Were Phobos and Deimos once a single Martian moon that split up? Not likely, says new study

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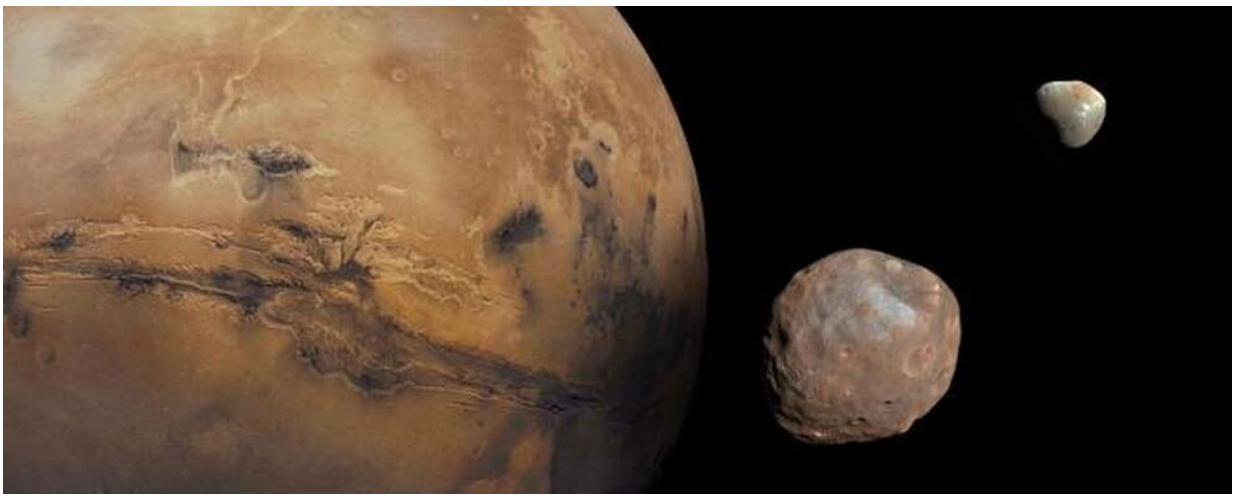

A composite image of Mars and its two moons, Phobos (foreground) and Deimos (background). Credit: NASA/JPL/University of Arizona

The origin of Phobos and Deimos, the two Martian moons, has been a mystery to astronomers. These two bodies are a fraction of the size and mass of the Moon, measuring just 22.7 km (14 mi) and 12.6 km (7.83 mi) in diameter. Both have a rapid orbital period, taking just 7 hours, 39 minutes, and 12 seconds (Phobos) and 30 hours, 18 minutes, and 43 seconds (Deimos) to complete an orbit around Mars. Both are also irregular in shape, leading many to speculate that they were once

asteroids that got kicked out of the Main Belt and were captured by Mars' gravity.

There's also the theory that Phobos and Deimos were once a single moon hit by a massive object, causing it to split up (aka the "splitting hypothesis"). In a recent paper, an international team of scientists led by the Institute of Space and Astronautical Science (ISAS) revisited this hypothesis. They determined that a single moon in a synchronous orbit would not have produced two satellites as we see there today. Instead, they argue, the two moons would have collided before long, producing a debris ring that would have created an entirely new moon system.

The paper that describes their findings recently appeared online and will be published in *The Planetary Science Journal*. The research was led by Dr. Ryuki Hyodo, a researcher with the Department of Solar System Sciences at ISAS, a part of the Japan Aerospace Exploration Agency (JAXA). He was joined by researchers from the Earth-Life Science Institute at the Tokyo Institute of Technology, the Paris Globe Institute of Physics at the Universite de Paris, and the Orbital Dynamics and Planetary Group at Sao Paulo State University.

As noted, the subject of where Mars' moons came from has become a hot topic of date for astronomers in recent years. Historically, astronomers have leaned toward the Capture Hypothesis, which states that Phobos and Deimos were once D-type asteroids. These are asteroids composed of organic-rich silicates, carbon, and silicates that contain no water (anhydrous) that may have water ice in their interiors. This hypothesis is largely motivated by observations that revealed similarities in spectra between D-type asteroids and these moons.

Alternately, the Giant Impact Hypothesis states that an impactor struck Mars, creating a debris ring around the planet that accreted to form two rubble-pile objects. This is similar to the most widely-accepted theory of

how the Earth-moon system formed billions of years ago due to an impact with a Mars-sized object named Theia (also called the giant impact hypothesis). More recently, it has been proposed that Phobos and Deimos may not be primordial objects that resulted from capture or an impact but are the remains of a primordial moon that broke apart.

This theory has been dubbed the "ring-moon recycling hypothesis," which was put forth in a 2021 paper by Amirhossein Bagheri et al. According to this hypothesis, this progenitor moon was ripped apart 1 to 2.8 billion years ago, either by tidal forces or an impact. The resulting debris would have formed a ring around Mars that was eventually recycled to form Phobos and Deimos. As astronomers have noted, this model presents some issues, which include the fact that Mars would still have a ring system. As Dr. Hyodo explained to Universe Today via email, he and his team noted that there are other issues:

"Studying the tidal evolution of the moons back in time, Bagheri et al. (2021) found a solution that Phobos and Deimos could once have orbits that would cross each other. This is their evidence: saying that Phobos and Deimos were once a single moon that was split to form Phobos and Deimos. Note that if you change parameters that control the tidal evolution, the orbits of Phobos and Deimos in the past do not cross each other. The idea of Bagheri et al. is based on their parameters that have resulted in orbital crossing in the past."

To test this hypothesis, Dr. Hyodo and his colleagues began with the assumption that Phobos and Deimos were once a single body. They then conducted numerical simulations that combined geophysical and tidal-evolution models of a Mars–satellite system. From this, said Dr. Hyodo, they determined that it was highly unlikely that Phobos and Deimos originated from a single object:

"We then calculated successive orbital evolutions of the moons in the

direct 3-body approach (Mars-Phobos-Deimos), which can precisely calculate close encounters, gravitational interactions, and collisions between moons. We found that the two moons would most likely (more than >90% by chance) collide with each other within a very short timescale after the splitting (