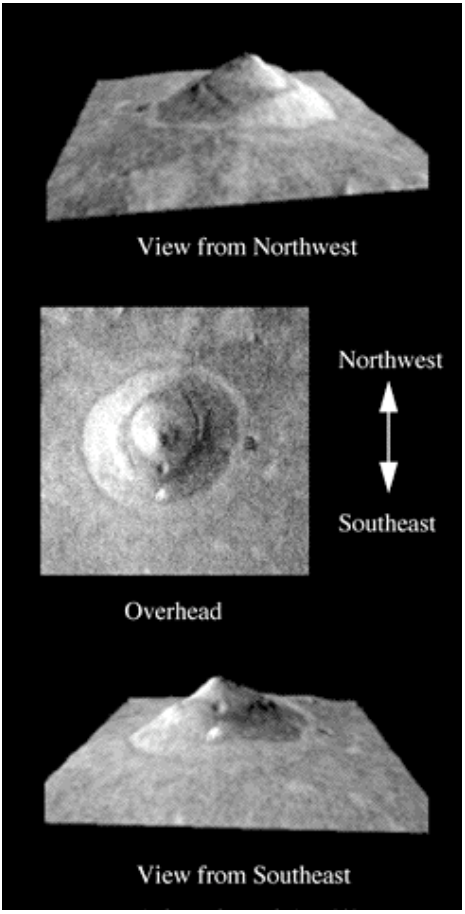

Figure 95 Overhead view of Tholus from 35A74 along with two perspective views generated from the overhead image using shape from shading and image perspective transformation. (Movie available in animated content.)

Exhibits 15 and 16: Tholus — Anomalous Geomorphology and Fine-Scale Detail

The Tholus is a large mound-like feature located about 30 km southeast of the Face. The Tholus was originally discovered by Hoagland in seeking additional objects from which to derive spatial and angular relationships. According to Erjavec and Nicks:

> "They [the Tholus and several other features with similar morphologies] display no evidence of vulcanism, are not impact related and are difficult to explain as remnants of larger non-distinct landforms because of their symmetrical shapes and uniform low gradients."

Like the Face and Fortress, the Tholus also contains fine scale details — details that should not be there if it is a natural object. Two narrow grooves wind up the formation, clockwise and counter-clockwise, from the northwest to the southeast. On the southeast side of the object is a circular pit that can be clearly resolved in the three available images of the Tholus. 3-D analysis (Figure 95) indicates that one set of grooves leads to this pit (an opening?) which is located about half way up the side of the object.

Exhibit 17: Cliff — Anomalous Geomorphology

The Cliff (Figure 96) is an elongated mesa topped by a sharp ridge-like feature running down its length. Hoagland discovered the Cliff and found that it lies roughly in line with the City square and the Face. Perhaps more puzzling than its unusual geomorphology is its placement next to a fairly large crater. Erjavec and Nicks state:

> "Cursory observation of this crater indicates its formation from impact. The impact is surrounded by rampart-style ejecta ('Yuty-type') and displays all of the features of a rampart crater, including characteristic overlapping sheets of ejecta with lobate margins, raised rims along the ejectamenta's outer edges and the extension of ejecta about two crater diameters away from the impact."

So if the adjacent crater was caused by meteoric impact and the Cliff is a naturally occurring formation that existed prior to the impact, why is there no sign of damage or debris flow around the Cliff as a result of the impact? It appears to be the opinion of most planetary scientists that differential erosion is probably responsible for the formation of many, if not all, the landforms currently under study in this part of Mars. However, Erjavec and Nicks have not found sufficient evidence to support this claim, particularly with respect to the Cliff.

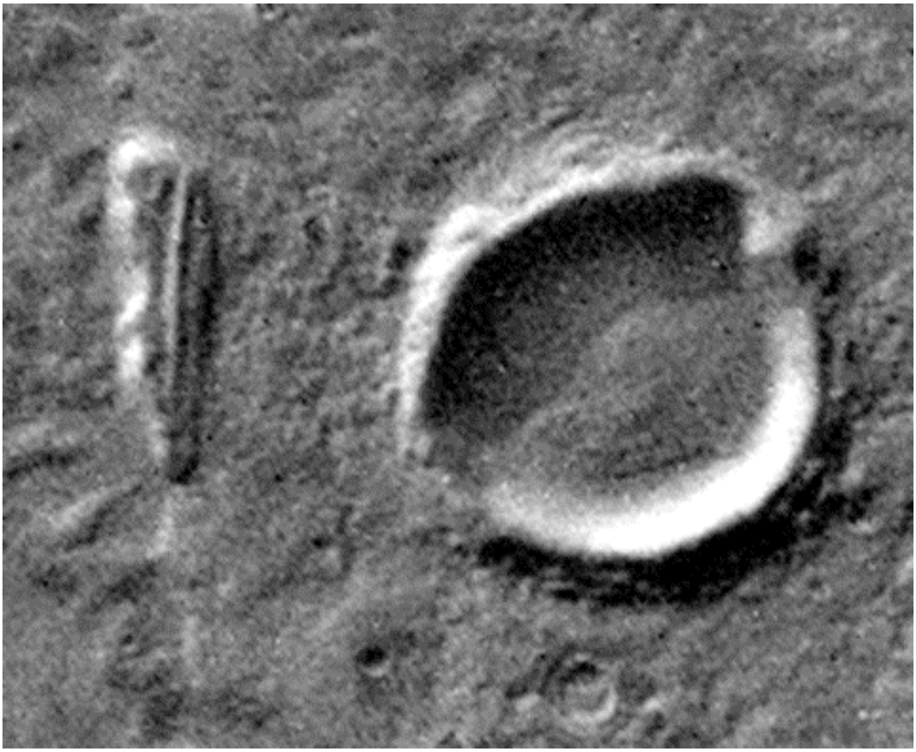

Figure 96 Cliff and adjacent impact crater.

Extraordinary Claims Require Extraordinary Evidence

No single piece of evidence conclusively proves that these objects on the surface of Mars are either natural or artificial. The architectural design, facial proportions, and overall artistic impression suggested the possibility at the outset that the Face might be an artificial object. Subsequent tests of this hypothesis involving the enhancement of subtle detail in the Face, shape-from-shading/synthetic image generation to determine if the Face is an optical illusion, and fractal analysis to assess its shape in a quantitative manner have all provided cross-confirming evidence that support the original hypothesis. Other unusual objects have also been found nearby that appear to be related to one another.

Table 4 summarizes the evidence reviewed and discussed in the preceding sections. Not included here are the summer solstice relation, or the angular relationships related to tetrahedral geometry discovered by Hoagland since they are difficult at present to evaluate. The evidence in the table is of the type that could be used in practice to detect a new archaeological site on earth using aerial or satellite imagery. The question which remains is to what extent can the evidence be assessed collectively and quantitatively?

Table 4 Evidence in support of the hypothesis that the objects in Cydonia are artificial in origin.

Object(s)	Evidence
Face	General features
Face	Facial proportions
Face	Architectural symmetry
Face	Subtle detail
Face	Persistence of facial features over variations in sun angle and viewing geometry
Face	Non-fractal structure
Face and rounded formation in city	Similar gross morphology
Fortress	Geometrical shape
Fortress	Fine-scale detail
Fortress and pyramid in City	Similar size and morphology
Fortress, Face, rounded formation and pyramid in City	Similar size and orientation
Mounds	Repeated spatial and angular relations, grid pattern
Mounds, Face, and larger objects in City	Alignment of larger objects in City and Face with grid pattern
D&M Pyramid	Anomalous geomorphology
Tholus	Anomalous geomorphology
Tholus	Fine-scale detail
Cliff	Anomalous geomorphology

As mentioned earlier Bayesian inference provides one method of evaluating a set of hypotheses against a given body of evidence. The probability that a particular hypothesis is true given some piece of evidence divided by the probability that a particular hypothesis is false given the same evidence is known as the likelihood ratio. Taking into account only the prior belief, i.e., without examining any evidence at all, the probability that the hypothesis is true divided by the probability that the hypothesis is false is called to the prior odds. 50-50 odds means that a hypothesis is equally likely to be true or false. An extraordinary claim, i.e., a "long shot", might correspond to odds of, say, one in a million.

Our ultimate goal is to determine the likelihood that the collection of features is artificial given a set of measurements. To start, we need to determine the likelihood that a particular feature is artificial given a single measurement. Unfortunately, most of the evidence in the above table is qualitative in nature. It is difficult to try to quantify the probability that the Face is artificial given its symmetry, facial proportions, fine scale detail, etc. On the other hand the fractal model-fit is a measure that can be used in principle to compute the likelihood that the Face is artificial.

In terrestrial imagery fractal analysis of man-made objects gives a higher fractal model-fit error than that of natural objects. In other words the probability of observing a high value of the fractal model fit will be greater for man-made objects than for natural objects. Preliminary analysis of terrestrial data give likelihood ratios between 3 to 5 [18].

Ultimately we want to determine the likelihood ratio that a collection of objects is artificial given a set of measurements. To obtain a rough estimate for the purpose of the present discussion we assume that: 1) the sources of evidence are independent, 2) the likelihood value obtained for fractal analysis obtained over terrestrial study areas can be extended to Mars, and 3) this value is representative of the likelihood values of the other sources.

The first assumption is reasonable since different methods have been used to examine different aspects of this collection of features. If we assume that the Face is artificial it turns out that the performance of the fractal technique in differentiating between the Face and the surrounding background on Mars is comparable to its performance on Earth in differentiating between man-made objects and natural terrain. The third assumption is made in lieu of any specific knowledge concerning the likelihood for the other sources of evidence at this time.

The first assumption allows us to multiply the individual likelihoods to obtain the post odds, i.e., the likelihood ratio for the two hypotheses after all of the evidence has been taken into account. If we make the simplifying assumption that likelihoods are the same then the post odds can be shown to increase exponentially as the number of sources increases (Figure 97). The implication of this is that for a large number of sources, the weight of each individual piece of evidence does not have to be very large for the total evidence to be large. Even starting with prior odds of a one in a million, the post odds is significantly greater than one given the number of sources of evidence and their assumed likelihood values (Figure 98).

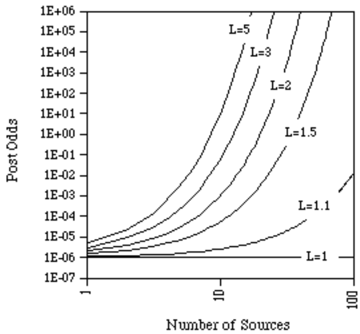

Figure 97 Post-odds increases dramatically as the number of sources increases for likelihood ratios greater than one.

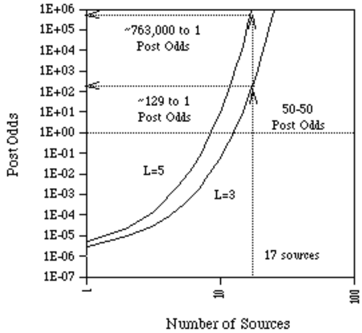

Figure 98 For N=17 sources and assuming individual source likelihood ratios between 3 and 5, the post odds are between 129 to 1 and 763,000 to 1 in favor of our hypothesis.

Extraordinary claims do require extraordinary evidence. But it does not have to come from a single source. Weak evidence from multiple independent sources will do just as well. As demonstrated here it is the quantity and diversity of all of the evidence, rather than any one piece, that makes the evidence in support of our hypothesis so strong. The alternative hypothesis is, of course, that the Face and other nearby objects are simply naturally-occurring geological formations. However no convincing geological mechanisms have to date been put forth that are capable of explaining the diversity of forms, the patterns of organization, and the subtlety in design exhibited by this collection of objects.

A Scientific Double-Standard

Despite evidence summarized in this presentation which suggests that certain features on the Martian surface may not be natural, the planetary science community has refused to even consider the question in a responsible scientific manner [7]. A major stumbling block seems to be that because current theories indicate that liquid water was present for too short a period of time for indigenous life to evolve on Mars, a native intelligence could not have created these objects. The possibility that they were built by a visiting intelligence is considered to be too speculative. But such a position is inconsistent with on-going SETI projects which assumes that there are a sufficient number of ETs in the galaxy to warrant such a search in the first place. To date, SETI has been almost exclusively a radio search program and has produced no convincing evidence for ETs. Alternative SETI proposals have been put forth that involve a search for ET artifacts on planetary surfaces within our solar system [3,4]. Although the same arguments which support radio search also justify a search for ET artifacts, these alternative SETI proposals have not received mainstream support. The reluctance to accept near earth SETI strategies (as well as the possibility of UFOs) is based on the widespread view in the planetary science community that few if any extraterrestrial intelligences are capable of traveling the great distances between stars. Such a view strongly biases opinion against near-earth SETI programs. This bias is so strong that it appears that very strong evidence is required to even consider the question [19].

This bias also seems to be compounded by the expectation that ET artifacts on planetary surfaces will be clearly recognizable. For example, in a study performed before the launch of Mariner 9, Sagan and Wallace concluded that a resolution of 50 meters/pixel or better is required to detect signs of intelligent activity (roads, dams, urban areas) from low earth orbit [20]. Since Viking Orbiter did image the surface of Mars at resolutions exceeding 50 meters/pixel it should have been capable of detecting similar patterns of activity on Mars. But the expected signs of activity mentioned in Sagan's paper were those of an active planetary civilization (our own) and thus do not apply to Mars today. The study did not account for the collapse and deterioration of structures that might have been constructed on Mars long ago. One estimate provides for one ET visitation to our solar system every 10 million years [3]. If large structures were constructed tens of millions of years ago they have probably become significantly degraded by the Martian environment.

The objects under investigation were imaged at resolutions slightly below 50 meters/pixel. They do not resemble contemporary structures but appear to be sophisticated in design and layout. Is it possible that they are really quite old and have undergone deterioration over time? Perhaps the trained eye and experience of an archaeologist may be just as important, if not more important than that of the planetary scientist in this regard. However the specific question concerning the origin of these objects on Mars is one that can and must be answered through a dedicated effort to re-image these objects in the future.

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VIII. REALIZATION

> "I can't help but believe there is something very exciting to be found on this mission. I don't know enough to put my finger on what it is, but it's there. It's there." — Statement by NASA scientist Glenn Cunningham just before the launch of Mars Global Surveyor, 1997.

It has been over twenty years since the original Viking pictures in this book were taken. In 1988, the former Soviet Union sent a pair of probes to Mars and one of its tiny moons, Phobos. Unfortunately, both probes failed early in their missions and provided no useful new photographs of the Red Planet. The next mission, Mars Observer was launched on September 25, 1992 from the Kennedy Space Center aboard a Titan III rocket. According to NASA, the spacecraft was lost in the vicinity of Mars after an explosion of the fuel and oxidizer elements on August 21, 1993 when the spacecraft began its maneuvering sequence for Martian orbital insertion.

Like the first edition of this book which was published as Mars Observer was en route to Mars, the release of the second edition follows the launch of two U.S. spacecraft to the Red Planet. A third spacecraft, Russia's Mars 96 Orbiter failed to reach Earth orbit and was lost. In the following pages the two U.S. spacecraft, Mars Global Surveyor (MGS) and Pathfinder, are briefly described with particular attention to the MGS orbiting imaging instruments — instruments that we hope can shed new light on the Martian Enigmas. Should any of these probes find evidence for life on Mars, microbial or otherwise, it is likely that public and political interest in a manned mission will increase. We conclude with a brief summary of an innovative new concept known as Mars Direct for getting men to Mars within ten years at a cost of less than 20% of NASA's existing budget.

The Mars Global Surveyor spacecraft

MGS will be a polar-orbiting spacecraft designed to provide global maps of surface topography, mineral distributions, and global weather. It is the first of a series of orbiters and landers to be launched every 26 months, as Mars moves into alignment with Earth. The payload includes the Mars orbital camera, thermal emission spectrometer, ultra-stable oscillator, laser altimeter, magnetometer/electron reflectometer and Mars relay system [1].

Launched with a Delta II expendable vehicle from Cape Canaveral, Fla., in November 1996, the spacecraft will cruise 10 months to Mars, where it will be initially inserted into an elliptical capture orbit. During the following four months, thruster firings and aerobraking techniques will be used to reach the nearly circular mapping orbit over the Martian polar caps. Aerobraking, a technique which uses the forces of atmospheric drag to slow the spacecraft into its final mapping orbit, will provide a means of minimizing the amount of fuel required to reach the low Mars orbit. Mapping operations are expected to begin in late January 1998.

The spacecraft will carry a portion of the Mars Observer instrument payload and will use these instruments to acquire data about Mars for a full Martian year, the equivalent of about two Earth years. The spacecraft will then be used as a data relay station for signals from U.S. and international landers and low-altitude probes for an additional three years.

Table 5 Mars Observer camera characteristics

Optics	
Wide angle camera	140 degree field of view
Narrow angle camera	0.4 degree field of view
Resolution @ 400 kilometer altitude	
Wide angle camera	280 meters/pixel
Narrow angle camera	1.4 meters/pixel
Detectors	
Wide angle camera	3456 element charge coupled device
Narrow angle camera	2048 element charge coupled device
Spectral Response	
Wide angle camera (blue)	0.58 to 0.62 microns (red) and 0.4 to 0.45 microns
Narrow angle camera	0.5 to 0.9 microns (panchromatic)
Electronics	
32 bit, 10 Mhz, 1 MIPS microprocessor	
12 Mbyte DRAM buffer	
Data rates up to 29260 bits/sec (real time)	

MGS will circle the planet once every two hours, maintaining a "sun synchronous" orbit. In such an orbit the sun is at the same angle above the horizon in each image. This will allow the mid-afternoon lighting to cast shadows in such a way that surface features stand out. Unfortunately, such an orbit will not permit the Face and other features to be imaged under the variety of lighting conditions that may be necessary to confirm their artificiality.

In the Viking pictures, all of the objects of interest were imaged in the afternoon. It is recommended that MGS take high-resolution overhead photographs in the early morning and, if possible, in the late afternoon as well. This will optimize overall visual contrast as well as minimizing the loss of critical information in the most deeply-shadowed areas. Mars Observer should strive to avoid duplicating Viking's exact sun-angles (Table 6) in order to provide the maximum number of cross-checks for shape-from-shading and other kinds of analysis performed thus far.

Assuming sufficient longevity for the MGS spacecraft, true stereoscopic imaging should be undertaken as the next priority. Both images of each stereo pair should be taken as close together in time as possible in order to minimize lighting differences; i.e., on the same pass if possible, or on different passes at about the same time of day. For optimal stereo viewing the convergence angle should be about 11.3°, which corresponds to a base-to-height ratio of about 1:5 (e.g., if the orbiter's altitude is 500 km, the frames should be taken 100 km apart). If wide-angle stereo imaging is successful and the required degree of targeting precision is available, high-resolution stereoscopy should then be attempted.

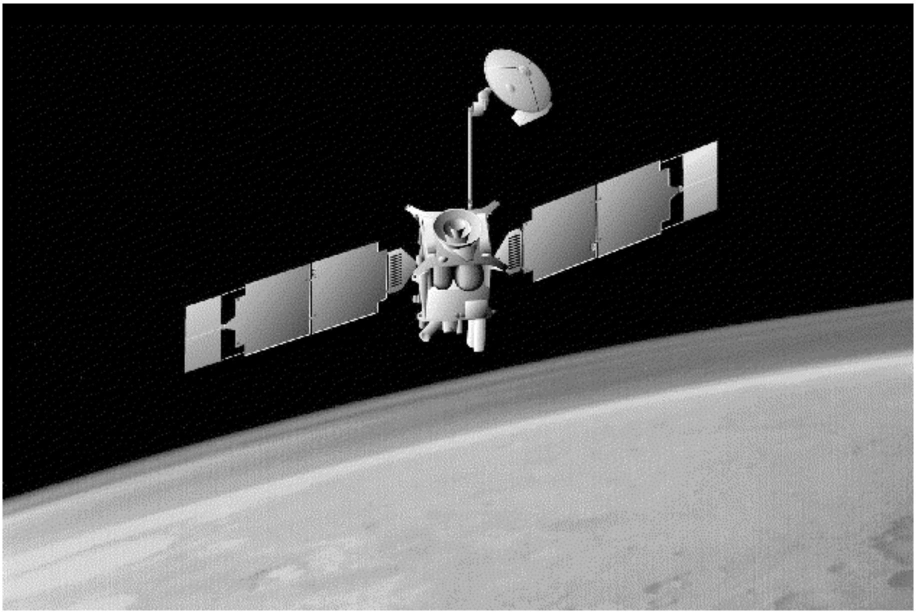

Figure 99 Mars Global Surveyor spacecraft in mapping configuration (NASA)

Table 6 Viking data summary

Targeted Object	Latitude	Longitude	Viking Frame Numbers	Viking Solar Zenith	Viking Solar Azimuth
Face	41.0°N	9.5°	35A72	80°	268.6°
			70A13	62.6°	266.5°
Fortress	40.9°N	9.8°	35A72	80°	268.6°
			70A11	62°	266.5°
D&M Pyramid	40.7°N	9.5°	35A72	80°	268.6°
			70A11	62°	266.5°
			70A13	62.6°	266.5°
Cliff	40.35°N	8.96°	35A73	80°	268.6°
Crater Pyramid	46.4°N	3.2°	43A01-4	84.8°	267.7°
Runway	34.7°N	212.8°	86A08	42.8°	250.4°
Bowl	40.3°N	10.8°	70A10	62.3°	266.9°

It is recommended that the best currently-established coordinates be used as a starting point for preliminary wide-angle imagery to provide the basis for accurate targeting of the MGS camera. Coordinates in this table were derived from the Science Data block [2], U.S. Geological Survey 1:1,000,000 scale topographic maps of Mars, and a coordinate grid derived by Merton Davies in 1982.

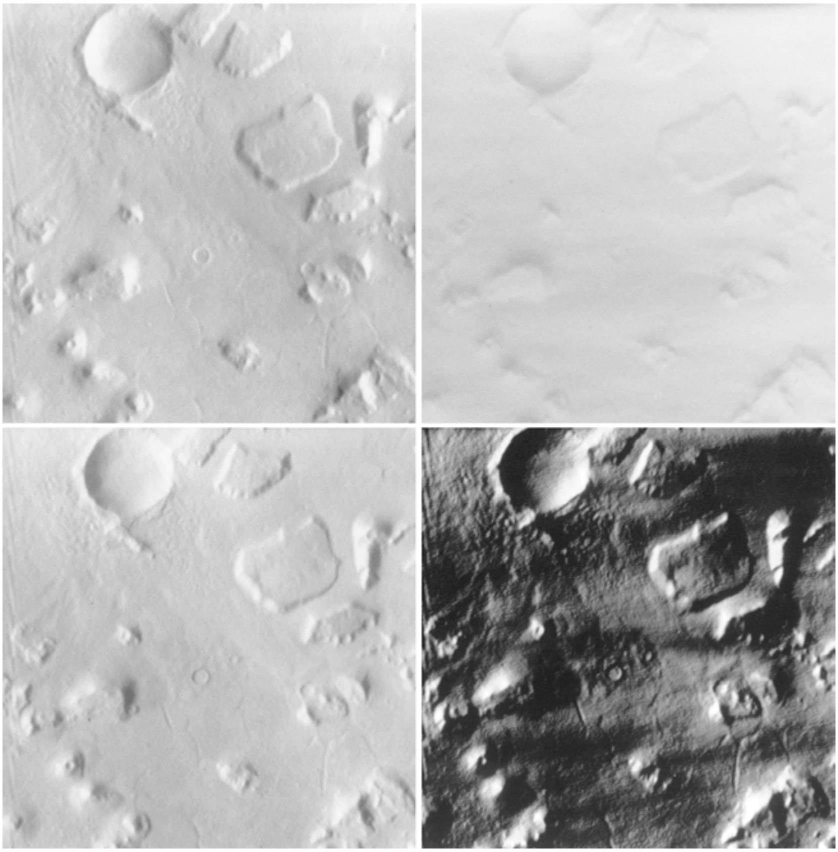

Figure 100 These computer simulations demonstrate how drastically the appearance of a scene can change depending on the position of the sun, and therefore how critical the choice of sun angles can be to the successful reimaging of these anomalies. Upper-left is in the mid-morning, upper-right is at noon, lower left is in mid-afternoon and lower right is just before sunset on the same landscape, a portion of 70A10.

The Mars Pathfinder

The technical objective of the Mars Pathfinder mission is to demonstrate the feasibility of low-cost landings on and exploration of the Martian surface. The scientific objective is to better characterize the Martian environment for further exploration. The spacecraft is scheduled to enter the Martian atmosphere without going into orbit around the planet and land on Mars with the aid of parachutes, rockets and airbags, taking atmospheric measurements on the way down. Prior to landing, the spacecraft will be enclosed by three triangular solar panels (petals), which will unfold onto the ground after touchdown [3].

The spacecraft contains a stationary lander and a surface rover known as Sojourner. The lander will first transmit engineering and science data collected during entry and landing. An imaging system on a pop-up mast will then obtain a panoramic view of the landing area and transmit it to Earth. Finally, the rover will be deployed. The bulk of the lander's task will be to support the rover by imaging rover operations and relaying data from the rover to Earth. Sojourner is a six-wheeled vehicle, which will be controlled by an Earth-based operator, who will use images obtained by both the rover and lander systems. The primary objectives are scheduled for the first seven days, all within about 10 meters of the lander. The extended mission will include longer trips away from the lander over about 30 days.

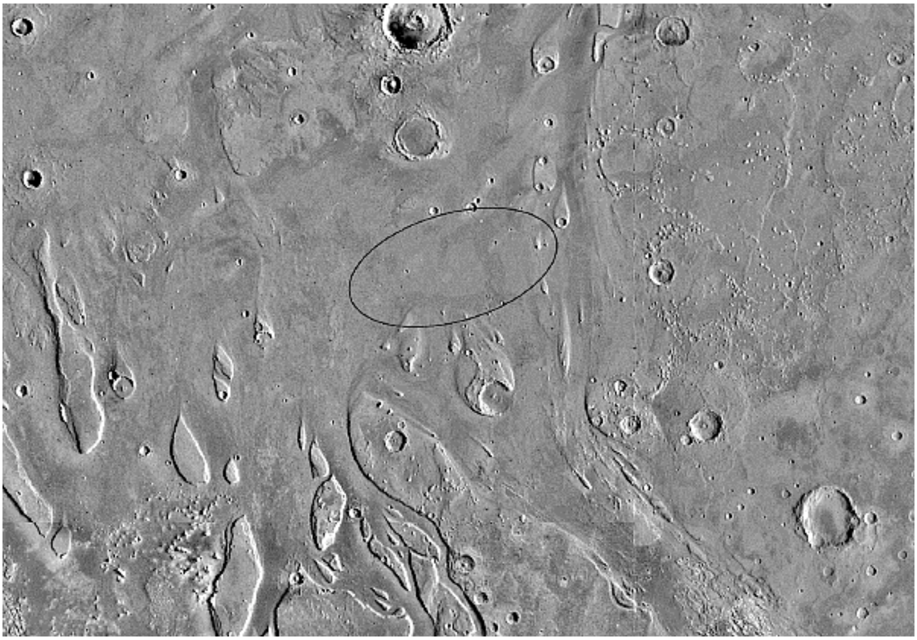

Figure 101 The Mars Pathfinder landing site will be in the Ares Vallis region of Mars, a large outwash plain near Chryse Planitia. This region is one of the largest outflow channels on Mars, the result of a huge flood over a short period of time flowing into the Martian northern lowlands. (NASA)

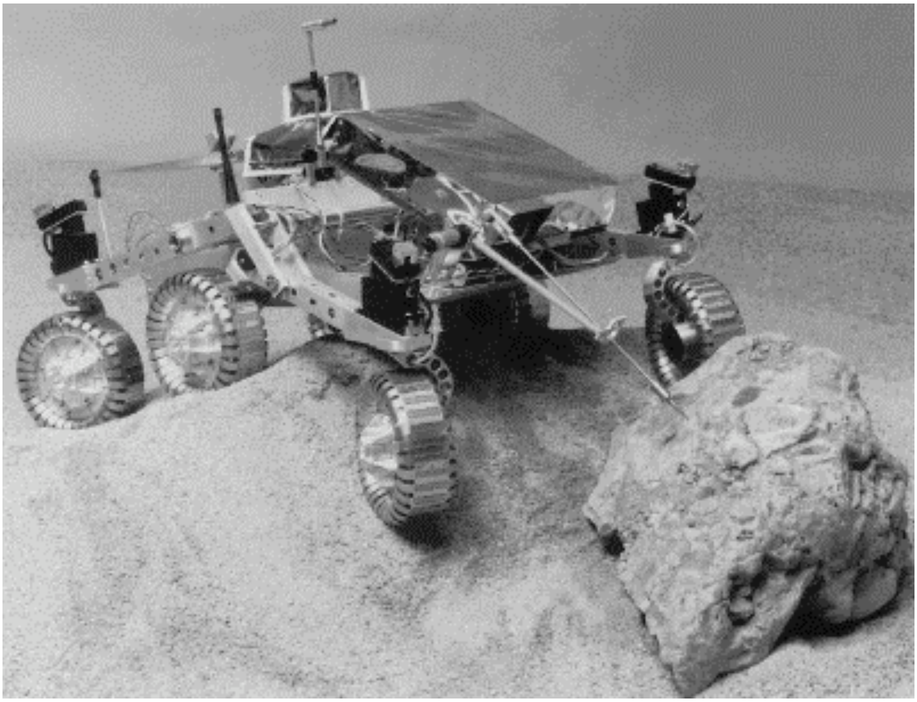

Figure 102 The rover "Sojourner" is a six-wheeled vehicle, which will be controlled by an Earth-based operator, who will use images obtained by both the rover and lander systems. (NASA)

Mars Direct

While Mars Observer was en route to Mars, President Bush signed into law the Space Exploration Initiative (SEI).

> "I have approved the next in a series of steps to be taken by the National Aeronautics and Space Administration (NASA), the Department of Defense (DOD), the Department of Energy (DOE), and other federal agencies regarding the planning for, and conduct of, the nation's Space Exploration Initiative (SEI) which includes both Lunar and Mars elements, manned and robotic missions and supporting technology... The SEI objectives, which build upon previous accomplishments, as well as upon existing programs, include a return to the moon this time to stay and human expeditions to Mars."

At the present time funding for manned missions is on hold. But it is likely that if any of the above missions finds evidence for life on Mars, planning for manned exploration will accelerate. One of the most creative and responsive proposals for landing men on the moon and Mars has been developed by Robert Zubrin. According to Zubrin [4]:

"The need currently exists for a coherent architecture for the Space Exploration Initiative (SEI). By a coherent architecture what is meant is a clear and intelligent set of objectives and a simple, robust, and cost-effective plan for accomplishing them. The objectives chosen should offer the maximum payoff, and their accomplishment should enhance our ability to achieve still more ambitious objectives in the future. The plan, in order to be simple, robust, and low cost, should not make inter-dependent missions (i.e. lunar, Mars, and Earth orbital) that have no real need to be dependent on each other. The plan should, however, employ technology that is versatile enough to play a useful role across a wide range of objectives, so as to reduce costs through commonality of hardware. Finally, and most importantly, technologies must be chosen that maximize the effectiveness of the mission at the planetary destination. It is not enough to go to Mars; it is necessary to be able to do something useful when you get there..."

Mars Direct uses a new expendable launch vehicle known as Ares which is based technology derived from the Space Shuttle. The first step to Mars uses Ares to send a 40 ton payload to the Red Planet consisting of an unfueled methane/oxygen driven two-stage ascent and Earth return vehicle (ERV), 6 tons of liquid hydrogen cargo, a 100 kW nuclear reactor mounted in the back of a methane/oxygen driven light truck, a small set of compressors and automated chemical processing unit, and a few small scientific rovers. This payload aerobrakes into orbit around Mars and lands with the help of a parachute. After landing the truck is telerobotically driven a few hundred meters away from the lander, and the reactor is deployed to provide power to the compressors and chemical processing unit. The chemical processing units react the hydrogen brought from Earth with Martian CO_2 to produce methane and water. The methane is liquefied and stored, and the water electrolyzed to produce oxygen, which is stored, and hydrogen, which is recycled. The chemical processing unit produces 24 tons of methane and 84 tons of oxygen. The total bipropellant produced is 108 tons, or a leverage of 18:1 compared to the hydrogen brought from Earth needed to produce it. Ninety-six tons of the bipropellant will be used to fuel the ERV, while 12 tons are available to support the use of high powered chemically fueled long range ground vehicles.

The propellant production having been successfully completed, two more Ares are sent to Mars during the next launch window. One is an unmanned fuel-factory/ERV just like the one launched earlier, the other is a habitation module containing a crew of 4, provisions for 3 years, a pressurized methane/oxygen driven ground rover, and an aerobrake/landing engine assembly. Artificial gravity is provided to the crew on the way out to Mars by tethering off the burnt out Ares upper stage and spinning up at 1 rpm. The manned craft lands at the previously prepared landing site containing a fully fueled ERV. This surface rendezvous plan has several levels of backup available to assure mission success.

However, assuming the surface rendezvous is successful and the ERV checks out, the second ERV will be landed several hundred miles away to start making propellant for the next mission.

Instead of taking fuel and other expendable with them, Mars Direct synthesizes them from the Martian environment. The staging of the mission leaves behind a string of fully equipped bases on Mars. Thus in addition to getting men and equipment to Mars cheaply and safely, Mars Direct provides the infrastructure necessary to establish a permanent presence on the Red Planet.

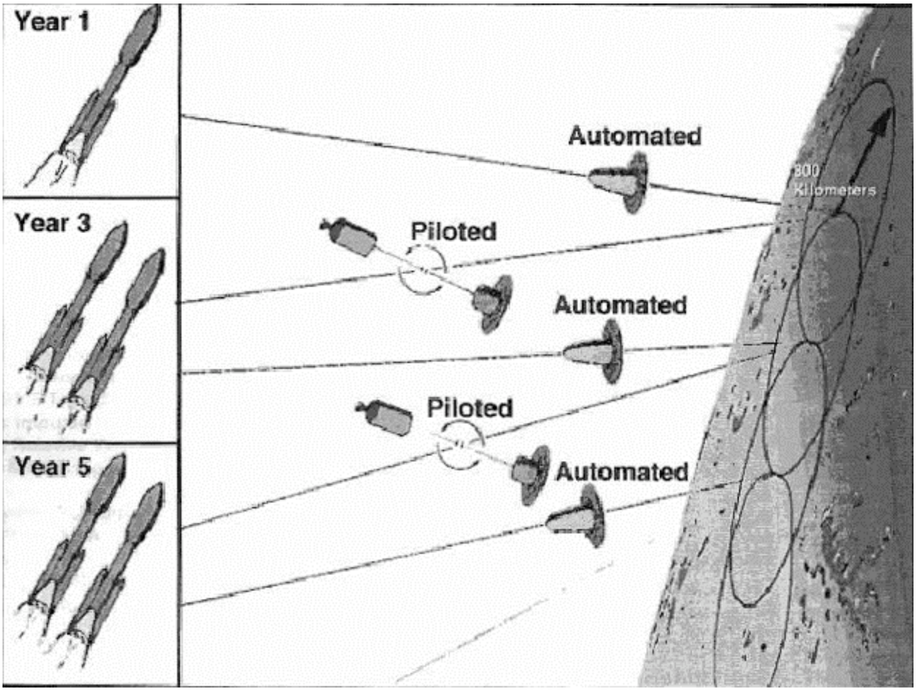

Figure 103 Mars Direct mission concept. (Robert Zubrin/Robert Murray)

Figure 104 Mars Camp consisting of factory ERV, habitation module, ground rover, and chemical processing unit. (Robert Zubrin/Robert Murray)

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1. http://barsoom.msss.com/mars/global_surveyor/mgs_project_releases/mgs_fact_sheet.html

2. M. Carr, *The Surface of Mars*, Yale University Press, New Haven CT, 1981.

3. http://nssdc.gsfc.nasa.gov/planetary/mesur.html

4. R.M. Zubrin, D. A. Baker, and O. Gwynne, "Mars Direct: A Simple, Robust, and Cost Effective Architecture for the Space Exploration Initiative," *AIAA-91-0328, American Institute of Aeronautics and Astronautics*, 1991.

IX. ALIEN LANDSCAPES

"They had a house of crystal pillars on the planet Mars by the edge of an empty sea, and every morning you could see Mrs. K eating the golden fruits that grew from the crystal walls... Afternoons, when the fossil sea was warm and motionless, ... you could see Mr. K himself in his room, reading from a metal book with raised hieroglyphs over which he brushed his hand, as one might play a harp. And from the book, as his fingers stroked, a voice sang, a soft ancient voice, which told tales of when the sea was red steam on the shore and ancient men had carried clouds of metal insects and electric spiders into battle." — Ray Bradbury, *The Martian Chronicles*, 1946

Up to this point we have focused our attention on isolated objects such as the Face, objects in the City, and other unusual features. It is now time to step back and view larger portions of the Martian landscape with the help of computer graphics in order to visualize these objects within the context of the surrounding terrain.

Image Perspective Transformation

Image perspective transformation allows pictures taken from one perspective to be viewed from another. It is an important tool in computer graphics used in many applications; for example, by the military for mission planning and reconnaissance, by landscape architects for land-use planning, and by the media for creating computer-generated flybys of the Earth and planets.

The image that is to be transformed, generally taken looking straight down (a so-called "nadir" view) from overhead, is first registered to (superimposed on) a computer model of an elevation map to produce a 3-D scene model. A 2-D image from any point of view can now be derived by computing the 2-D positions of points in the 3-D scene model that can be seen from that point of view.

The transformation from 3-D scene coordinates to 2-D image coordinates also depends on how far the viewer is from the scene, the focal length of the simulated 2-D imaging system and the field of view (Figure 105). To simulate images acquired by satellites through a telephoto lens, a parallel projection is used in which light rays travel in parallel lines and receding surfaces do not appear to converge. For images that appear as if acquired up close, receding surfaces appear to converge toward a vanishing point; therefore, parts of the scene that are nearer to the observer appear larger than those farther away. (The mathematics of computer graphics and image projections are covered in books by Foley and Van Dam [1] and Horn [2].)

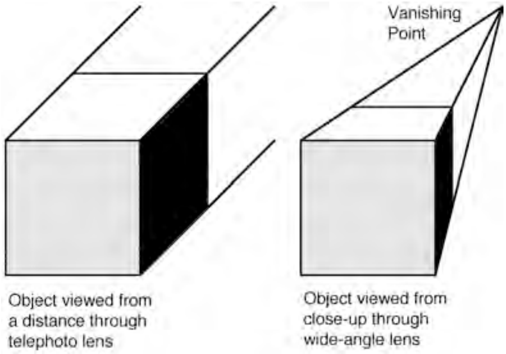


Figure 105 Image perspective transformations of a cube as if viewed from far away through a telephoto lens, and from close-up using a wide-angle lens.

Figure 106 Image over San Luis Obispo California taken by the French SPOT satellite. The image was acquired from almost directly overhead at a resolution of 10 meters per pixel. (©1991 CNES, provided by SPOT Image Corporation.)

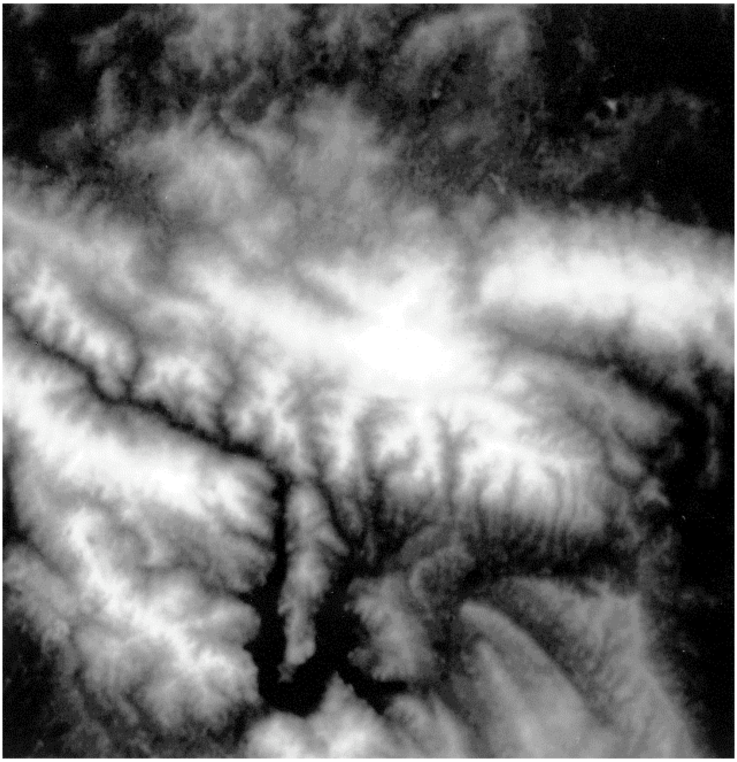


Figure 107 Image of elevations registered to SPOT image. (Digital elevation model provided by the U.S. Geological Survey.)

Figure 108 Simulated perspective view of the same scene, as if from an aircraft that is due south, about 60° above the horizon.

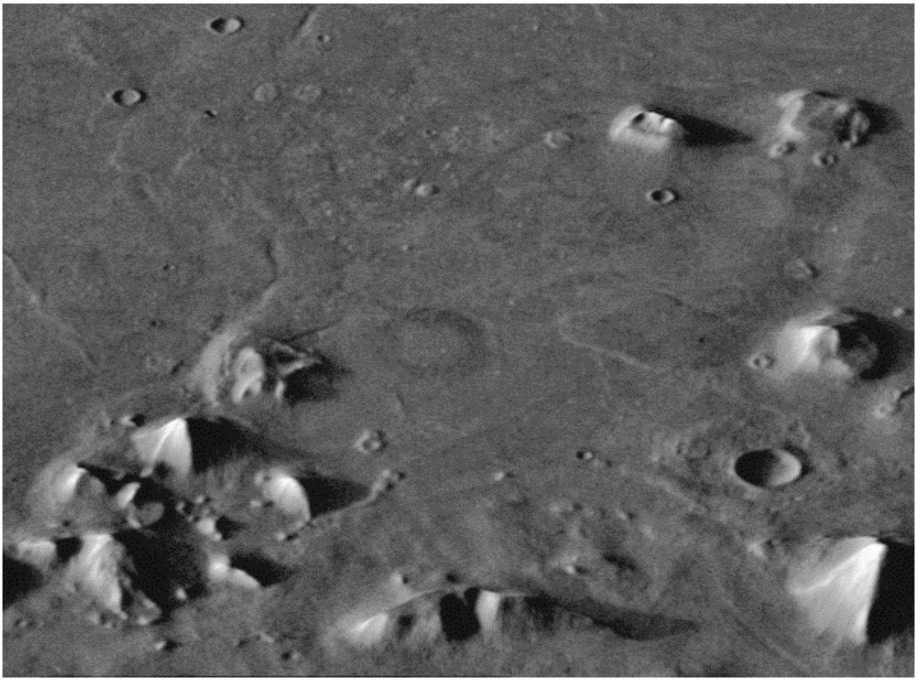


Figure 109 Computer generated perspective view of the City and Face. According to Erjavec and Nick's geological analysis of this area, there is some evidence for the existence of a paleo shoreline — in this picture, running from left to right between the City and Face. On this side of this hypothetical shoreline, the terrain gradually rises with the City (lower left), D&M pyramid (lower right), and the surrounding terrain above "sea level." Depending on the amount of water present, The Face and the two mesas to its right could have been surrounded by water, in effect appearing as islands a few kilometers off shore.

Perhaps the most striking effects produced by image perspective transformations are those of relief and obscuration that are not present in images taken from directly overhead (Figure 106 vs. Figure 108). When the scene is viewed off-nadir (not looking straight down), features are shifted by an amount that depends on their height and the position of the observer. (This is exactly the effect that is seen in stereo images.) Also, as the observer moves from zenith toward the horizon, portions of the scene become obscured by taller objects in the foreground.

Topographic Maps of Cydonia

While elevation data have been compiled over much of the Earth, there are few detailed topographic maps of Mars. On Earth, mapping agencies build topographic maps from pairs of stereo photographs taken from the air. Lack suitable stereo coverage over Cydonia, single image shape-from-shading has been used here to generate the elevation data (Figure 111) needed for image perspective transformation.

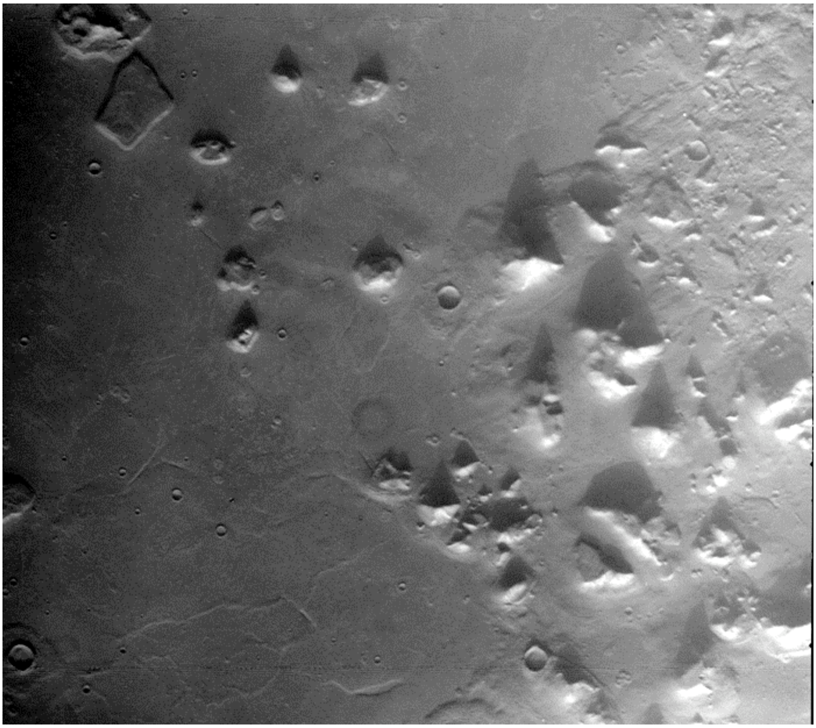


Figure 110 35A72 image rotated so that the sun is from below

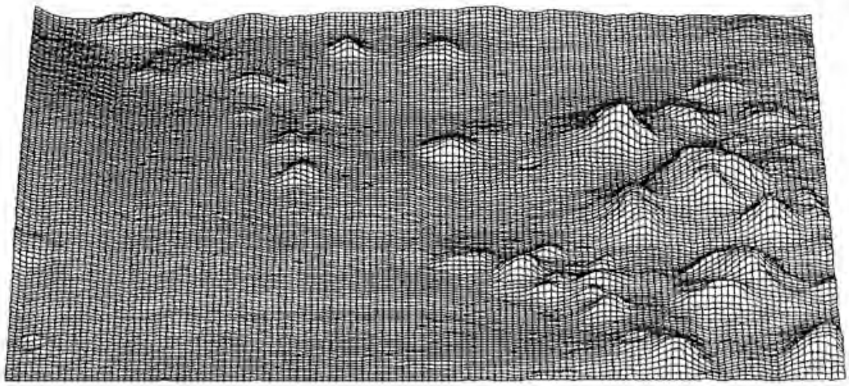


Figure 111 Perspective plot of computed elevation surface (zenith angle = 45°)

Panoramic Views

Once the elevation map has been derived, panoramic views (Figure 112- Figure 114) of the Cydonia complex can be generated via image perspective transformation. The three views shown were generated with the viewer located northwest, northeast, and southwest of the site at an angle of 30° above the horizon. The ruggedness of the terrain south of the Face past the D&M pyramid is more evident in the perspective views. One can also visualize the existence of an ancient shoreline between the lower cratered terrain to the east and the higher knobby terrain to the west.

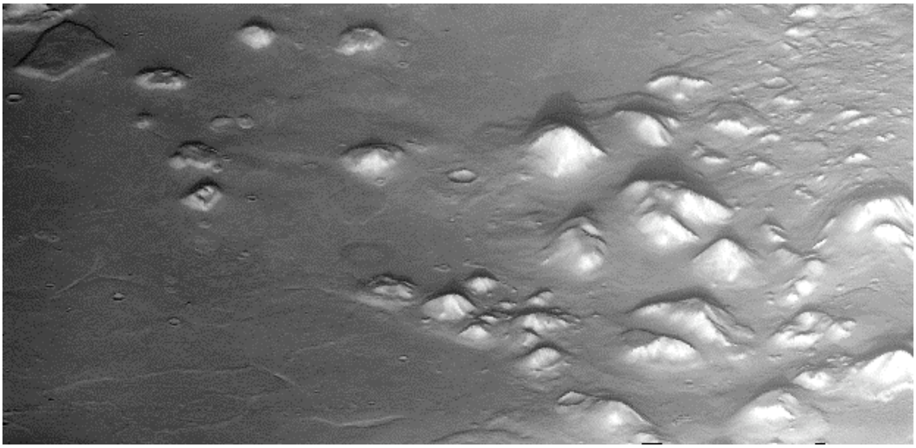


Figure 112 View of Cydonia site from the northwest (zenith angle = 60°)

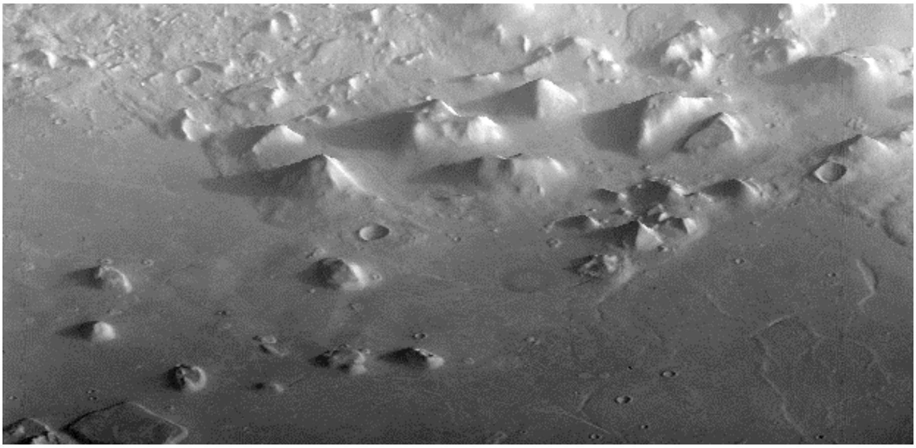


Figure 113 View of Cydonia site from the northeast (zenith angle = 60°)

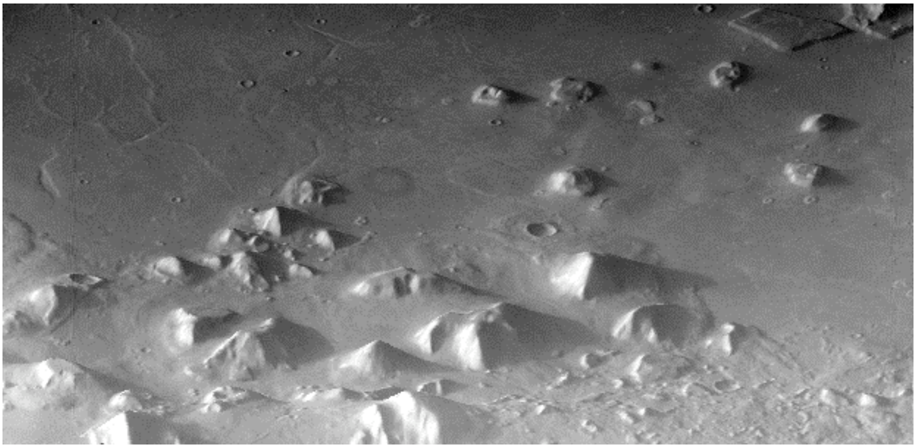


Figure 114 View of Cydonia site from the southwest (zenith angle = 60°)

Simulated Flight Over Cydonia

Using the elevation map and image it is also possible to create animated flights through the scene. Key frames from an animation sequence (Figure 116) show how terrain features might appear from a low altitude aircraft. The flight path starts from a point west of the City with the simulated aircraft moving in an easterly direction (Figure 115). Just before reaching the D&M pyramid it banks to the left and heads straight for the Face.

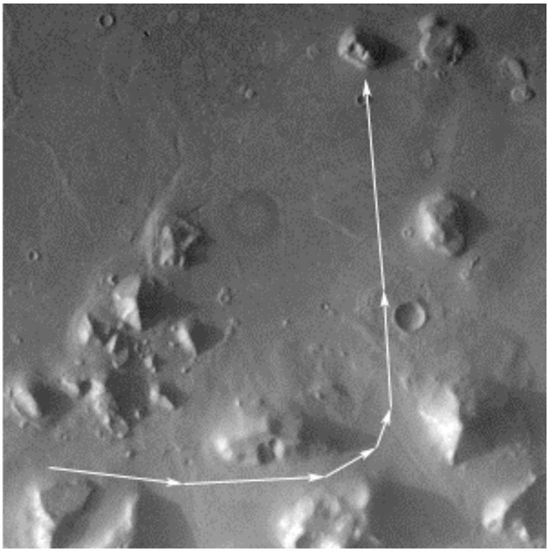


Figure 115 Flight path for animation sequence

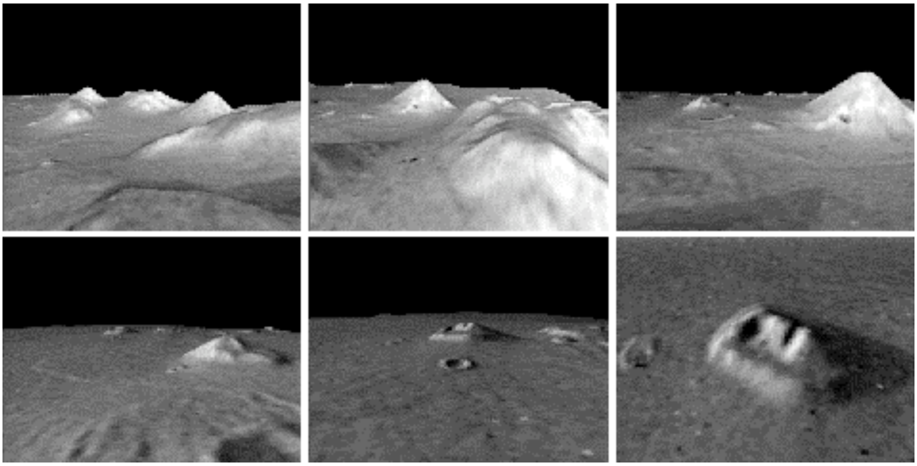


Figure 116 Key frames along flight path. Upper left frame is from near the start of the flight path west of the City looking east. (Movie available in animated content.)

Stereoscopic View of Cydonia Site

Because of the 15 degree difference in sun illumination between 35A72 and 70A13 it is difficult to visually combine the two into a stereo image. In 1993 Vincent DiPietro found another image over the area containing the Face and City. This image, Viking frame 561A25, has a resolution of 162.7 meters/pixel compared to 47.13 and 43.42 meters/pixel for 35A72 and 70A13, respectively. Although the resolution of 561A25 is about four times worse than 35A72 and 70A13, the difference in solar zenith angle between 35A72 and 561A25 is only about 3 degrees — small enough so that they can be visually combined into a stereo pair. The stereo image pair shown here (Figure 117) was produced by coregistering these two images and displaying 561A25 on the left and 35A72 on the right. Although the 4 to 1 difference in image resolution does reduce one's ability to visually fuse the two images it is still possible to get an idea of the relative height of the features in this area. Note the relatively low relief of the Fortress, Face and objects in the City compared to the much higher relief of the D&M pyramid and the landforms to the south.

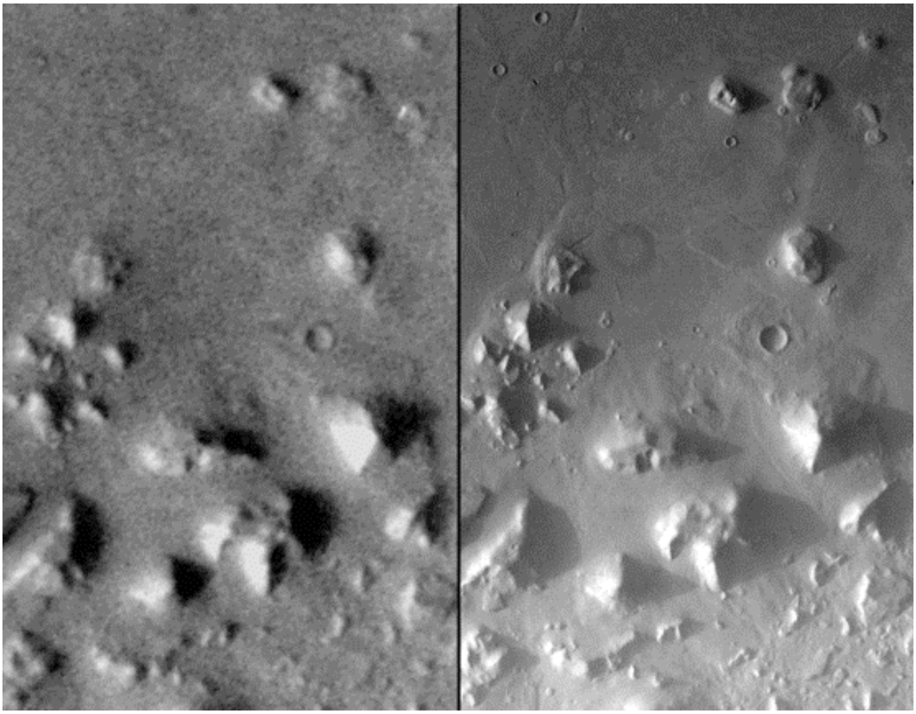


Figure 117 Stereo image obtained by displaying 561A25 on the left and 35A72 on the right

Views of D&M Pyramid

The D&M pyramid is one of the more enigmatic objects in Cydonia. Its geometry has been the subject of much speculation and debate. A stereoscopic image pair derived from Viking Orbiter frames 70A11 and 70A13 (Figure 118) shows evidence of both 4- and 5-sided symmetry. The buttresses suggest a 5-sided structure. On the other hand there is some indication that the western face lies at right angles to the southern face. Yet in the lower sun angle image (35A72) the impression that the western face follows the pentagonal layout of the buttresses is stronger.

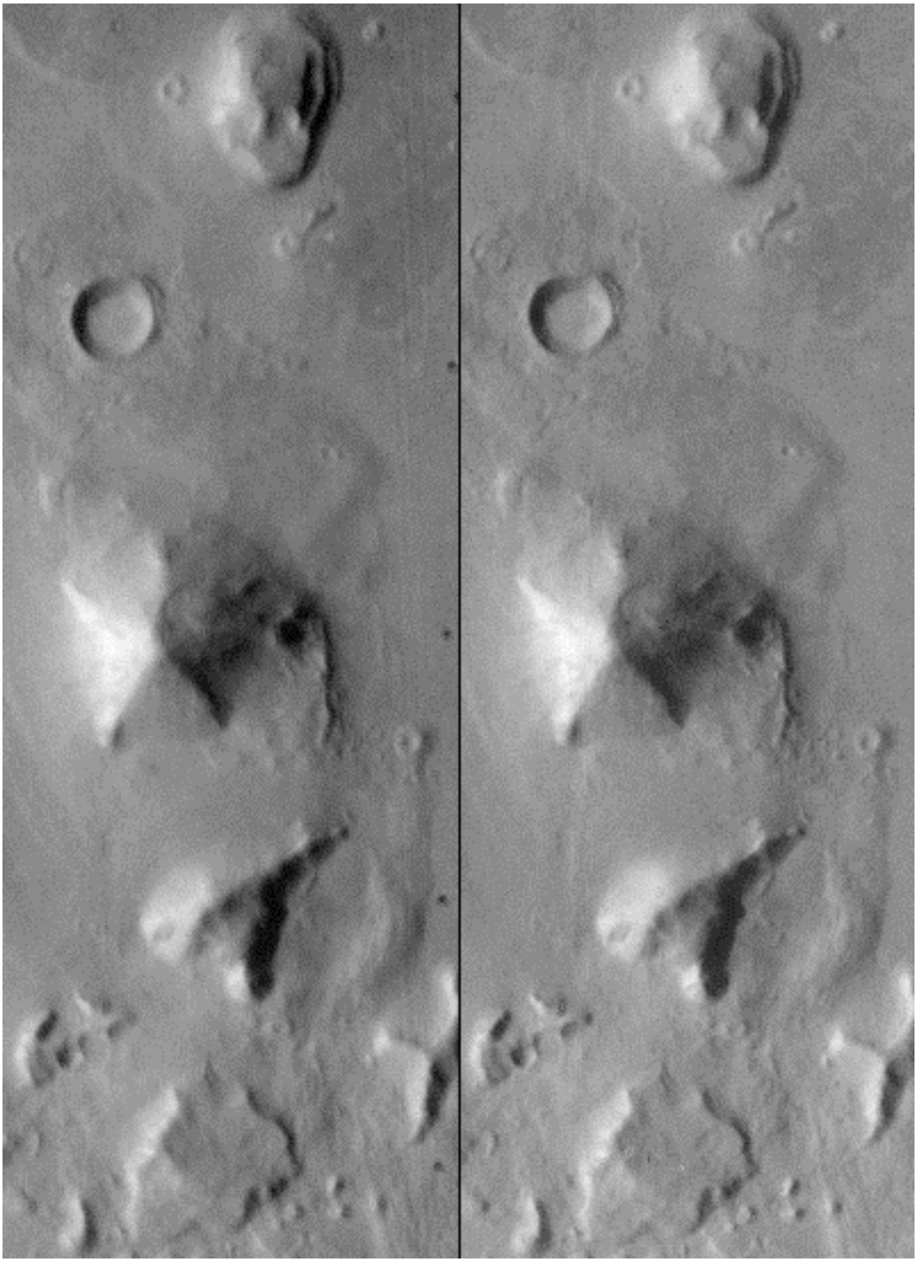


Figure 118 Side-by-side stereo image over the area of overlap between Viking frames 70A11 and 70A13. The baseline distance B between orbiter positions is approximately 51 km and the altitude of the spacecraft H=1725 km. For a pixel size D=48 meters, the resolvable height (for a 1 pixel parallax shift) is 2DH/B = 5.34 km. From shadow analysis the height of the D&M is about 1.25 km. Thus the height of the D&M will cause of parallax shift of about 1/4 pixel.

Simulated perspective views from around the D&M provide additional insight into its structure (Figure 119). The view from the south shows the southern face to be the best defined one with a straight base, symmetrical sides, and well-defined apex. It also appears to be facing very nearly due south. The flatness of the southern face is also evident in the view from the west. Three fairly well-defined pyramidal faces can be seen from this direction. Moving toward the north, the object no longer looks like a pyramid. The western side differs from all others. It is convex in shape and less sloped than the other sides. The view from the west shows that what had been believed to be a crater or hole at the base of the formation is actually an opening in its side. The convexity of the west side suggests that the opening may be the entrance to a tunnel leading to the center of structure.

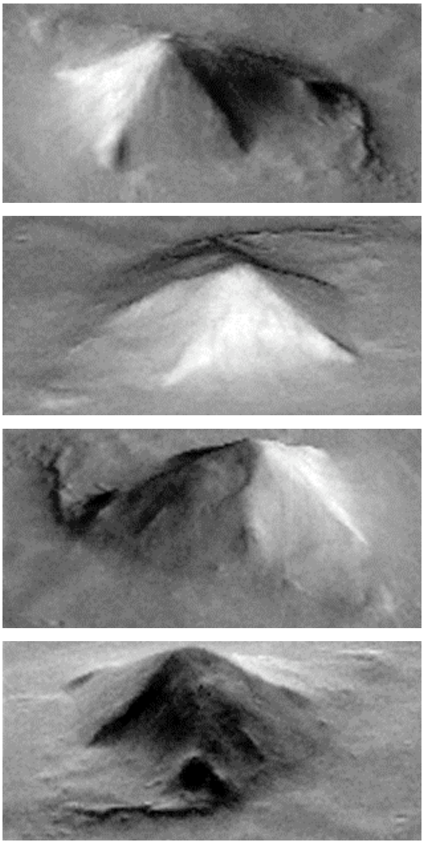


Figure 119 Four views from around the D&M pyramid derived from 70A11 image and derived elevation map. (Movie available in animated content.)

References

1. J. D. Foley and A. Van Dam, *Fundamentals of Interactive Computer Graphics*, Addison-Wesley, Reading, MA, 1983.

2. B. Horn, *Robot Vision*, MIT Press, Cambridge, MA, 1986.

X. A POSSIBLE TERRESTRIAL CONNECTION

"You must be prepared for a surprise, and a very great surprise." — Neils Bohr.

Several years after Vincent DiPietro and Gregory Molenaar rediscovered and analyzed Viking orbiter imagery of the Face on Mars, Richard Hoagland found other unusual objects nearby. Hoagland noticed that the City appeared to be aligned with the Face; in particular, that a line through the mouth points directly at the City. He reasoned that the City would be an ideal location to view the Face in profile. The angle of this line between the City and Face which he measured to be 23.5 degrees north of due east, suggested something more — the possibility that the alignment might be solsticial and thus provide a clue as to how old this collection of objects might be.

Hoagland's line from the City Square through the mouth of the Face is, in effect a line between two points, for example, like the line from the center of Stonehenge to the heel stone which marks the summer solstice sunrise. Where the choice of points in Stonehenge is clear, Hoagland's have been criticized as being somewhat arbitrary.

Following up on other early discoveries by Hoagland, Horace Crater and Stanley McDaniel analyzed a number of small mound-like objects in the City and found that a subset of them lie at the vertices of a rectilinear grid. It has also been shown that the Face and three of the larger objects in the City, namely the Fortress, an adjacent pyramid-like structure, and a rounded formation also appear to be aligned with this grid pattern. The similarity in orientation of the grid and these other larger objects suggests the possibility that what we are seeing might be indications of an underlying pattern of organization — a pattern of organization not unlike that of many of the Mesoamerican sites (e.g. Teotihuacan). So instead of using the orientation of a single line between two somewhat arbitrary points, why not use the average of the orientation angles of these structures in Cydonia as an estimate of the orientation angle of the site as a whole? Averaging the orientation of the Face and the three larger objects in the City mentioned above together with that of the mounds gives a value of about 33.3 degrees. This value is considerably different from the one computed by Hoagland. If he is correct in his hypothesis that the alignment is solsticial, what is the implication of this difference?

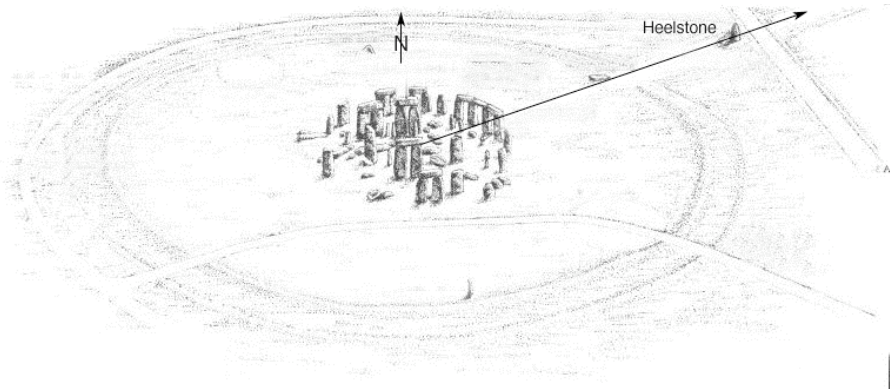


Figure 120 The line from the center of Stonehenge through the Heelstone marks the location of the summer solstice sunrise (about 24° north of east).

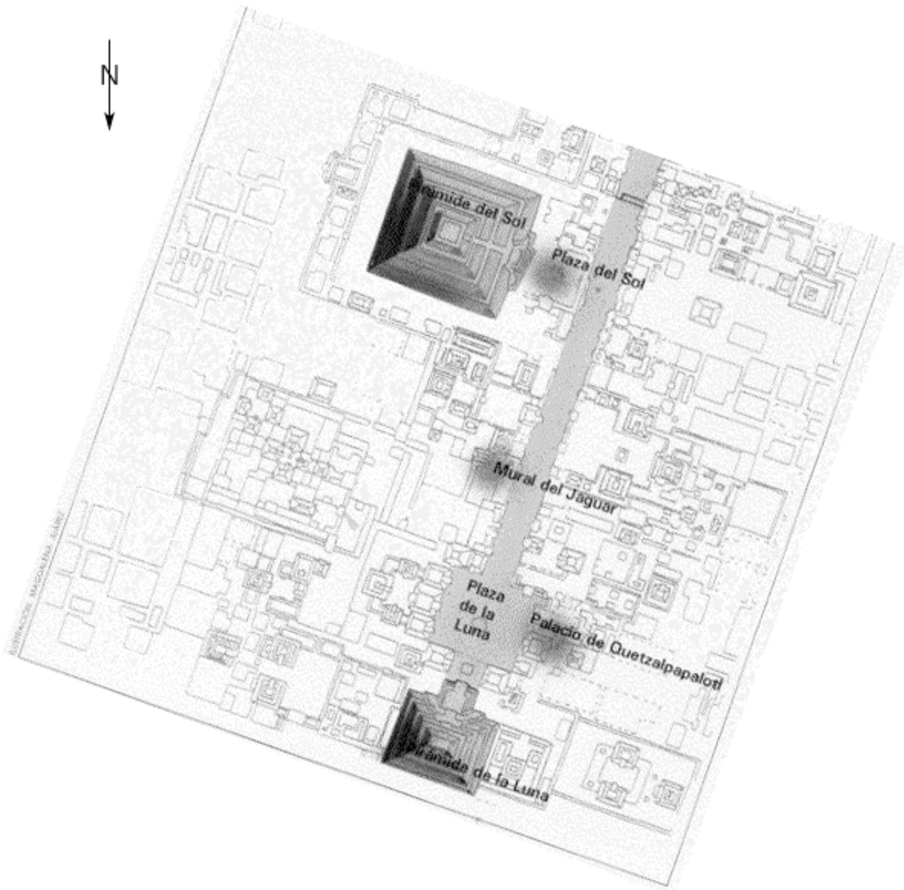


Figure 121 Map of portion of Teotihuacan. All of the structures which make up this site are oriented in the same direction, 15° 25' east of north.

The Solstice Hypothesis

Sir William Herschel who first measured the axial tilt of Mars in 1783 suggested that Mars, like Earth, had seasons. The point on the horizon where the sun rises and sets changes with the season. On the first day of autumn (vernal equinox) the sun rises in the east and sets in the west, regardless of latitude. With each passing day, the sun rises and sets further to the south making increasingly shorter sweeps of the sky. The days get shorter and the nights longer. On the first day of winter (winter solstice), the sun rises at its maximum point to the south of east and sets at its maximum point south of west. The cycle continues. Day by day the sun rises less south of east until on the first day of spring (vernal equinox) it again rises due east. Day by day, the sun rises and sets further to the north making increasingly longer sweeps of the sky. The days get longer and the nights shorter. On the first day of summer (summer solstice), the sun rises at its maximum point to the north of east.

The angle north of east that marks the summer solstice sunrise depends on the latitude of the observer and the axial tilt. Today Mars' axis is tilted about 25 degrees from its orbital plane. It can be shown that for this obliquity angle, the location of the summer solstice sun rise on Mars at the latitude of the City and Face is 34.2° north of east. For the sun to rise on the first day of summer at the angle of the line between the City and Face which Hoagland had calculated, the obliquity of Mars would have to be about 17.5°. In 1973, William Ward developed a model (Figure 123) for how the obliquity of Mars changes over time. Using Ward's model, Hoagland determined that his alignment was last satisfied about 500,000 years ago. If the City and Face are artificially constructed objects, he concluded that they must be at least half a million years old.

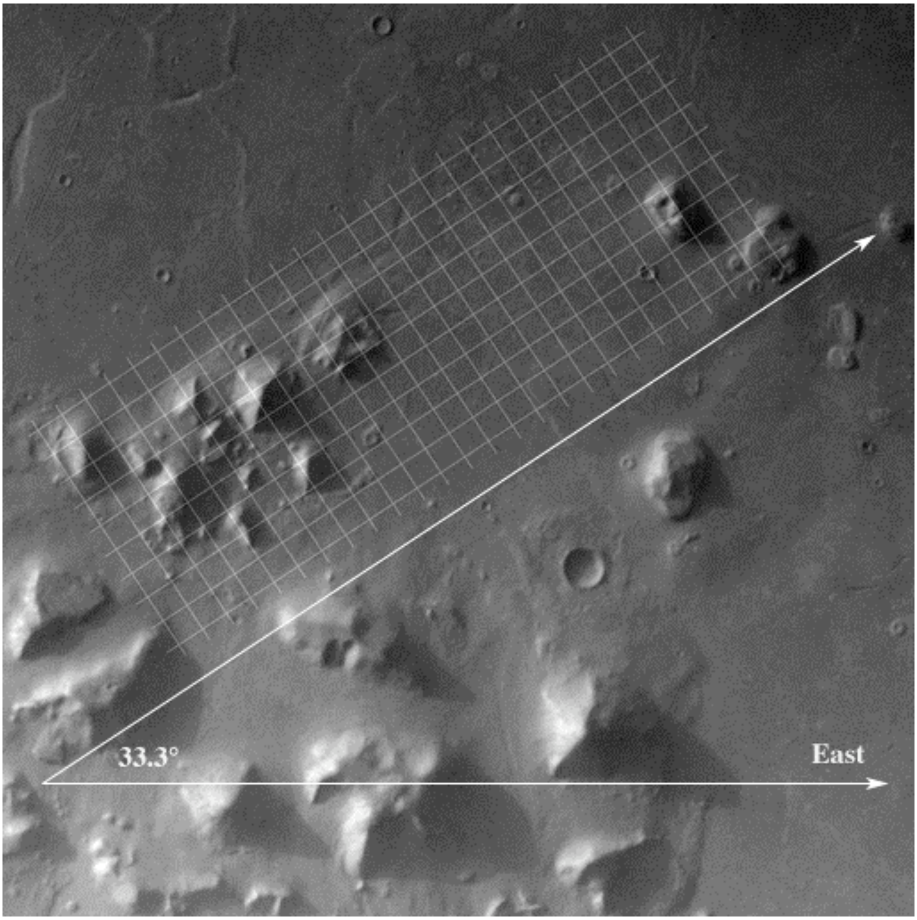


Figure 122 Cydonia site on Mars. The cross-hatched pattern which overlays the region containing the City and Face is oriented at 33.3° north of east. Note the southern face of the D&M pyramid is oriented due south. Today the line of the summer solstice sunrise is only about 1° north of the indicated sightline indicating a much more recent date for the site provided the alignment is in fact solsticial in nature.

A Second Look at the Alignments

As stated above, the sun currently rises at a point 34.2° north of east on the first day of summer. This is only about 1° north of our estimate of the orientation of the Cydonian site — about 33.3° (Figure 122). Given this new estimate, it can be shown that the sun last rose in line with these objects on Mars about 33,000 years ago. Another alignment could have occurred about 120,000 years ago. In contrast to Hoagland's analysis, we have made no assumptions about the Face being viewed from the City Square, have used not one but the average of nine independent measurements, and have based our measurements on new map-projected Viking imagery provided by NASA. Two questions need to be addressed. First, if the objects are artificial, is the alignment significant? And second, is the alignment solsticial?

Finding other sites on Mars with a similar arrangement would tend to suggest that the alignment is significant. Two other sites have been found. The first is contained in Viking frame 70A10 southwest of the City and Face (Figure 124). The site contains a circular formation situated on a raised rectangular platform (the "Bowl") oriented in the same general north of east direction as the City and Face. It also contains a pyramidal object ("B pyramid") that seems to be aligned to the cardinal directions, specifically, its southern face points due south, like the southern face of the D&M pyramid. The second site (Figure 125), found by Ananda Sirisena is farther to the west and contains a similarly aligned pyramidal object ("King Pyramid") with a south pointing face, and another bowl-like formation ("Ft. Aetherius") oriented in a similar north of east direction. Thus all three sites contain a pyramidal object that appears to be aligned to the meridian (Figure 126) plus at least one other object oriented in the same general north of east direction (Figure 127).

Can these similarities be coincidental? Are these sites trying to tell us something about when they were built?

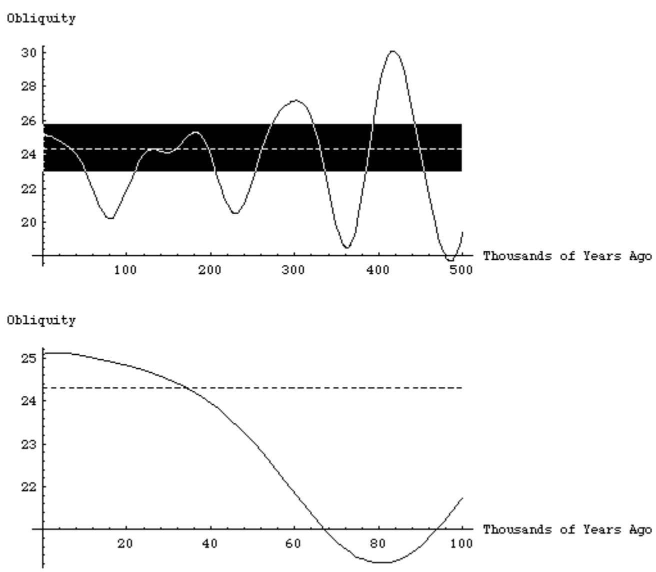


Figure 123 Obliquity curves for Mars based on a model developed by Ward. The dotted line in the top curve is the value of the obliquity (24.4°) corresponding to the orientation angle (33.3°) of the City and Face complex. The region highlighted represents the range of obliquity values (24.4 ± 1.5°) that correspond to the uncertainty in the estimate of the orientation of the complex (33.3° ± 2.07°). In the bottom curve we see that the earliest this alignment was satisfied was probably about 33,000 years ago. The next earliest time was a little over 120,000 years ago.

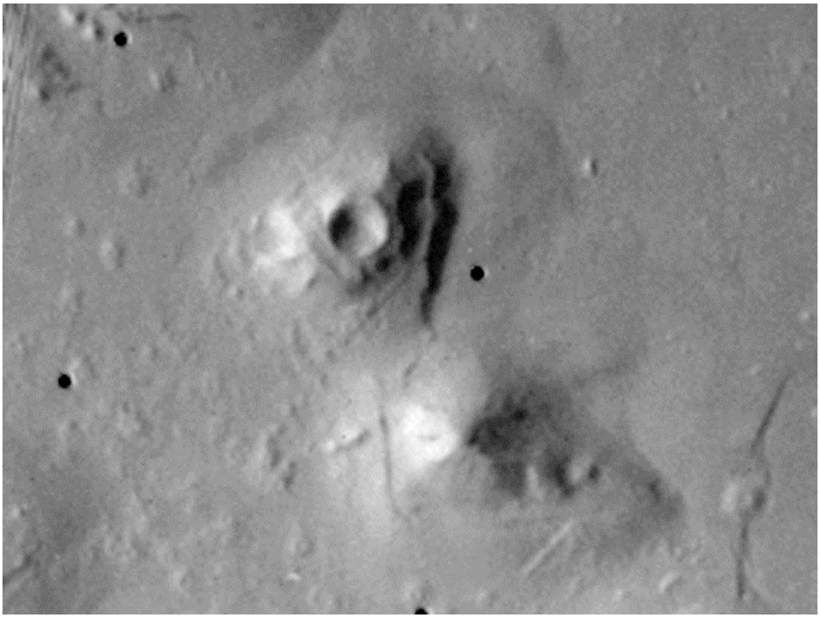


Figure 124 Second site from frame 70A10 west of the City and Face containing bowl-like formation and nearby pyramidal object.

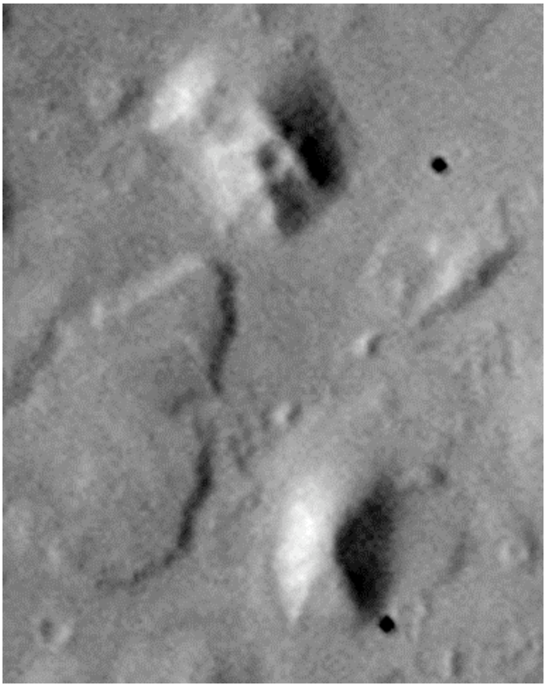


Figure 125 Third site from frame 70A01 even further to the west.

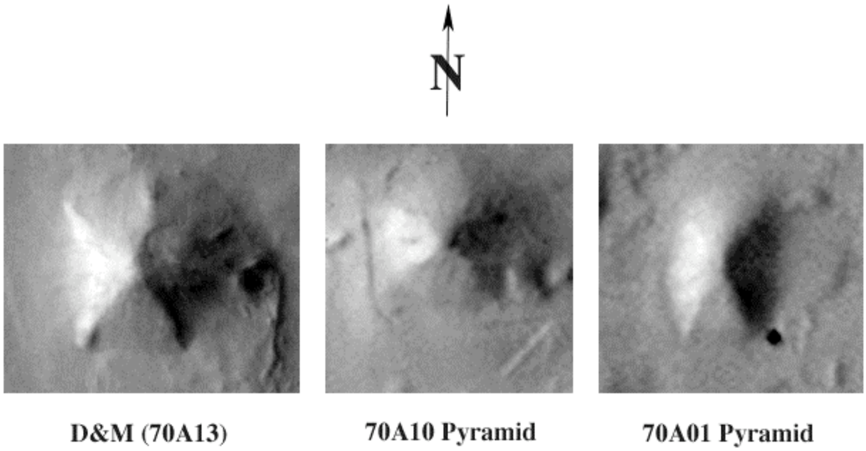


Figure 126 All three sites contain a pyramidal object that appears to be oriented along the cardinal directions.

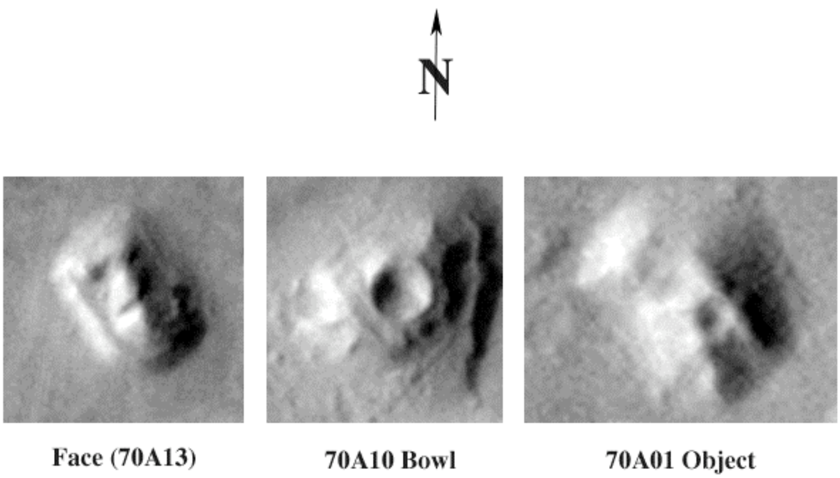


Figure 127 All three sites also contain at least one object oriented in a similar north of east direction.

Speculation

It is my belief at this time, that the alignments are significant and that they are solsticial. In terms of a possible connection between Earth and Mars, alignments satisfied 33,000 years or 120,000 years ago are much more interesting and potentially more relevant than those satisfied a half a million years ago. 120,000 years ago is smack in the middle of the period on Earth when Homo Sapiens first appeared. According to the fossil record our new species evolved slowly at first. Then about 33,000 years ago dramatic changes began to take place. We find at this time during the last Ice Age, the first known work of art — a carved piece of ivory in the shape of a horse discovered in Vogelherd, Germany, the earliest calendar showing the phases of the moon inscribed on a piece of reindeer antler, and a little later, Venus figurines throughout Europe, and spectacular cave paintings in southwestern France.

Paleoarchaeologists have learned much about our evolution. But there are too few artifacts and too many missing pieces of the puzzle. Could these structures on Mars hold a few more of the missing pieces? Could the discovery of artificial objects on Mars shed new light on the mysterious origin of man on Earth? Wouldn't it be ironic if our quest to know what is "out there" leads us back to ourselves? Depending on what the Mars Global Surveyor spacecraft finds when it reaches the Red Planet, we may soon know.

Appendix A — Hoagland's Cydonia Relations

Fractal analysis addresses the local small-scale behaviors of the terrain. Other researchers have worked at the opposite end of the scale, applying what might be termed a "systems approach" to testing the intelligence hypothesis on the Viking photos. The essence of this approach is the analysis of larger-scale patterns and relationships. This avenue was first explored by science writer Richard C. Hoagland in the early 1980s, at a time when the Face was believed to be a singular, isolated anomaly. Although initially skeptical, Hoagland reasoned that if the Face were the product of intelligence, other artifacts might reasonably be found nearby, perhaps providing a broader base of evidence to support the hypothesis.

In examining the Viking photos more closely, not only did Hoagland succeed in identifying other candidate objects, but observed that they seemed to be geometrically aligned with the Face. In particular, a rectilinear grouping of polyhedral objects (the "City") appeared to be arrayed parallel to the major axes of the Face. Hoagland projected sightlines from the City toward the eastern horizon to investigate the possibility of solar or stellar alignments, as would be found in similar terrestrial situations. In doing so he successfully established that an observer at the "City Square" would have seen the summer solstice sun rise directly over the eyes of the Face approximately a half-million years ago (based on the best current estimates of Mars' axis wobble over a million-year cycle). The discovery of the anomalous Cliff followed soon thereafter, as it lay directly in the path of the projected solstice sightlines.

Upon detailed measurement of the D&M Pyramid, Hoagland observed that it, too, seemed to be involved in a fabric of relationships: its axis of symmetry appeared to point directly at the Face, its left "arm" at the City Square, and its right "arm" at the Tholus (itself apparently centered on a line extended from the Cliff's ridgeline).

Additionally, several key points in the Cydonia Complex appear to be located at a geometric progression of intervals along a roughly southwest-northeast axis: The ratio of distances between the City's western boundary, the City Square, the eastern Fortress wall and the eastern edges of the Face and Cliff, appears to be 1:2:4:8.

Hoagland maintains that while any of these facts in isolation is of little significance in itself, the chances of their all occurring randomly is very small and provides stronger support for the intelligence hypothesis.

KEY TO CYDONIA RELATIONSHIPS DIAGRAM

A) The City, a collection of polyhedral features contained within an area whose major axes parallel those of the Face.

B) The City Square, apparently located at the exact lateral center of the City. Viewed from this centerpoint, the Summer Solstice sun rose directly over the Face, about 1/2 million years ago.

C) The Fortress, at the northeast corner of the City. Its east wall appears to point directly at the D&M Pyramid.

D) The D&M Pyramid, named for its discoverers DiPietro and Molenaar. The D&M is approximately 500 meters tall and 2.5 km long. Its major axis seems to point precisely at the Face, its left arm at the City Square, and its right arm at the Tholus, with a total subtended angle of 120°, or 1/3 of a circle. The D&M Pyramid appears to sit astride North latitude 40.868 degrees, whose arc-tangent equals the value of e/π.

E) The Face, about 350 meters high and 2.5 km from crown to chin.

F) The Cliff, perched on the "pedestal" (ejecta blanket) of a large impact crater. The Cliff's ridgeline is angled 19.5 degrees to true north. According to Hoagland, this angle is also expressed in the axis tilt of Mars 1/2 million years ago.

G) The Tholus. Aligned with Cliff's ridgeline. Its shape, proportions and peripheral ditch are virtually identical to those found in similar prehistoric structures on Earth. The Cliff, D&M Pyramid and Tholus appear to form a right triangle.

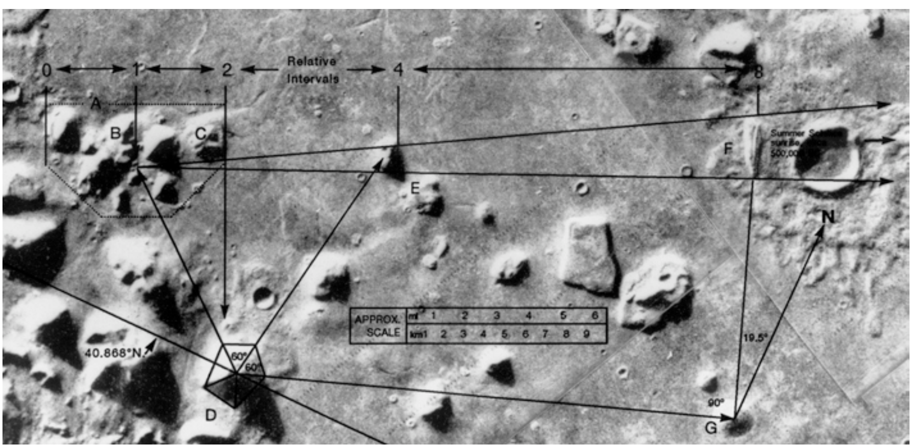


Figure 128 Diagram of relationships observed in Cydonia by Hoagland, Torun and others. This simplified graphic representation is intended for illustrative purposes only. Any attempt to verify the claimed values should be based upon larger-scale, orthographically-rectified reproductions.

Appendix B — Torun Model of the D&M Pyramid

In 1988, Erol Torun, a cartographer employed by the U.S. Defense Mapping Agency, challenged Richard C. Hoagland's claim that objects in Cydonia displayed complex geometries unlikely to occur naturally. Upon making his own measurements, however, Torun verified Hoagland's claim to his own satisfaction. Hoagland and Torun then went on to make additional mathematical observations and claims, some of which we reproduce here.

Table 7 Torun's model of the internal geometry of the D&M Pyramid expressed in terms of angles, angle ratios and trigonometric functions. (It should be noted that Hoagland's and Torun's measurements were performed on orthophotos. Ortho-photos are produced by a process known as rectification that 1) removes geometric distortions due to camera tilt (i.e., camera not pointing straight down) and terrain relief, and 2) registers the image to a set of control points; landmarks whose geographic coordinates are known to a high degree of precision. Once this is done, the coordinates of any point in the orthophoto can be readily determined and distances and angles between points computed accurately. It should also be noted that all measurements and relationships are stated by Torun and Hoagland as angles, ratios and trigonometric functions, which are universal, rather than in terms of particular number systems, which are culturally relative.)

Angles		**Angle Ratios**	**Trigonometric Functions**
A: 60	$\pi/3$	$C/A = \sqrt{2}$	$\tan A = \sqrt{3}$
B: 120	$2\pi/3$	$B/D = \sqrt{3}$	$\tan B = -\sqrt{3}$
C: 85.3		$C/F = \sqrt{3}$	$\sin A = \sqrt{3}/2$
D: 69.4	$e/\sqrt{5}$	$A/D = e/\pi$	$\sin B = \sqrt{3}/2$
E: 34.7		$C/D = e/\sqrt{5}$	$\tan F = \pi/e$
F: 49.6	e/π	$A/F = e/\sqrt{5}$	$\cos E = \sqrt{5}/e$
G: 45.1		$B/C = \pi/\sqrt{5}$	$\sin G = \sqrt{5}/\pi$
H: 55.3		$D/F = \pi/\sqrt{5}$	$H/G = e/\sqrt{5}$

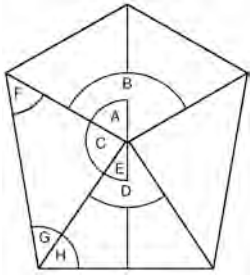


Figure 129 Internal model of the D&M Pyramid developed by Torun.

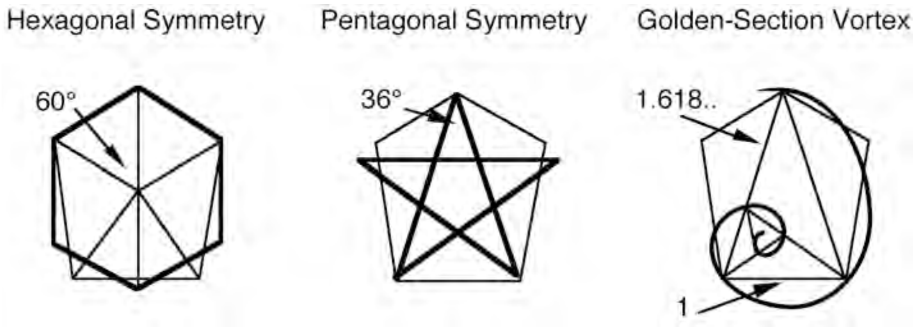


Figure 130 If Torun's model for the D&M Pyramid is correct then its base would contain the generative elements of hexagonal and pentagonal symmetry, and the Golden Section vortex.

Hoagland and Torun claim that if the latest Mars Control Point coordinates by Merton Davies at RAND Corporation are accurate, the apex of the D&M Pyramid is located at 40.868° N which equals the arc tangent of e divided by π, two of the mathematical constants believed by Torun to be expressed redundantly in the D&M's own internal geometry. According to Davies, the possible margin of error is ±0.017°.

Torun's tetrahedral model supplies a mathematical constant (2.72069, the ratio of the surface area of a tetrahedron to that of its circumsphere) that is a close approximation of e (2.71828). When this approximation is substituted for e, then e/π is the arc tangent of 40.893°, a latitude also encompassed by the D&M Pyramid if its apex is located at 40.868°N. Hoagland and Torun argue that this close fit between a fundamental element of tetrahedral geometry and the values measured both in the D&M's internal structure and in its sitting, provides additional keys to what they view as a "mathematical message" in Cydonia.

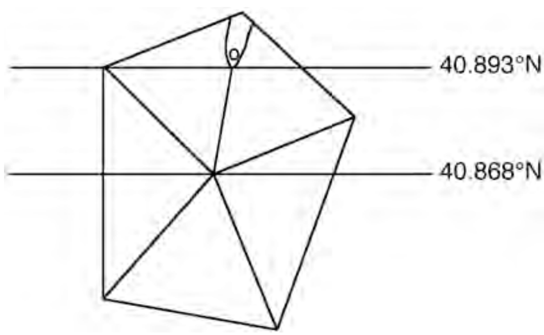


Figure 131 Using Mars Control Point coordinates provided by Merton Davies, the apex of the D&M Pyramid is located at 40.868°N the arc tangent of e divided by π.

Table 8 Major atmospheric and geologic phenomena that occur within three degrees of the "tetrahedral" latitude, 19.5 degrees.

Body	Phenomenon	Comments	Latitude
Earth	Hawaii volcanic plume	Most active on planet	19.5°N
Moon	Tsiolkovskii	Unusually large crater located in volcanic region	19.6°S
Mars	Olympus Mons	Largest volcano	19.3°N
Jupiter	Great Red Spot	Singular vortex	21°S
Io	Loki	Major volcanoes	19°N
	Maui		19°N
	Pele		19°S
	Volund		22°N
Saturn	North Equatorial Belt South Equatorial Belt	Torun notes that Saturn has a hexagonal cloud band around its North pole, and that two nested tetrahedra will yield hexagonal symmetry when viewed along their primary axis.	20°N 20°S
Uranus	1-2 degree temperature drop, as measured by the Voyager IRIS experiment.	Possibly caused by deep-set upwellings pushing clouds to higher altitudes, and thus cooler temperatures.	20°N 20°S
Neptune	Great Dark Spot	Singular vortex	20°S

Hoagland states that his study of the "tetrahedral" aspects of the Cydonia mathematics has led him to make certain observations and predictions regarding planetary energetics. For example, he has observed that the major volcanic and vortical phenomena (the largest volcanoes and "dark spots") on given bodies the solar system seem to occur almost invariably at about 19.5 degrees of latitude — the latitude that corresponds with the intersection of three vertices of a polar-oriented tetrahedron and its circumsphere. Whether the relationship is causal or coincidental remains to be determined.

Torun's Comments on the Geomorphology of Mars and the Cydonia Relationships

"One of the most important aspects of Martian geology is that Mars is geologically similar to the Earth — much more so than any other body in the solar system. Partly because of this similarity it is difficult to dismiss the unusual objects of Cydonia as simply the product of an utterly alien environment. Any natural explanation would need to provide a specific geomorphological model for the formation of a 5-sided structure that appears to include six mathematical constants and whose apparent axis of symmetry points directly at an object bearing the likeness of a humanoid face.

"Considering the Face, the City, the City Square, the D&M Pyramid, the Cliff and the Tholus, we now have a complex of objects that exhibit architectural, anthropomorphic and other visually-anomalous qualities. In addition to their appearance, we must also consider whatever geometry is present, and the information that this geometry may represent. In Cydonia, specific angles and mathematical values are represented, not once but redundantly. Furthermore, this pattern seems to relate to the physics of stellar and planetary bodies.

"Thus we have here key elements of solid science, including redundant measurements and the development of a pattern that can be used to identify and describe other phenomena. It is this recovery of useful information that speaks most eloquently for the probability of intelligence on Mars. While theoretically it may be possible for this many coincidences to have occurred as a result of purely natural forces, the actual likelihood is next to zero.

"An unknown factor in some of these observations is the remaining margin of error in the data derived from the Viking Photos. I don't think we will ever get five-significant-digit accuracy until the Cydonia Complex is reimaged by Mars Observer. That, of course, will answer the broader questions as well. Meanwhile, this close grouping of so many anomalous forms and mathematical close-fits seems entirely extraordinary."

Appendix C — Terrestrial Comparisons

Terrestrial features provide familiar reference points for evaluating the unique quality of the Face and other unusual objects on Mars. The shear size and grandeur of these objects often invites comparison to the Egyptian pyramids and Sphinx.

The area in the Giza plateau containing the three largest pyramids of Khufu, Khafre, and Menkaure (Figure 132) is several square kilometers in size. On Mars, the Face and surrounding objects occupy an area several orders of magnitude larger. Where the distance between the Great Pyramid and the Sphinx is less than a kilometer, the distance between the Face on Mars and the D&M pyramid is over 20 kilometers.

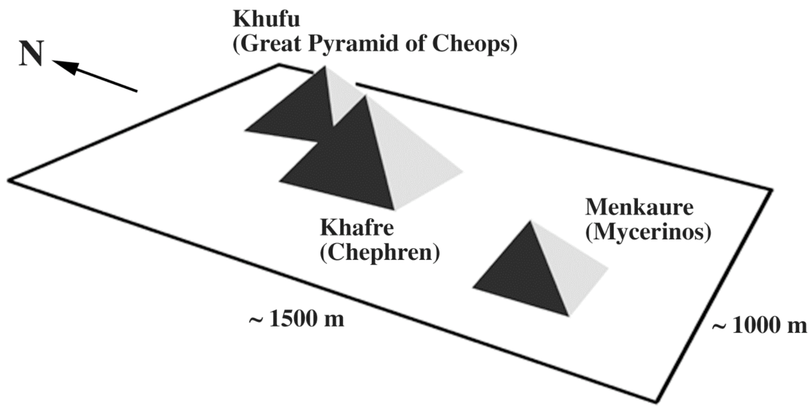


Figure 132 Layout of Egyptian pyramids (Derived from computer model of Giza plateau developed by Oriental Institute Computer Laboratory, University of Chicago)

The Great Pyramid of Khufu has four sides. Its height is 135 meters and the length of its base is 229 meters. This wonder of the Ancient World is dwarfed by the objects on Mars (Figure 133). The height of the D&M pyramid is about 1250 meters and the lengths of its sides are between 2700 and 3800 meters — about ten times longer than those of the Great Pyramid. Thus, its area is more than 100 times larger, and its volume over 1000 times greater than that of one of the largest structures on Earth!

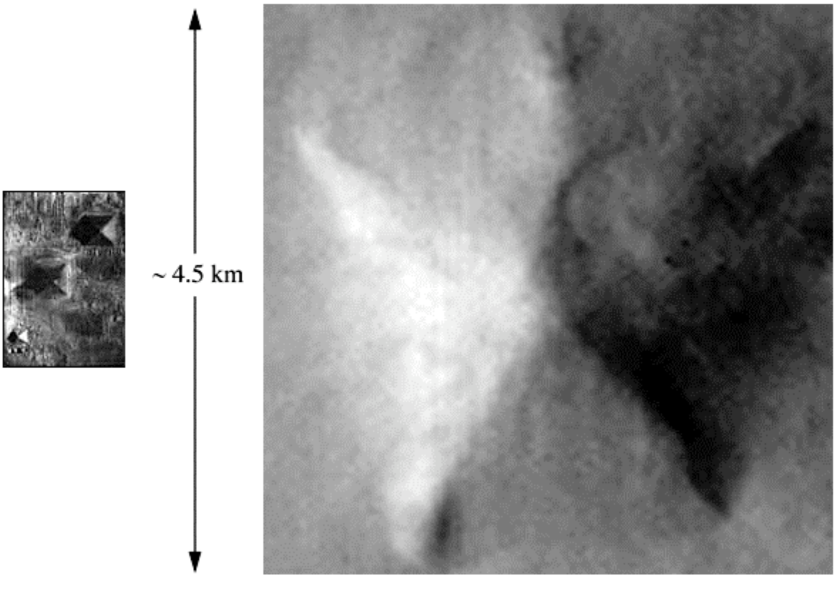


Figure 133 Photographs of the three Egyptian pyramids in Giza and the D&M pyramid on Mars printed at the same scale for comparison.

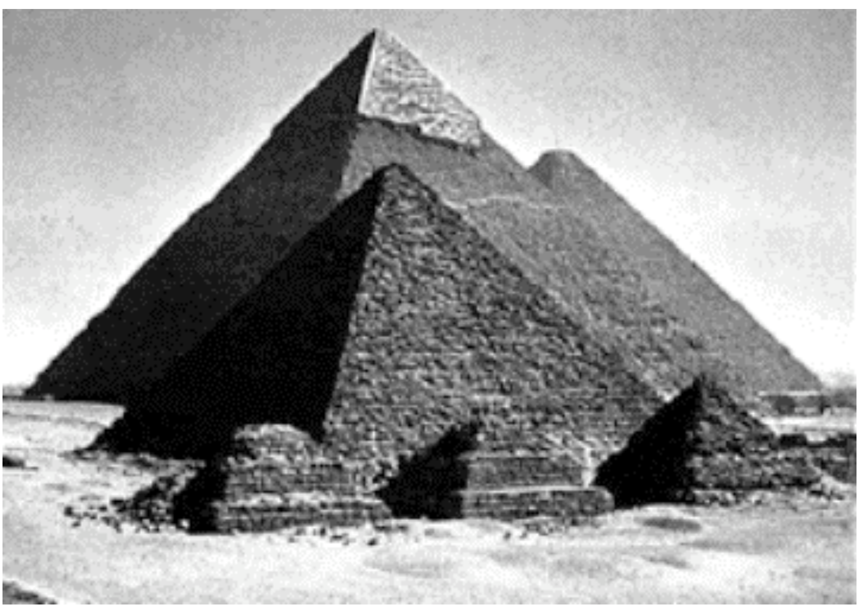


Figure 134 Ground view of the three pyramids in Giza. Menkaure is closest in front of Khafre, which is in front of Khufu. View is looking towards the northeast.

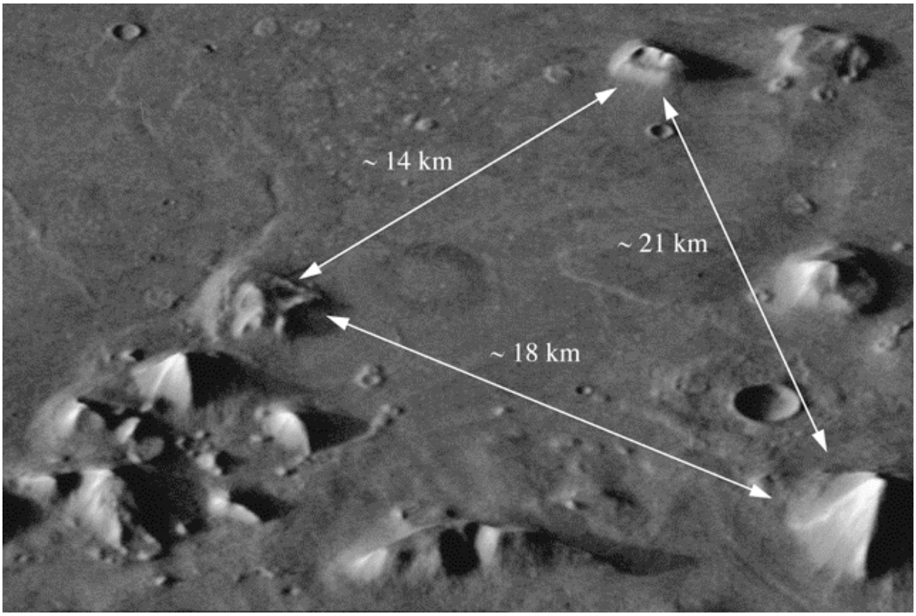


Figure 135 Layout of objects in Cydonia. Distances between objects over an order of magnitude greater than that between pyramids on Giza Plateau.

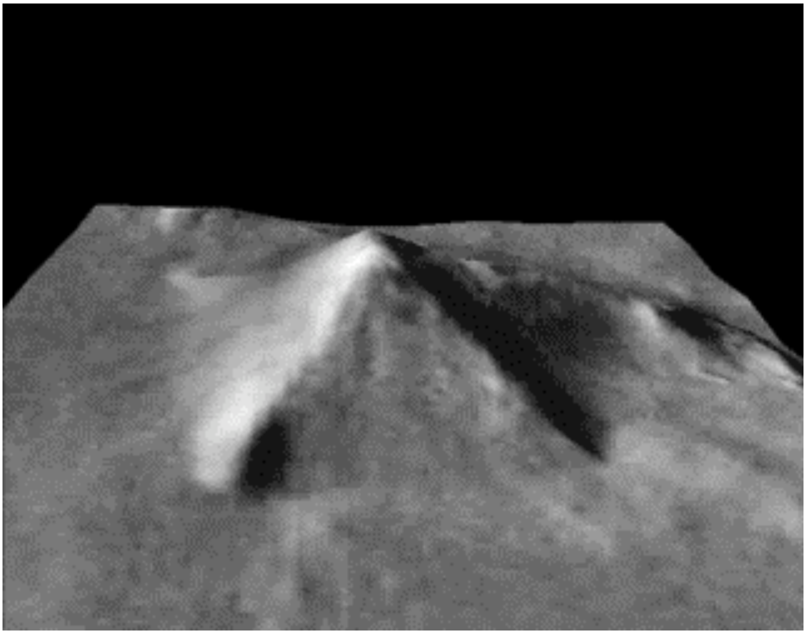


Figure 136 Simulated view near ground level of the D&M pyramid. View is looking north-northeast.

There is no comparison between the Egyptian Sphinx and Martian Face, at least in terms of their size. The Face on Mars is about 2 km long and 400 meters in height. The overall length of the Sphinx is about 45 meters. It's head is about 10 by 4 meters. Yet the feature most like the Face here on Earth is the Sphinx. Natural rock formations look like faces only when viewed in profile from a very specific location. On the other hand, the Face on Mars and the Sphinx maintain their face-like appearance over a wide range of illumination conditions and vantage points.

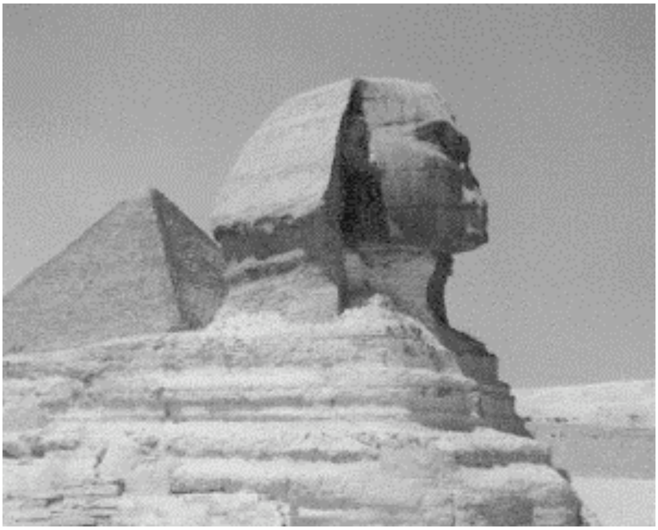


Figure 137 The Sphinx gazes towards the eastern horizon

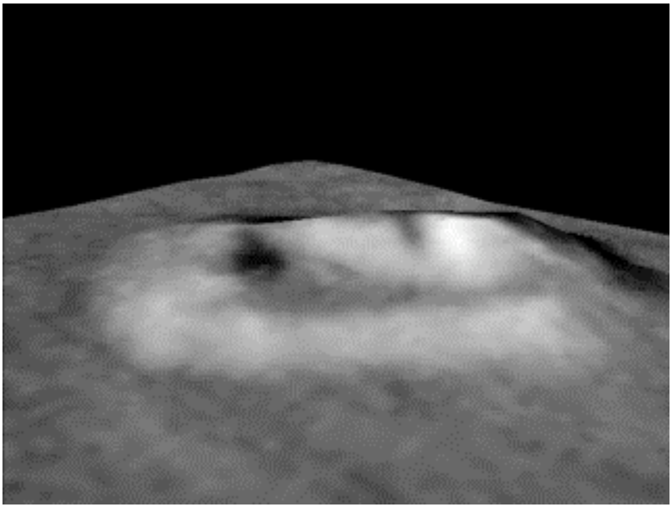


Figure 138 The Face on Mars stares up into space

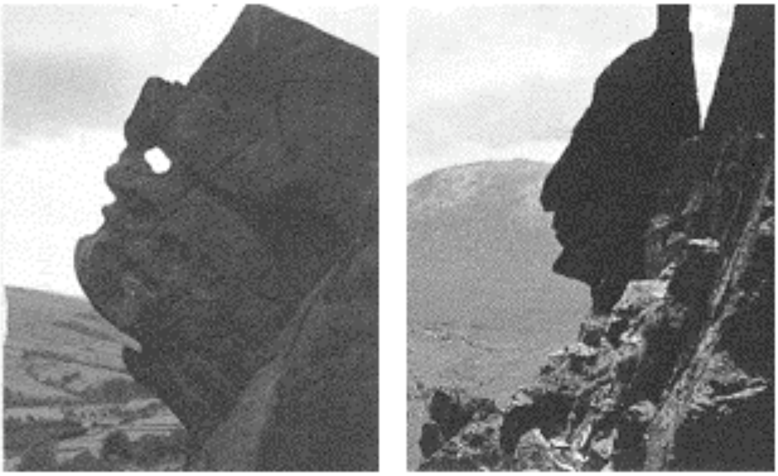


Figure 139 Winking Eye and Sphinx Rock are two naturally occurring rock formations in the U.K. that resemble faces in profile.

It is noted however that there are objects on Earth as big as the structures on Mars. About 100 km southwest of the city of Xi'an, in the People's Republic of China, stands an enormous earthen pyramid 300 meters high (Figure 140). Its age and origin are currently unknown.

Figure 140 Large earthen pyramid in Xi'an province in China roughly comparable in size to the D&M pyramid

To be fair we must ask ourselves if a Face on Mars is really so strange — after all in the 1940s a Japanese-American artist by the name of Isamu Noguchi proposed a face be built on Earth — to be seen from Mars (Figure 141).

Figure 141 "Pyramidal Memorial to Man to be Visible from Mars," designed by the Japanese-American sculptor Isamu Noguchi in 1947. The proposed size of the nose is one mile in length.

One final thought on the size of these objects: The dozen-or-so anomalous structures noticed to date in various Martian regions display a surprisingly narrow range of sizes — about two to four kilometers in their longest dimensions. The laws of fractal behavior dictate generally that, if natural, a significant portion of the anomalies should lie outside this limited range. This should be particularly so on Mars, whose terrain tends to be more varied in scale than that of Earth. Advocates of the intelligence hypothesis theorize that this relative consistency of structural scale might be a signature of purposeful design, particular construction technologies, population size, and/or environmental factors such as gravity, temperature and atmospheric composition. In this scenario purposeful design would include mass habitation or industrial activity, the low Martian gravity would permit the economical construction of relatively large forms, and the low ambient temperature would dictate the collection of solar energy over as large an area as possible. The hostile environment of the Martian surface might indeed demand architecture of some similar design, perhaps partially underground.

Appendix D — Identifying the Subjective Factors

Most of the known Martian anomalies were discovered by intensive visual examination of selected Viking photographs. The following table defines some of the qualitative criteria by which these objects have distinguished themselves visually from their surroundings. These criteria are subject to individual interpretation as to matters of degree.

Table 9 Subjective factors

Observed Characteristics	**Objects**
Geometrical Structure (linearity, rectilinearity, parallelism, etc.)	• Stripes on Face • D&M Pyramid • Fortress • Cliff • Runway • Bowl Complex • Crater Pyramid • Crater Pyramid furrows
Periodicity (regular repetition of a form)	• Stripes on Face • Runway "cones" or "pyramids" • Geometrical pattern in walls of Fortress
Anomalous surface smoothness	• City • Face • Tholus • D&M Pyramid • "Bow-tie" in Runway Complex • Bowl
Other anomalous texture	• Striations in terrain east of Cliff • Furrows near Crater Pyramid
Lack of damage, or other anomalous behavior, within primary blast radius of impact crater	• Crater Pyramid • Cliff • Concave area to the east of the Cliff • Furrows near Crater Pyramid

Relative symmetry	• Face • D&M Pyramid • Cliff • City • City Square • Runway “Bow-Tie“ • Tholus • Crater Pyramid
Similarity to familiar terrestrial artifacts	• Runway (particle accelerator or mass driver) • Tholus (prehistoric burial mound) • Crater Pyramid (4-sided terrestrial pyramids) • Bowl (amphitheater, Mesoamerican structure) • Helmet stripes on Face (Pharaonic headpiece) • Crater-Pyramid Furrows (mining excavations)
Linear Arrangement	• City Square – Face – Cliff – Solstice • Runway "Cones" or "Pyramids"
Parallelism and Rectilinearity	• Arrangement of City • Relationship of City to Face • Right angles: D&M – Tholus – Cliff • Right angles: D&M – Fortress – Cliff
Mutual Orientation	• East wall of Fortress points at D&M Pyramid • D&M Pyramid’s long axis points at Face • D&M Pyramid’s left “arm” points at City Square • D&M Pyramid’s right “arm” points at Tholus • Cliff’s long axis points at Tholus

Appendix E — On Martian Meteorites, Microbes, and Faces

In 1976, two Viking Landers set down on the Martian surface to conduct the first search for organic life on the Red Planet. According to Dr. Gilbert V. Levin, a member of the Lander science team,

> "The Viking Labeled Release (LR) experiments conducted on Mars in 1976 returned data satisfying its pre-mission criteria for the presence of life in the samples of surface material analyzed. Placed in sealed chambers, the samples were moistened with organic nutrients laced with radioactive carbon and monitored for the evolution of radioactive gas as evidence of metabolism. Both Viking landing sites, 4,000 miles apart, produced strong positive responses. As controls, portions of the samples which had produced the positives were heated to temperatures designed to distinguish chemical from biological agents. Each of a total of nine separate reactions was consonant with a biological entity. Together, the results constitute strong evidence for the existence of microorganisms an Mars. Conflicting evidence was generated by the Viking Gas Chromatogram Mass Spectrometer (GCMS) experiment which sought organic compounds and found none. This major dilemma was "solved" by the majority of the scientific community by opting for the conservative conclusion: Chemistry. Various extreme environmental factors were cited to support the view that Mars is hostile to life..." [1].

Then a few years later an article was published in the journal *Nature* announcing the discovery of organic compounds in a Martian meteorite:

> "The meteorite EETA 79001 which many believe to have originated on Mars contains carbonate materials thought to be Martian weathering or alteration products. Accompanying the carbonates are unexpectedly high concentrations of organic materials (defined here as carbonaceous matter that has a low stability towards oxidation and so combusts at < 600° C; the term 'organic' does not necessarily imply an origin by biogenic processes). Although the carbon isotope composition of these materials is indistinguishable from terrestrial biogenic compounds and so cannot be used to assess the source, we argue here that their occurrence in an interior sample of a clean Antarctic meteorite militates [argues] against a wholly terrestrial origin..." [2]

Recently in the August 16, 1996 issue of the journal *Science*, a list of researchers headed by David S. McKay published an article entitled: “Search for Life on Mars: Possible Relic Biogenic Activity in Martian Meteorite ALH84001.” In the article they describe their analysis of a sample from a meteorite found in Antarctica in 1984 that is believed to have been blasted from Mars by a huge impact about 16 million years ago. Their findings:

> "In examining the Martian meteorite ALH84001 we have found that the following evidence is compatible with the existence of past life on Mars:
>
> (i) an igneous Mars rock (of unknown geologic context) that was penetrated by a fluid along fractures and pore spaces, which then became the sites of secondary mineral formation and possible biogenic activity;
>
> (ii) formation age for the carbonate globules younger than the age of the igneous rock;
>
> (iii) SEM and TEM [electron microscope] images of carbonate globules and features resembling terrestrial microorganisms, terrestrial biogenic carbonate structures, or microfossils;
>
> (iv) magnetite and iron sulfide particles that could have resulted from oxidation and reduction reactions known to be important in terrestrial microbial systems; and
>
> (v) the presence of PAHs [polycyclic aromatic hydrocarbons] associated with surfaces rich in carbonate globules."

They then go on to state:

> "None of these observations is in itself conclusive for the existence of past life. Although there are alternative explanations for each of these phenomena taken individually, when they are considered collectively, particularly in view of their spatial association, we conclude that they are evidence for primitive life on early Mars" [3].

Although the results of the Viking Lander experiments suggested the possibility of life, an alternative explanation that the reactions were due to Mars' soil chemistry became the accepted wisdom at the time. But now the planetary science community’s opinions about the possibility of life on Mars seem to be changing, based not on the actual recovery of a live microbe but on circumstantial evidence — carbonate materials that resemble fossils and organic compounds that could be the byproducts of primitive life forms.

Since the discovery of an enormous humanoid face on Mars in 1976, independent researchers have been attempting to build a case in support of the hypothesis that certain formations on Mars are artificial in origin. Unfortunately the mainstream scientific community in general and NASA in particular has been unwilling to even consider the question in a responsible manner. It should be clear to all the evidence that microbes may have once lived on Mars is no different, in essence, than the evidence that the Face might have been carved by intelligent beings. Like the case for Martian microbes, all of the evidence to date is indirect and circumstantial. Taken individually each piece of evidence has alternative explanations. But together the body of evidence that the Face and other nearby objects are artificial structures is compelling, and perhaps even stronger (by virtue of the fact that we have so many more independent pieces of evidence) than that for microbes. Accepting one hypothesis while rejecting the other is arbitrary. It is not scientific.

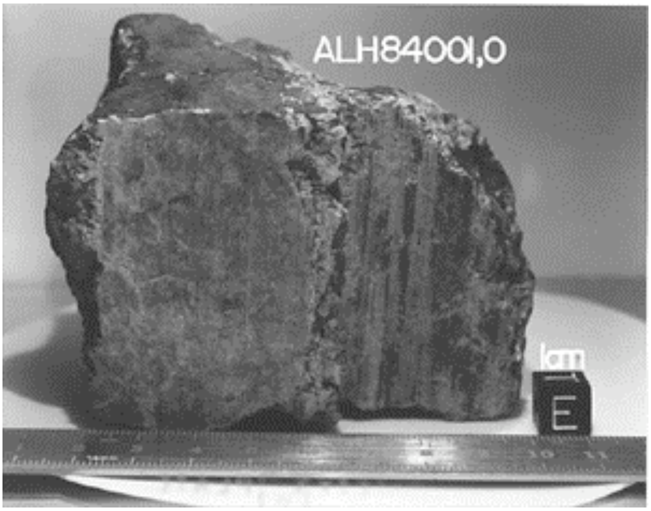


Figure 142 Meteorite ALH84001 found in Antarctica in 1984 that is believed to have been blasted from Mars by an impact about 16 million years ago. (NASA)

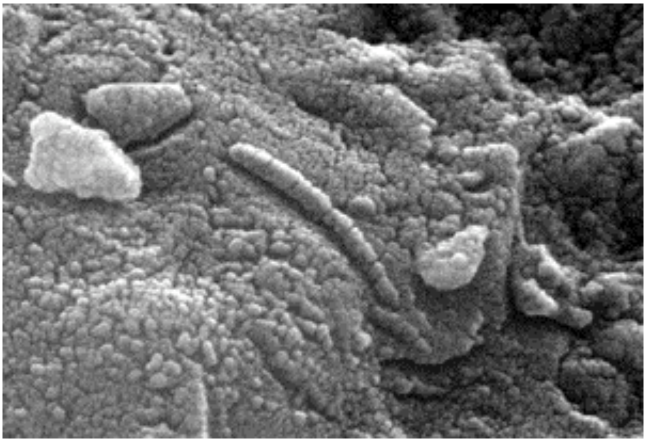


Figure 143 High resolution scanning electron microscope image that shows a tube-like object less than 1/100th the width of a human hair that is believed to be the fossilized evidence of primitive life that existed on Mars 3.6 billion years ago. (NASA)

References

1. *International Tesla Society's Mars Forum*, November 13-14, 1993, Colorado Springs, CO.

2. I.P. Wright, M.M. Grady, and C.T. Pillinger, "Organic Materials in a Martian Meteorite," *Nature*, Vol. 340, 20 July 1989.

3. McKay, D.S., Gibson, E.K., Thomas-Keprta, K.L., Vali, H., Romanek, C.S., Clemett, S.J., Chillier, X.D.F., Meachling, C.R. and Zare, R.N., "Search for past life on Mars: Possible relic biogenic activity in Martian meteorite ALH84001," *Science*, Vol. 273, 16 August 1996.

Appendix F — Mars Anomalies Research Chronology

1976

Viking takes first picture (35A72) of the Face on Mars on July 25.

Walter Hain in Germany sees an image of the Face in a NASA film on December 15.

1977

Vincent DiPietro finds picture of Face in NASA archives. DiPietro and Greg Molenaar find second image of Face (70A13).

1979

DiPietro and Molenaar begin the process of image enhancement for the Face, including the development of the Starburst Pixel Interleave Technique (SPIT).

Walter Hain in Germany publishes *Wir, vom Mars (We from Mars),* a compilation of myth and fact about the planet which includes the suggestion that the Face may be artificial.

1980

DiPietro and Molenaar publish *Unusual Martian Surface Features.* On June 16, DiPietro and Molenaar present their work at the 156th Meeting of the American Astronomical Society in College Park, Maryland.

1981

Richard Hoagland meets DiPietro and Molenaar at the first *Case for Mars* conference in Boulder, Colorado in July.

1983

Hoagland contacts DiPietro and Molenaar about a different subject, but on seeing more recent photographic enhancements, becomes interested in the Face.

Hoagland hypothesizes existence of City. Identifies Fortress and other pyramidal objects in City as well as smaller mound like objects. Notices that objects seem to be aligned and that the alignment may be solsticial.

Hoagland and anthropologist Randy Pozos organize Independent Mars Investigation computer conference during the summer. Hoagland begins conference with first entry in December.

1984

"Martian Chronicles" computer conference takes place during the first quarter of 1984. Participants include John Brandenburg, Lambert Dolphin, Bill Beatty, and Jim Channon along with DiPietro, Molenaar, Hoagland, and Pozos. Last entry made by Hoagland in March.

Hoagland and Thomas Rautenberg at the University of California at Berkeley discuss second parallel investigation (Mars Investigation Group).

John Brandenburg presents results of Independent Mars Investigation at *Case for Mars II* conference in Boulder in July.

August issue of the magazine *Soviet Life* reports discovery of pyramids on Mars by Russian author, Vladimir Avinsky.

Discover magazine reports on *Case for Mars II* conference in September issue — no mention of Independent Mars Investigation paper. In same issue Carl Sagan proposes joint U.S./Soviet mission to Mars and mentions "enigmatic landforms" on Mars.

In the fall, Rautenberg, economist David Webb, Carl Sagan, and Louis Friedman (Executive Director of The Planetary Society) meet in Washington. Friedman refuses to look at images of the Face. Off to the side, Sagan tells Webb, "These are very interesting, but if anyone asks me I will deny that the meeting took place."

1985

In January, Hoagland and Sagan discuss Mars anomalies at National Academy of Sciences meeting in Washington. Sagan offers to review any material on the subject and anticipates exchanging papers in the literature.

In February, Mark Carlotto contacts Rautenberg and sets up meeting. Rautenberg provides Carlotto a copy of Viking data tapes.

Series of newspaper articles come out critical of the Independent Mars Investigation during the spring. University of California withdraws sponsorship of Mars Investigation Group.

On June 2, Sagan publishes article entitled: "The Man in the Moon" in *Parade Magazine*. Article includes a colorized version of Viking frame 70A13 in which the crucial shadows are obscured by the added color. Sagan is highly critical of Face and investigators — none of which are mentioned by name.

Interviews with Sagan and others at *Steps to Mars* conference held mid July in Washington indicate growing resistance to Mars anomalies in the planetary community.

1986

On July 23, 1986, DiPietro speaks with Sagan at the National Academy of Sciences in Washington, D.C. DiPietro shows pictures to Sagan of the enhancements of the face with the eyeball detail. DiPietro agrees to send photos to Sagan.

Carlotto sends Sagan draft of paper on 3-D analysis of Face. Carlotto and Sagan exchange letters late in the summer. The paper which is entitled: "Digital Imagery Analysis of Unusual Martian Surface Features" is subsequently submitted to the planetary science journal *Icarus*.

Brian O'Leary organizes Mars Anomalies Research Society. Members include Brandenburg, Carlotto, DiPietro, Webb, and others.

Hoagland publishes "The Curious Case of the Humanoid Face on Mars" in the November issue of *Analog* magazine.

Two books published in 1986: *The Face on Mars* by Randy Pozos, and *Planetary Mysteries* by Richard Grossinger.

1987

Early in February, O'Leary submits paper to *Icarus* entitled: "Comments on Imagery of the Face on Mars and Nearby Objects."

In mid March, Carlotto's paper is rejected by *Icarus* on the grounds that it is "not of sufficient scientific interest."

O'Leary's paper is also rejected by *Icarus* on similar grounds. This is the same journal that previously published eleven papers by O'Leary, none of which had ever been rejected.

Carlotto revises paper and submits to the journal *Applied Optics* in September.

Hoagland's book *The Monuments of Mars* is published in 1987.

1988

Carlotto's paper is accepted and published in the May 15 issue of *Applied Optics*.

Russia launches Phobos I and II probes to Mars in July. Contact lost with Phobos I en route to Mars.

Following press conference at National Press Club in Washington D.C., popular articles about the Face appear in *New Scientist* (July 7) and *Newsweek* (July 25).

Over the summer, Erol Torun performs geomorphological analysis of D&M pyramid and concludes that it could not have been formed by any known geological process on Mars. Also develops a geometrical model of the D&M in which are embedded numerous universal mathematical constants.

Hoagland subsequently shows these same universal constants are reflected in relationships between the D&M and other objects in the Cydonia complex and that latitude of the D&M on Mars can be expressed in terms of the same constants.

In December, Hoagland, Carlotto, and Torun present research results to audience at Goddard Space Center in Maryland.

On December 18, a new paper entitled: "A Method for Searching for Artificial Objects on Planetary Surfaces" describing fractal analysis of the Face is submitted to the journal *Nature*.

Less than two weeks later the paper is returned, the editor refusing to review it.

1989

In March erroneous radio transmissions send Phobos II into an uncontrolled spin as it approached the tiny Martian moon.

Fractal paper is submitted to the *Journal of the British Interplanetary Society* (*JBIS*) at the end of March.

Hoagland, Carlotto, and Torun meet with Congressman Robert A,. Roe, Chairman of the House of Representative Committee on Science, Space, and Technology in April.

1990

Fractal paper is accepted and published in May issue of *JBIS*. Revised version of O'Leary paper that was rejected by *Icarus* entitled: "Analysis of Images of the Face on Mars and Possible Intelligent Origin" also appeared in same issue.

In July Sagan writes Carlotto to thank him for video footage used in a revised version of his *Cosmos* series.

1991

Brandenburg, DiPietro and Molenaar publish "The Cydonian Hypothesis" in the spring issue of the *Journal of Scientific Exploration* in where they hypothesize the Face was built by indigenous Martians.

Hoagland suggests the geometry of the D&M pyramid and its external relations to other nearby objects are based on tetrahedral geometry.

Carlotto's book *The Martian Enigmas* is published in 1991.

1992

Mars Observer launched on September 25.

Prompted by press coverage of the Face, Professor Stanley V. McDaniel begins an independent evaluation of the methodology used by researchers studying the Martian features, and of NASA's response to their research.

1993

Invited paper by Carlotto entitled "Digital image analysis of possible extraterrestrial artifacts on Mars" appears in April issue of the journal *Digital Signal Processing*.

Don Ecker, director of research for UFO Magazine, locates document produced by The Brookings Institution in early 1960s that suggests scientists may consider suppressing the discovery of extraterrestrial life or artifacts. Ecker relays this information to Hoagland, who relays it in turn to McDaniel for inclusion in his report.

Mars Observer is lost in the vicinity of Mars on August 21. This together with loss of Mars Observer prompts accusations by Hoagland that NASA is covering up the discovery of artificial structures on Mars.

Mars researchers meet in September in Cody Wyoming at conference organized by Tom and Cynthia Fell.

McDaniel completes his analysis of the independent Mars investigations as well as NASA's conduct in the matter. His findings are published in *The McDaniel Report* late in 1993.

1994

McDaniel coordinates the formation of the Society for Planetary SETI research (SPSR) to study the Mars anomalies. Members are drawn from a variety of academic and professional fields.

Physicist Horace W. Crater begins study of small mound formations at Cydonia. Geologists James Erjavec and Ronald Nicks begin development of a geological map of the Cydonia region.

1995

Initial results of Crater's analysis of the mound formations indicate the presence of a radical statistical anomaly arising from the non-random distribution of the mounds.

In two papers privately distributed within the SPSR, "Geometric Solution to the Pentad" and "Geometric Construction of the Square Root 2 rectangle," McDaniel proposes a regular grid pattern accounting for the geometric distribution of the mounds.

In June, McDaniel and Crater presented two talks at the 14th meeting of the *Society for Scientific Exploration* in Huntington Beach, California. McDaniel's talk "Artificial Structures on Mars" summarized Mars anomalies research to date. Crater's talk "A Statistical Study of Angular Placements of Features on Mars" presented an analysis of a number of small mound-like objects in the City.

1996

In May, Carlotto and archaeologist Jim Strange from the University of South Florida presented talks at the 15th meeting of the *Society for Scientific Exploration* in Charlottesville, Virginia. Carlotto's talk "Do Certain Martian Surface Features Suggest an Extraterrestrial Hypothesis?" presented probabilistic analysis of existing evidence for artificiality along with several new pieces of evidence based on a comparative analysis of several of the features. Strange's talk "Can Archaeological Method Apply to Planetary SETI?" examined the randomness of the mounds studied by Crater and McDaniel and Torun's geometrical model of the D&M pyramid.

Helmut Lammer publishes a paper, "Atmospheric Mass Loss on Mars and the Consequences for the Cydonian Hypothesis and Early Martian Life-Forms" in the autumn issue of the *Journal of Scientific Exploration*. Paper argues against Brandenburg's hypothesis that the Face and other structures on Mars were built by native Martians.

Sagan publishes his last book, *Demon Haunted World*. Although highly skeptical of the Mars anomalies, he states that the hypothesis can be tested and so opens up the subject to scientific inquiry.

Pathfinder and Mars Global Surveyor are launched in the fall.

Russians launch Mars 96 Orbiter which fails to reach Earth orbit.

1997

Van Flandern publishes a preprint of "New Evidence of Artificiality at Cydonia on Mars", showing that the Face was located close to the old Martian equator and had a "face-upright" orientation (major axis oriented north-south) with respect to it. Van Flandern finds this fact consistent with his exploded planet hypothesis, which holds that Mars was a moon of a larger planet since exploded. The Face would have been prominent on the Mars equator as seen from such a planet.

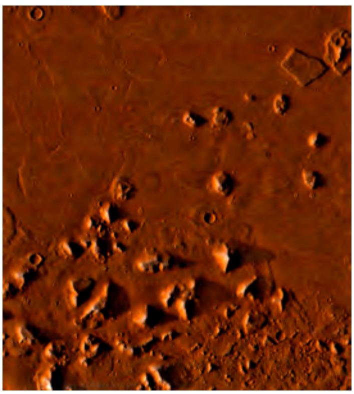
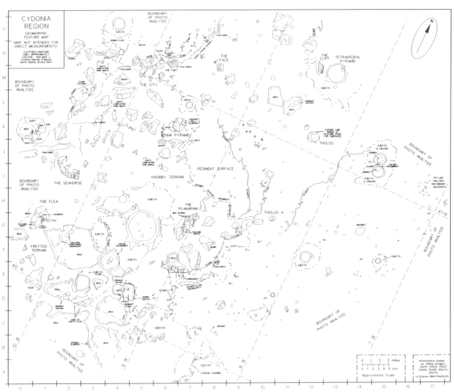
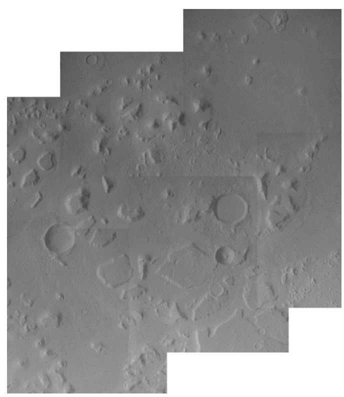
Carlotto's paper "Evidence in Support of the Hypothesis that Certain Objects on Mars are Artificial in Origin" is published by the *Journal of Scientific Exploration*. Paper analyzes all of the evidence to date within a probabilistic framework showing it to satisfy Sagan's criterion for "extraordinary evidence."

Appendix G — Multimedia Content

Additional content is contained in two zip files that can be downloaded along with the electronic edition of this book.

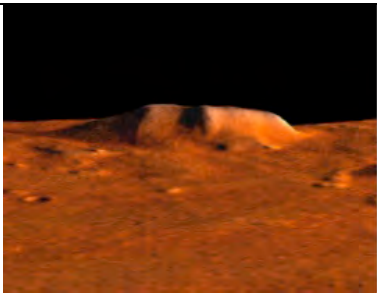
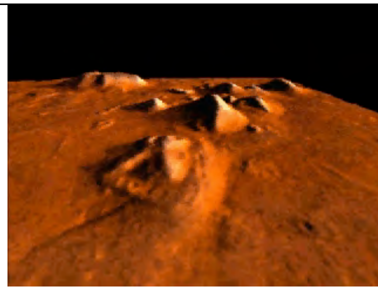
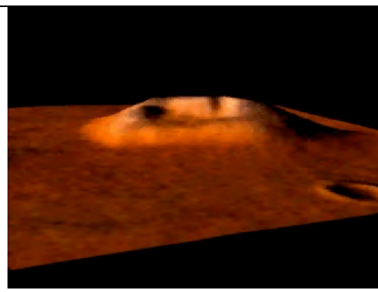
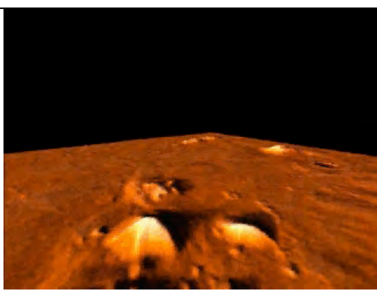
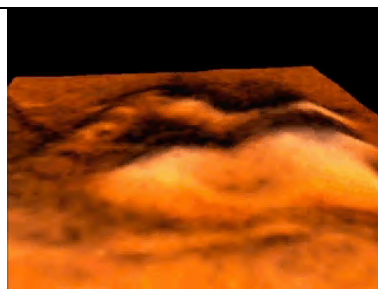
High Resolution Images

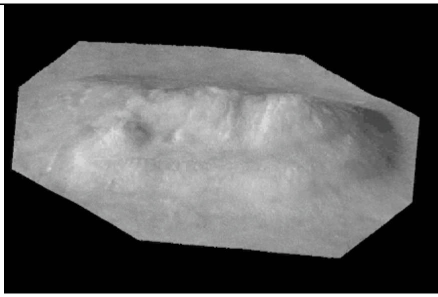
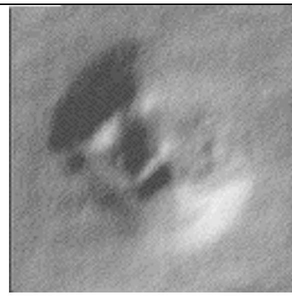
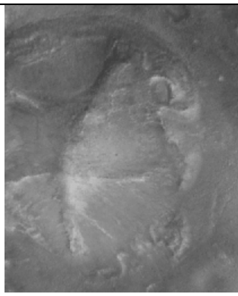
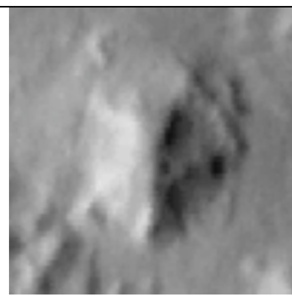
Images 1 and 2 are colorized full frame Viking images. Image 3 is the full resolution geomorphic feature map of Cydonia region created by James Erjavec and Ronald Nicks. Image 4 is a composite of Viking frames over Cydonia collected during orbit 70.

 1) colorized35A72.tif	 2) colorized70A13.tif
 3) geomorphicMapfullRes.tif	 4) Orbit70Mosaic.tif

Video Clips

The table below shows key frames from the video clips. Clip 1 is a QuickTime VR visualization from a vantage point between the City and Face. Clips 2-6 are colorized Viking image fly-throughs and rotations. Clip 7 blends perspective views of the Face derived from Viking and MGS images. Clip 8 simulates the appearance of the Face during a spring day on Mars. Clips 9 and 10 blend Viking and MGS overhead views of a pyramid in the City and the Fortress. Clip 11 is a QuickTime VR visualization of the Tholus. Clip 12 blends Viking images of the City pyramid and Fortress showing their structural similarity.

 1) colorCydoniaQTVR.mov	 2) colorCydoniaFlyThru.avi
 3) colorDM.avi	 4) colorFace35.avi
 5) colorFlyFromCityToFace.avi	 6) colorFort.avi

 7) faceMGSVikMorph.avi	 8) faceSpringLighting.avi
 9) pyrMGSVikMorph.avi	 10) fortMGSVikMorph.avi
 11) TholusQTVR.mov	 12) vikPyrFortMorph.avi

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