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Five Remaining Martian Mysteries

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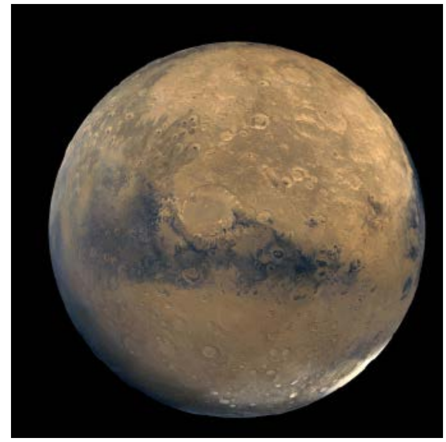
# Five Head-Scratching Martian Mysteries



*Mars holds secrets. Credit: NASA/JPL-Caltech/USGS*

Mars looms large in the scientific imagination, as well as in fiction. Of all the worlds of the solar system, it's the only one Earth-like enough for exploration with Earth-like tools: Its atmosphere is thin and transparent, its surface is dry and cold, and it's close enough for regular study.

We've probed the Red Planet by telescope for centuries. And over the past 50 years, we've even sent instruments for a closer look. However, in geological terms, that's just a sliver of time. Mars's deep history remains a mystery.

"A major issue that we have pretty much in all of Mars studies is that we just don't know what was going on in the distant past," said planetary scientist Eryn Cangi of the University of Colorado Boulder.

Scientists have found volcanoes, dried lake beds, and other signs that the planet once looked very different, but many mysteries about why and how it changed remain. Here are five linked tangles scientists have yet to unravel.

### 1. Why Is the Southern Hemisphere So Bulgy?

Maps made by the Viking orbiters from the 1970s—the companions to the Viking 1 and 2 landers—showed that the Martian hemispheres are strikingly different.

"On average, the southern highlands are 5 kilometers higher in elevation than the lowland, and the crust is tens of kilometers thicker," said planetary geophysicist James Roberts of the Johns Hopkins University Applied Physics Laboratory. The pockmarked southern hemisphere also stands out against the relatively flat north.

"As for why, we don't really know," Roberts said.

Plate tectonics could explain such a sharp boundary. But data strongly suggest that the Martian crust is one plate, with no faults or strong enough tectonic activity to create what we observe.

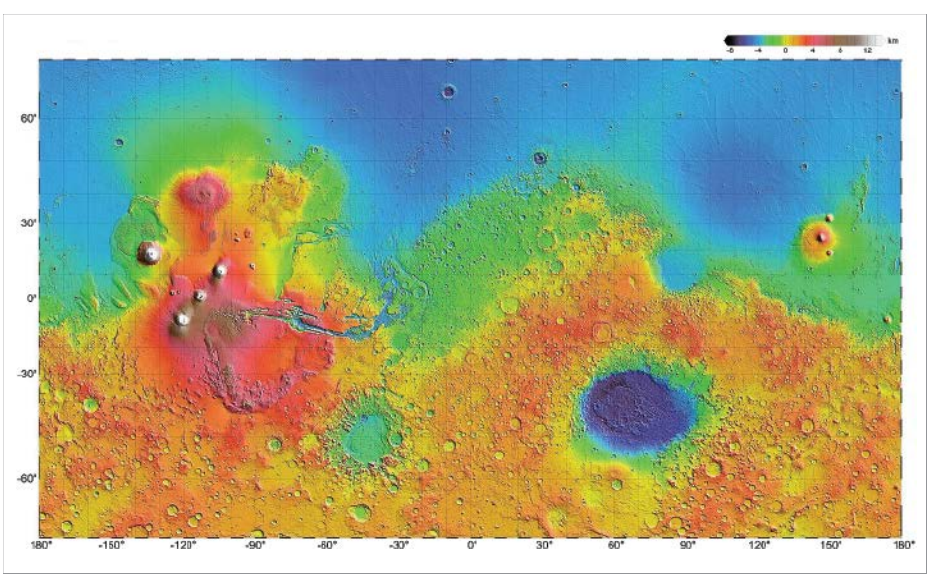
Researchers have proposed other explanations, including a large impact early in the solar system's history, similar to the one that formed our Moon. However, such a huge impactor would leave a type of basin scientists have yet to identify, Roberts explained.

Alternately, heating within the planet could have been lopsided. A mantle plume under the southern hemisphere—possibly itself spurred by an impact—could both push up and thicken that half of the planet, explaining the higher elevation and crustal thickness.

The details, however, are difficult to confirm experimentally.

"The way to do that is to get a huge hot buttery network of seismometers on the ground," Roberts said. Such a global spread of observations could help determine whether the hemispheres experience different seismic activity and measure how geologically turbulent the planet is everywhere rather than in just one spot.

"[The InSight lander] was great, but there's only so much you can do with one station," he explained.




*This map from the Mars Orbiter Laser Altimeter shows the topographic dichotomy of the hemispheres. Nearly the entire northern hemisphere (blue shades) lies below the average planetary radius, whereas the southern hemisphere (red shades) is higher by several kilometers. Credit: NASA/JPL/USGS*

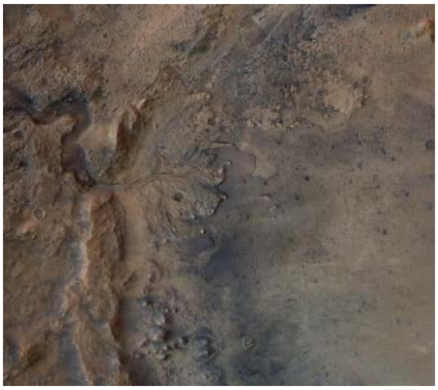
### 2. Where Has All the Water Gone?

Since the late 1990s, NASA's Mars Global Surveyor and Mars Reconnaissance Orbiter, as well as other orbiters have mapped dried river channels and what look like ancient shorelines. Rovers have found other signs that Mars was wetter in the past than it is today.

"We don't know exactly when the water was particularly stable on the surface," Cangi said. "We think it was very early in Mars's history, but we don't have enough data points to understand how [conditions] changed over time."

It's also unclear what happened to all that water. Cangi and other researchers study how gases escape the Martian atmosphere using hydrogen and its isotope deuterium. These processes could explain how water first evaporated and then disappeared into space, but that still reveals little about conditions millions or billions of years ago.

Some scientists have proposed that an ocean once existed on low-lying areas of the planet's northern hemisphere. Others are more skeptical, pointing out that if we don't know how relatively small lakes and rivers vanished from Mars, it's that much harder to



*The Mars Express Orbiter captured signs of an ancient river delta in Jezero crater. Credit: ESA/DLR/FU-Berlin*

explain how an ocean dried up. Data supporting a huge body of water are also scant.

"We should see evidence of shorelines, [and] it's just not there!" said planetary scientist Tanya Harrison of the Earth and Planetary Institute of Canada, who has worked extensively with remote sensing data from Mars. "There's also not really any evidence across the northern plains of what you would expect to see [from] marine floor deposits."

**"We should see evidence of shorelines, [and] it's just not there!"**

### 3. Why Is Mars an Ice Ball?

One known major reservoir of water is frozen: the Martian cryosphere.

"Mars has ice buried in its near surface and on the surface at the poles," said planetary scientist Margaret Landis of the University of Colorado Boulder. "The problem is, we don't know how it got there [or] if the polar deposits are gaining or losing mass."

The polar caps were first observed in the 17th century, though they were only later confirmed to be ice, when scientists watched them grow and shrink with the seasons. NASA's Mars Odyssey spacecraft and Phoenix lander, which touched down at roughly 68° north latitude, confirmed the presence of subsurface ice when the lander's excavation tool dug up white material that melted.

Getting a handle on the cryosphere's history, Landis said, requires global studies like those that geologists and climatologists carry out on Earth. That means collecting ice cores, rock cores, and other samples that are difficult to obtain on Mars, whether by robot or eventually humans.

### 4. Is There Methane?

Few things in science are as frustrating as inconsistent data. The European Space Agency's (ESA) Mars Express orbiter first measured methane in the planet's atmosphere in the early 2000s. NASA's Curiosity rover later detected the gas at the surface.

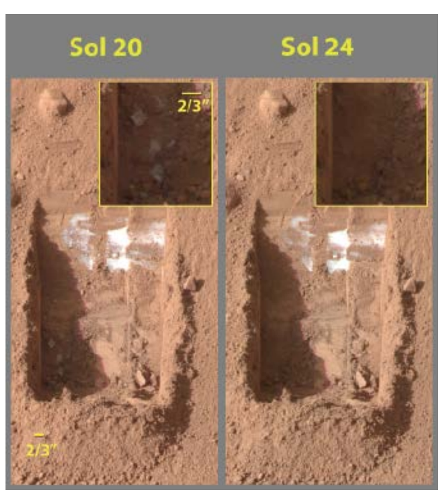
On Earth, methane is commonly produced by life, so finding it on Mars was very exciting.

"Later efforts to detect methane and understand how it changes over a longer timescale have not been very successful," Cangi said, pointing out that the sensitive ESA and Roscosmos ExoMars Trace Gas Orbiter spacecraft has failed to find significant amounts of methane since it reached the planet in 2016. "From below, we think we are seeing methane on the surface, but from above, we're not seeing anything," Cangi puzzled.

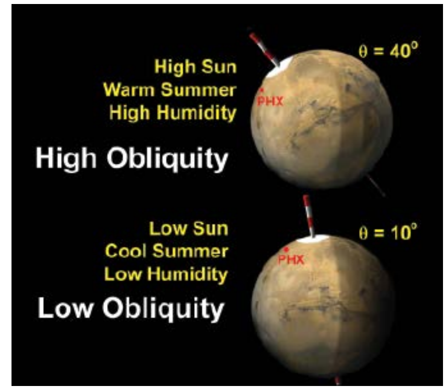
Nonbiological processes can make methane as well (serpentinization is one example), so solving the inconsistencies in data wouldn't help in the search for evidence of life. However, understanding why the measurements don't match is an ongoing priority for Martian research.

### 5. How Much Does the Planet Wobble?

One link between these mysteries is the lack of data about the Red Planet's obliquity—how




*The Phoenix lander dug up evidence of melting ice. Credit: NASA/JPL-Caltech/University of Arizona/Texas A&M University*




*Scientists think Mars's spin axis wobbles over time. Credit: NASA/JPL/University of Arizona*

tilted its spin axis is—which determines how pronounced its seasons are.

Currently, Mars is tilted at almost the same angle as Earth, but both planets wobble over billions of years. We can trace Earth's changes, but we don't have that information for Mars yet.

"We think the obliquity changes chaotically over really long time frames, [so] you can't predict it," Cangi said. "Maybe Mars rotated straight up; maybe it was on its side, like Uranus. That has big implications for the climate: If you have a planet spinning on its side, then there's a whole side where there's no day [for half the year]."

On the other side, long periods of daylight might explain how Mars was once warm enough to hold liquid water. However, hypothesizing that this occurred too far in the past leads to its own problems because the young Sun was fainter and cooler than it is today.

Learning when and how Mars was warm requires a lot more detailed knowledge than researchers can obtain with present and future targeted surface missions, including those by human crews. And there's more at stake than curiosity.

"This is the climate history of another terrestrial planet," Landis said. It could double what we know about how a potentially Earth-like climate evolved. "In a more dire way, how terrestrial planets' climates change is a question we're going to really need a very solid answer to for policymaking decisions here on Earth. It has a lot of far-ranging consequences outside of understanding Mars."

By **Matthew R. Francis** (@DrMRFrancis), Science Writer