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Part 2: Silicas - and Hot Springs? - Could Mean Ancient Life On Mars

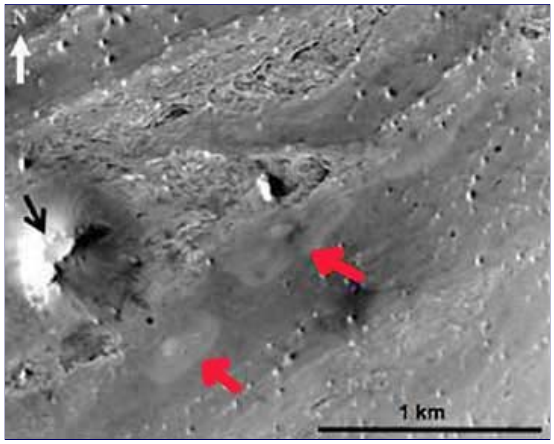
"To be honest, what would surprise me the most would be if life never was on the planet Mars. That would be surprising and give us all some pause and make us wonder – why?"
- Dorothy Z. Oehler, Ph.D, NASA Johnson Space Center

Dark "horse head" of Syrtis Major Planum rises at center of this Hubble telescope image of Mars. On the right side of that darkness is Elysium Planitia; on the left is Arabia Terra. Image courtesy Hubble.

Return to **Part 1**

February 27, 2009 Houston, Texas - Other scientists studying a completely different part of Mars in Arabia Terra have also discovered features they think are the residue of hot springs, largely based on the tell-tale oval rings that closely resemble hot springs in Yellowstone National Park and Dalhousie, Australia. In a recent issue of *Astrobiology*, NASA Johnson Space Center planetary geologists described one mound on Mars named Vernal crater that could be a dried up hot springs?

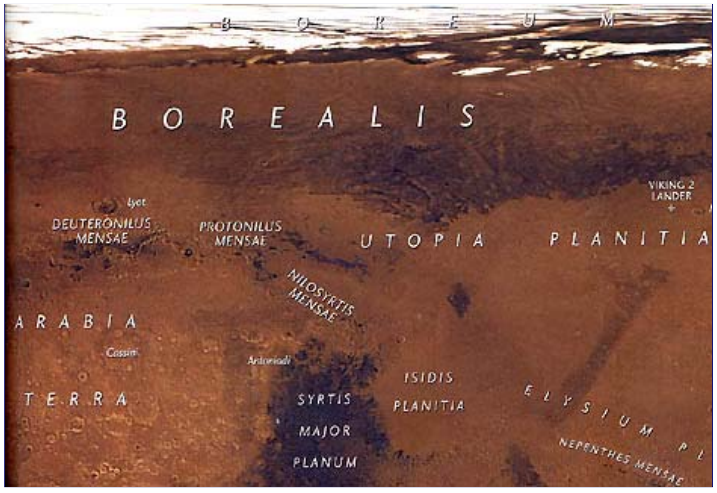
Hot Springs Features in Arabia Terra



HiRISE image where red arrows point to possible elliptical hot springs residues, including Vernal crater, on Mars. Black arrow shows nearby flat-topped outcrop. Image courtesy NASA.

Extinct dry spring left elliptical residue in
Australia's Dalhousie region. Image courtesy Google Earth.

One of the co-authors on the Astrobiology research is Dorothy Oehler, Ph.D., Research Scientist in NASA Johnson Space Center's Astromaterials Research and Exploration Science Directorate in Houston, Texas. This week she talked with me about the fascinating search for hydrothermal sites in Arabia Terra that is not considered a volcanic region like the Olympus Mons Tharsis volcanoes nearly 3,000 miles away.



Arabia Terra is lower left of above map at center of Mars just north of the equator.
Below, the red arrows point to Arabia Terra features photographed by the
Mars Reconnaissance Orbiter (MRO) that resemble dried up hot springs on Earth.

Interview:

Dorothy Z. Oehler, Ph.D., Research Scientist, Astromaterials Research and Exploration Science Directorate, NASA Johnson Space Center, Houston, Texas:
"We started looking in Arabia Terra for areas that might be interesting and there was a crater that has a very shallow slope into the crater. It could be easily accessed – you could drive into the crater and drive back out and in so doing, you could see a whole stack of sediments. So, that's why we honed in on this crater initially, now named Vernal crater after the town in Utah.

The image in Arabia Terra was taken by the spacecraft called Mars Reconnaissance Orbiter (MRO) and its High Resolution Imaging Science Experiment (HiRISE). The imagery is mainly in the visible, so it looks like something you see with your eyes and not infrared.

You can get resolution up to about a meter, which really means you are seeing something like 30 centimeters per pixel and you need three pixels to resolve something. So, people say it's about a meter resolution. It's amazing! We were able to see things we have never seen before on Mars. In the Vernal crater, we noticed some highly unusual features.

They jumped out at me right away as potentially being related to water because of their elliptical shape. They looked like nothing else we had ever seen on Mars. We decided that the most reasonable analogs are hot springs on Earth.

LIKE YELLOWSTONE NATIONAL PARK?

Yellowstone National Park circular hot springs.
Hot Springs are similar to geysers, but their underground channels are large enough to allow rapid circulation of water. Rising hot water releases heat energy by evaporation or hot water runoff, while convection currents return the cooler water to the underground system, thus maintaining equilibrium. The microorganisms which live in and around the hot springs often make the pools very colorful.

Yes, that's one kind of spring that forms terraces. A lot of people have seen those mammoth springs in Yellowstone with the terraces. And we thought we had terraces besides the oval shape. It was the terracing that really got our attention thinking about springs and we had some evidence of this in these features as well.

SOME ARE VERY SIMILAR TO THE DALHOUSIE, AUSTRALIA, PHOTO THAT WENT WITH YOUR REPORT IN *ASTROBIOLOGY*.

Right. We came across some papers on the Dalhousie springs and I noticed some particular similarities, particularly with the dried up Dalhousie springs. In a spring area, the water flow keeps moving; the subterranean water flow is not necessarily stable over time. It moves in areas that were active and become extinct. It's a highly changing environment where you will have extinct springs mixed in with active springs. Some of the extinct, dried up Dalhousie springs looked particularly like the Martian features.

IS IT POSSIBLE THAT ANY OF THE FEATURES THAT THE HI RISE HAS IMAGED ON MARS COULD BE ACTIVE SPRINGS YET TODAY?

Certainly that's a question that has intrigued all of us. In this case, our best guess is that these (in Arabia Terra) are not active today. And the reason for that is when you look at the high-resolution images, you can see some small impact craters within the (Martian) features themselves. If they were active hot springs today, you would think the craters would be covered up (by flow deposits). So, the features look a little older.

Also, the surface looks somewhat eroded, as if it is an older surface. We can't actually put an age on it, but we don't think they are current. Arabia Terra is an area with almost no evidence of volcanism and it's probably two or three thousand miles from the Tharsis and Olympus Mons volcanic region. There are no lava flows or thermal anomalies. There are no geomorphic features that look like lava in any way at all – none of the wrinkled ridges that are normally associated with lava flows. So, there is very little evidence for active volcanism or lavas in the area. So, we think, if these are springs, they are more like artesian sub-surface waters where the water is not necessarily very hot – not like Yellowstone – but since it's coming from below the ground, it's usually a little warmer than the surface area. It's not freezing. It's mobile, liquid water, so it's a little bit warmer. There are springs that come out in the Arctic and in Greenland where liquid water comes to the surface in an otherwise freezing area. So, that would be like an artesian setting.

DO YOU HAVE ANY COMPOSITION DATA ABOUT VERNAL CRATER?

Unfortunately, Arabia Terra is an area that has a lot of dust. The area we're in (Vernal crater) doesn't have as much dust as other areas of Arabia Terra, but it has more dust than a lot of other places on Mars. Unfortunately, our best guess is that a thin layer of dust in Arabia Terra prevented the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) from seeing clearly. Our CRISM data did not show anything except evidence of dust, in both infrared and visible, which is oxidized iron in the Martian dust.

Hot Springs - Key to Finding Life On Mars?

LET'S GO TO THE $64 MILLION QUESTION THAT EVERYBODY WANTS TO HAVE AN ANSWER TO. IF THERE ARE ACTIVE – OR WERE ACTIVE – HOT SPRINGS ON MARS, WARMTH AND WATER USUALLY MEAN LIFE. WHAT IS YOUR BEST SCIENTIFIC GUESS TODAY IF A ROVER WENT AND SCOOPED INTO THAT

GROUND AT THE VERNAL CRATER, WOULD THERE BE EVIDENCE OF MICROBES, PRESENT OR PAST?

I think that a setting that has had hot spring activity, whether related to volcanism or not, is a very important place to do a life search if living organisms have existed on Mars. The reason is that Mars is very dry and generally thought to have been dry for a long time. There certainly are pockets that have had more fluid movement. This Vernal crater is one of those pockets.

I can't tell you that there is going to be life there, but it is certainly the type of place where there would be water. And if we had found CRISM data to support our hypothesis, the Vernal crater would have been a very strong candidate for the Mars Science Laboratory (see below). But because the CRISM data were essentially bland, it didn't provide the strong support that people would like to see in the final site selection for the Mars Science Lab.

Best Places to Look for Life On Mars?

AS A SCIENTIST WHO HAS BEEN LOOKING FOR COMBINATIONS OF HEATED WATER COMING OUT ON THE SURFACE OF MARS, IF YOU WERE GOING TO SAY, 'THIS IS WHERE I WOULD MOST LIKE THE MARS SCIENCE LAB TO LAND, WHERE WOULD YOU LIKE TO SEE IT DIG?

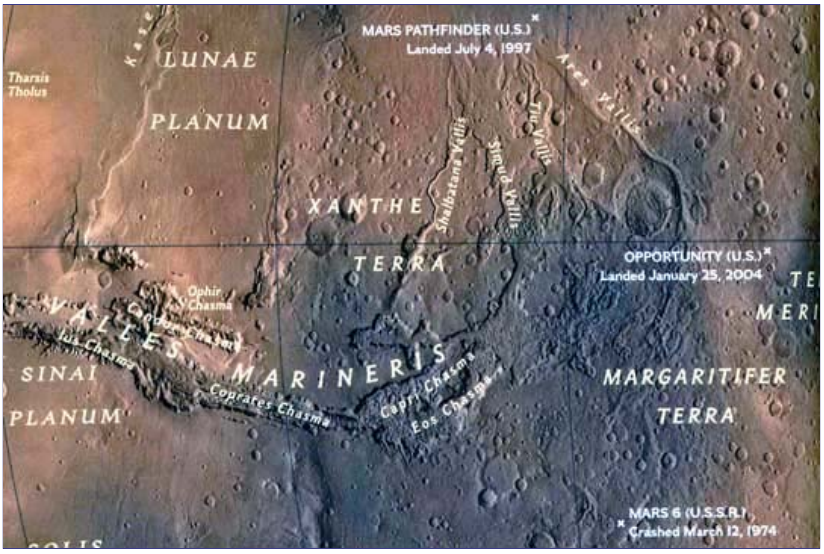
Oh, there are so many issues with landing the vehicle safely. You've got so much money in it. It's such an expensive venture that you just cannot take the chance of an unsafe landing. Unfortunately, there are many interesting sites that are very difficult to get to and might not be in the realm of what we can do in the next few years.

BUT WHAT WOULD BE AT THE TOP OF YOUR LIST REGARDLESS OF LANDING PROBLEMS?

I like areas that have evidence of water over time. For me, some of the deltas they have been looking at are very interesting. There's a delta called Eberswalde not far from Holden Crater. Both are south of the equator in Margaritifer Terra. Holden's wide floor has abundant layered sediments, channels, and large piles of debris at canyon mouths. These suggest a long history of deposits by water. And in Eberswalde Crater, just north of Holden, scientists have spotted what is surely the remnant of a river delta.

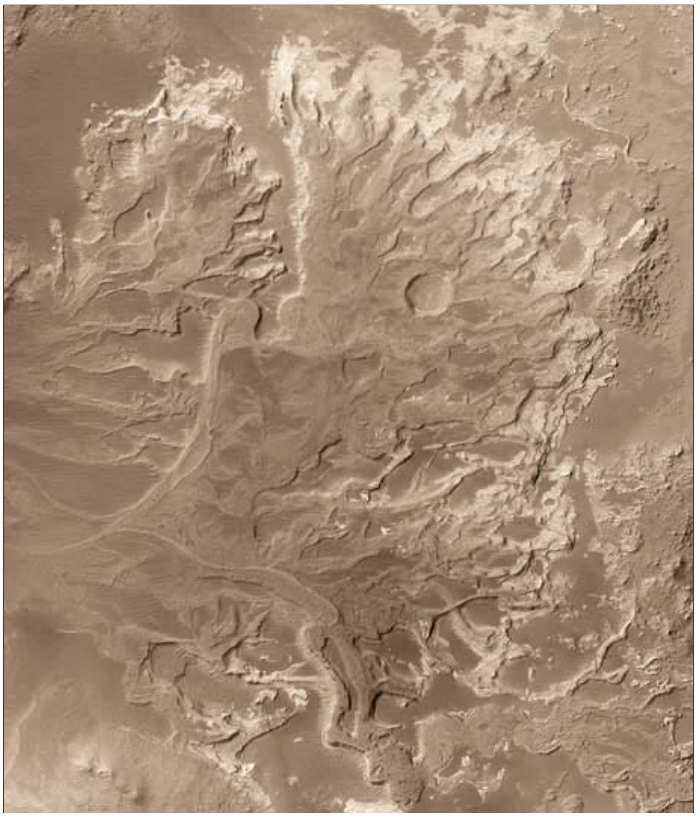
Holden Crater and Eberswalde Delta: Ancient Flowing Water and Life?

"Holden Crater has some of the best-exposed lake deposits and ancient megabreccia known on Mars. Both contain minerals that formed in the presence of water and mark potentially habitable environments. This would be an excellent place to send a rover or sample-return mission to make major advances in understanding if Mars supported life."
- Alfred McEwen, Ph.D., MRO's HiRISE Camera

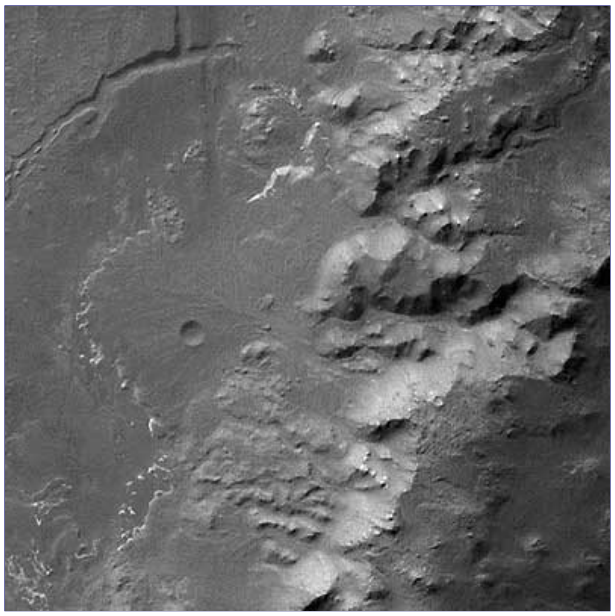


Margaritifer Terra (lower right map) south of the Martian equator and southwest of Opportunity's landing site contains the fossil delta of Holden Crater that is 96 miles wide

(154 kilometers) near 24.0°S, 33.7°W. Not far away is Eberswalde at 24°S, 33°W, formerly known as Holden NE. Eberswalde is a 65.3-kilometer-diameter crater. According to NASA, landforms in both craters provide strong evidence of prior existence of flowing water on Mars. Map © 2009 by National Geographic Society.



Eberswalde, formerly known as Holden NE, is a partially buried impact crater in Margaritifer Terra, Mars. The 65.3-km-diameter crater, centered at 24°S, 33°W, is named after the German town of the same name. It is a proposed landing site for the future Mars rover Mars Science Laboratory.The crater contains a fossilized and exhumed delta which was formed by the flow of a liquid, most likely water. The delta also provides unambiguous evidence that some Martian sedimentary rocks have been deposited in a liquid. The meandering of the channels provides evidence to support this. Image credit: NASA/JPL/University of Arizona.



Holden is a 140-kilometer-wide crater located in the Martian southern highlands notable for many features that seem to have been created by flowing water such as the delta pocked by a crater. In Holden crater, HiRISE discovered what might have been an ancient lake that held calm water for perhaps a thousand years and might have supported life. Image by ESA.

WHAT IS YOUR OWN GUT FEELING ABOUT FINDING LIFE ON MARS ANYWHERE?

My gut feeling is that there is a good chance that life probably did evolve on the planet early on. Whether it's still around or not, I think there is a chance, to be honest, and that

life does have a way of finding its own niches and adapting to changing situations. It might well be below the surface or in pockets here and there. I certainly would not be surprised.

If there were no life at all on the planet now – if it all died out – I would not be too surprised either.

To be honest, what would surprise me the most would be if life never was on the planet Mars. That would be surprising and give us all some pause and make us wonder – why?

It does seem that life evolved quickly on Earth and I would see no reason why it would not have evolved on Mars. I think Mars had all the ingredients early on – at least as we understand what ingredients are necessary for life to originate.

YOU HAVE RAISED A VERY GOOD POINT THAT SUGGESTS THE REASON WHY THERE IS SO MUCH CONCERN BY NASA AND OTHER SCIENTISTS TO LOOK FOR LIFE ON MARS IN ORDER TO ESTABLISH THAT LIFE IS MORE UNIVERSAL BEYOND EARTH, CORRECT?

Well, yeah. I think that has to be one of the most fascinating questions that we can even pose: Are we alone? Are we unique? Or is life something that happens everywhere in many places and with ease? Fascinating philosophical questions!

THERE WERE ALWAYS A LOT OF QUESTIONS FROM THE PUBLIC POINT OF VIEW ABOUT WHY ALL OF OUR MISSIONS TO MARS SO FAR WERE NOT EQUIPPED TO LOOK VERY MUCH FOR ORGANIC SIDE OF CHEMISTRY. IT WAS THE INORGANIC, GEOLOGY SIDE. SO HAVE WE HAD A FAIR TEST OF LIFE ON MARS YET IN ANY OF THE MISSIONS?

That's a good question. You know, my understanding is that even going back to Viking is that they did look for organics. But at that point, it was not understood how oxidized the surface of the planet was. The surface of Mars is very oxidized, so if there are going to be preserved organic materials, they are probably going to be at some depth underneath the surface oxidation. It's oxidized probably by a combination of UV (ultraviolet radiation from sun) and cosmic rays, which can get to the planet because of the loss of atmosphere.

And some people have speculated that peroxides have been formed by the UV and cosmic rays and might be adding to the oxidation of the surface.

THAT WOULD MAKE IT MORE DIFFICULT FOR LIFE TO EXIST ANYWHERE NEAR THE SURFACE?

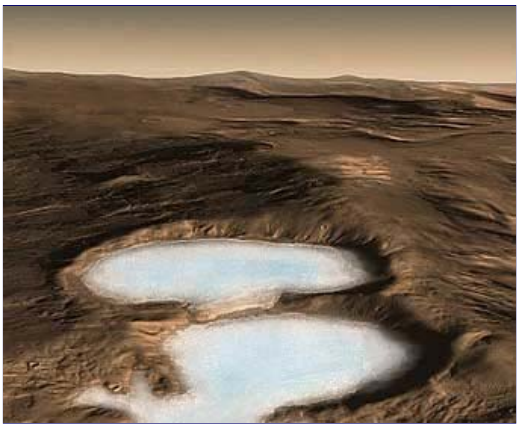
It would, unless life found some way to deal with it by a protective shell or something. But what it would mean is that some of the organic chemicals we have been looking for might not be preserved in the near-surface. They might just be oxidized, which would break them apart. So, we wouldn't find them. So, in general, life as we kind of understand it, if it's there (on Mars), it's probably going to be at some depth in the sub-surface.

WELL, DR. OEHLER, THAT GOES RIGHT TO ONE OF THE MOST RECENT DISCOVERIES IN THE PAST FEW MONTHS OF HEADLINES ABOUT BELOW THE SURFACE OF MARS IN SEVERAL PLACES, THEY HAVE FOUND LARGE CHUNKS OF GLACIAL ICE.

November 2008, NASA:

"Scientists discover concealed glaciers on Mars at mid-latitudes

> The concealed glaciers extend for tens of miles from edges of mountains or cliffs and are up to one-half mile thick. A layer of rocky debris covering the ice may have preserved the glaciers as remnants from an ice sheet covering middle latitudes during a past ice age.
>
> "Altogether, these glaciers almost certainly represent the largest reservoir of water ice on Mars that's not in the polar caps. Just one of the features we examined is three times larger than the city of Los Angeles, and up to one-half-mile thick, and there are many more," said John W. Holt of The University of Texas at Austin's Jackson School of Geosciences, lead author of a report on the radar observations in the Nov. 21 issue of the journal *Science*. "In addition to their scientific value, they could be a source of water to support future exploration of Mars."



In November 2008, data from NASA's Mars Reconnaissance Orbiter of vast Martian glaciers of water ice under protective blankets of rocky debris were rat much lower latitudes than any ice previously identified on the Red Planet. Graphic illustration by NASA/JPL.

Dr. Oehler: Yes, very exciting! Almost every month, there is some new information that comes out that makes everybody sit back and reassess all their thinking. And that's just one of them. And it's very exciting to find something like that!

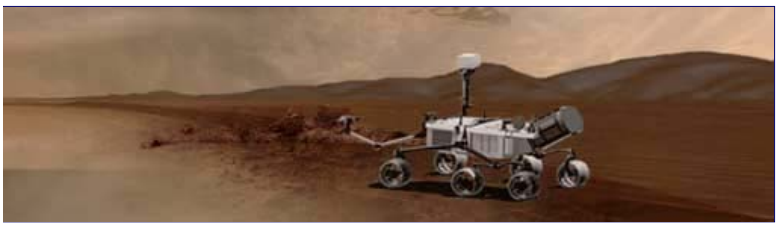
YES, DOESN'T IT MEAN THAT IF THERE IS GLACIAL ICE BENEATH THE SURFACE – BUT NOT THAT DEEP BELOW THE SURFACE – THAT THERE COULD BE MICROBES AND LIFE ASSOCIATED WITH PROTECTED, UNDERGROUND WATER ICE?

That's certainly a possibility. That's the sort of thing we would be looking for in the future. If there were big glaciers, just the pressure of the glaciers themselves would give you a liquid layer at some depth below that. But even that is unknown. Mars is very cold and has so little surface pressure that right now, liquid water is not stable anywhere on the surface.

IF ROVERS COULD DIG DOWN INTO COVERED GLACIERS ON MARS, DO YOU THINK THEY MIGHT FIND SIGNS OF LIFE?

Yes, if it's there, if they have the right instruments and if they could get to deep enough depths."

Mars Science Laboratory



NASA's Mars Science Laboratory (MSL) will launch two years later than previously planned, in the fall of 2011 for arrival nine months later in 2012. The mission rover illustrated above will have the most advanced research tools NASA has developed so far to study the early environmental history of Mars and look for signs of life. Image courtesy NASA.

NASA's most advanced rover called the Mars Science Laboratory (MSL) was supposed to launch in 2009, but the launch timeline has been pushed back to the fall of 2011 for arrival on Mars in 2012. Exactly where the MSL will land to look for signs of life is still a question, but odds are it will be close to Holden Crater and the Eberswalde Delta, south of the Martian equator in the Margaritifer Terra.

When the Mars Science Laboratory mission reaches Mars, NASA says it "will use new technologies to adjust its flight while descending through the Martian atmosphere, and to set the rover on the surface by lowering it on a tether from a hovering descent stage." That means NASA doesn't want to bounce rovers down like Spirit and Opportunity were bounced in the rubber cushioning back in January 2004.

NASA also reports that the Mars Science Laboratory "is engineered to drive longer distances over rougher terrain than previous rovers. The mission will explore a Mars site where images taken by NASA's orbiting spacecraft indicate there were wet conditions in the past. The rover will check for evidence of whether ancient Mars environments had

conditions favorable for supporting microbial life and preserving evidence of that life if it existed there."

Return to **Part 1**

More Information:

[Editor's Note: *Wikipedia* - "Olympus Mons is a shield volcano that is the tallest known volcano in the Solar System, located in the Tharsis bulge, a huge swelling in the Martian surface that bears numerous other large volcanic features. Among them are a chain of lesser shield volcanoes including Arsia Mons, Pavonis Mons and Ascraeus Mons. The volcanoes in the Tharsis region are 10 to 100 times larger than those on Earth. They were built from large magma chambers deep within the Martian crust. The Martian flows are also much longer. This is probably due to larger eruption rates and to lower gravity. One of the reasons volcanoes of such magnitude were able to form on Mars is because the hot volcanic regions in the mantle remained fixed relative to the surface for hundreds of millions of years.

The land immediately surrounding Olympus Mons is depressed 2 kilometers deep. Based on crater size and frequency counts, the surface of this western scarp has been dated from 115 million years old down to a region that is only 2 million years old. This is very recent in geological terms, suggesting that the mountain may yet have some ongoing volcanic activity.

Elysium Planitia is the second largest volcanic region on Mars. Elysium Planitia is centered on a broad dome that is 1,700 by 2,400 kilometers (1,060 by 1,490 miles) in size. It has smaller volcanoes than the Tharsis region, but a more diverse volcanic history. Three significant volcanoes include Hecates Tholus, Elysium Mons and Albor Tholus.

Not all Martian volcanoes are classified as shields with effusive lava eruption styles. North of the Tharsis region lays Alba Patera. This volcano is comparable to Olympus Mons in its horizontal extent but not in height. Its base diameter is 1,500 kilometers (930 miles) but is less than 7 kilometers (4.3 miles) high. Ceraunius Tholus is one of the smaller volcanoes. It is about the size of the Big Island of Hawaii and exhibits explosive eruption characteristics and probably consists of ashdeposits. Tyrrhena Patera and Hadriaca Patera both have deeply eroded features, which indicate explosive ash eruptions Mt. St. Helens is an example of an Earth ash eruption."]

For further reports about Mars, please see **Earthfiles Archive:**

- 01/25/2009 — Methane Mystery On Mars
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- 02/22/2005 — Frozen Sea Near Martian Equator Size of Lake Michigan
- 09/21/2004 — Part 2: Martian Water Ice and Organic Molecules - NASA Will Look for 'Unique Signs of Life' on Mars
- 09/20/2004 — Part 1: Martian Water Vapor and Methane Overlap in Equatorial Regions
- 07/22/2004 — Is Physicist Vittorio Formisano's Mars Data Being Suppressed by ESA?
- 05/06/2004 — Formaldehyde, Ammonia and Benzene Molecules on Mars? Would Probably Mean Life.
- 04/02/2004 — Updates on Spirit and Opportunity Rovers
- 03/31/2004 — Methane on Mars - Biology? Volcanic?
- 03/11/2004 — Updated - Mars Spirit and Opportunity Sol 65 and Sol 46
- 03/08/2004 — Updates from NASA's Rovers and ESA's Mars Express
- 03/05/2004 — Part 3 - Mars: A Sulfate Salty Planet - Could It Have Sulfate-Loving Microbes?
- 03/03/2004 — Part 1 - Mars: Meridiani Planum Was Once "Drenched With Water and Habitable"
- 03/03/2004 — Part 2 - Mars: Scientific Challenge of Identifying Substances
- 03/01/2004 — Opportunity Grinds Bedrock; Spirit Ready to Grind "Humphrey"
- 02/23/2004 — Is There Liquid Water on Martian Surface?
- 02/21/2004 — Update On Mars with Cornell Astronomer Steve Squyers,Principal Investigator on the Mars Rover Missions

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• 01/31/2004 — Opportunity Rolls Onto Martian Soil and Confirms Hematite
• 01/28/2004 — Mars - First Bedrock Seen Beyond Earth
• 01/25/2004 — Opportunity Lands on Mars - in "Muddy" Hematite?
• 01/24/2004 — Updated - Spirit Alive, But in "Critical" Condition. Mars Express Sees Water Ice and Ancient River Channel
• 01/21/2004 — Spirit Rover's First Martian Soil Analysis Has Surprises
• 01/19/2004 — Martian Soil "Clumpy" - Electrostatic Binding of Dust?
• 01/15/2004 — Spirit Is Moving in the Martian Crater
• 01/14/2004 — President Bush's Sets "New Course for America's Space Program"
• 01/09/2004 — Robotic "Geologists" on Mars
• 12/18/2003 — Beagle 2 Spacecraft Will Land on Mars Christmas Day.
• 12/07/2003 — "Smoking Gun" Evidence That Liquid Water Has Flowed on Mars?
• 08/27/2003 — No Ancient Oceans On Mars? Only Glaciers?
• 08/26/2003 — Mars At Its Closest August 27, 2003, At 2:51 a.m. PDT / 5:51 a.m. EDT.
• 06/02/2003 — Mars Express Radar Will "See" 3 Miles Into Red Planet's Crust
• 01/05/2003 — What Are the Grooves in the Martian South Pole?
• 06/01/2002 — Scientists Surprised by Abundance of Water On Mars
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• 06/26/2000 — 250 Photographs of Mars Show Signs of Water
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• 08/28/1999 — Oddball Quasar and Salt Water Inside Meteorite
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Websites:

Mars Science Laboratory: **http://mpfwww.jpl.nasa.gov/msl/**

Athabasca Valles HiRISE: **http://hirise.lpl.arizona.edu/PSP_008779_1905**

Athabasca Valles THEMIS: **http://en.wikipedia.org/wiki/File:Athabasca_Valles.JPG**

Science Journal, Athabasca Valles, Mars Volcano: **http://www.sciencemag.org /cgi/content/full/320/5883/1588c**

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