Moon water discovered: Dampens Moon-formation theory

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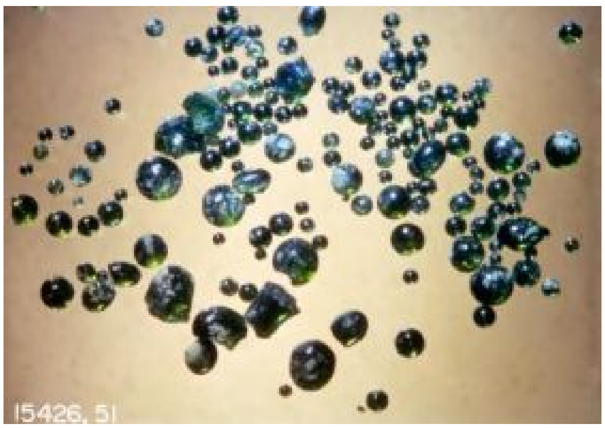

Researchers analyzed lunar volcanic glasses, such these gathered by the Apollo 15 mission, and used a new analytic technique to detect water. The discovery strongly suggests that water has been a part of the moon since its early existence -- and perhaps since it was first created. Credit: NASA

Using new techniques, scientists have discovered for the first time that tiny beads of volcanic glasses collected from two Apollo missions to the Moon contain water. The researchers found that, contrary to previous thought, water was not entirely vaporized in the violent events that formed the Moon. The new study suggests that the water came from the Moon's interior and was delivered to the surface via volcanic eruptions over 3 billion years ago. The finding calls into question some critical aspects of the "giant impact" theory of the Moon's formation and may have implications for the origin of possible water reservoirs at the

Moon's poles. The research is published in the July 10, 2008, issue of *Nature*.

It is believed that the Moon was formed when a Mars-size body collided with Earth some 4.5 billion years ago. This "giant impact" melted both objects and sent molten debris into orbit around the Earth, some of which coalesced to form the Moon. Under this scenario, the heat from the giant impact would have vaporized the light elements.

Over the past forty years there have been significant efforts to determine the content and origin of the volatile contents in the lunar samples. There is reliable evidence that the Moon's interior contains sulfur, some chlorine, fluorine, and carbon. Yet the evidence for indigenous H_2O has remained elusive, consistent with the general consensus that the Moon is dry.

The research team, with scientists from Brown University, Carnegie Institution for Science, and Case Western Reserve University, took advantage of new methods for analyzing lunar samples to detect tiny amounts of water. Co-author of the paper, Erik Hauri of the Carnegie's Department of Terrestrial Magnetism, developed new techniques that can detect extremely minute quantities of water in glasses and minerals by the technology called secondary ion mass spectrometry (SIMS). These technical advances were made in collaboration with engineers from Cameca Instruments (France), who manufactured the NanoSIMS instrument used to make these challenging measurements.

"For the past four decades, the limit for detecting water in lunar samples was about 50 parts per million (ppm) at best," explained Hauri. "We developed a way to detect as little as 5 ppm of water. We were really surprised to find a great deal more in these tiny glass beads, up to 46 ppm."

One glass bead told the tale of what happened. The researchers found that the volatiles decreased from the tiny sphere's core to its rim—a difference that indicates that some 95% of the water was lost during the volcanic activity. James Van Orman, a former Carnegie postdoc now at Case Western Reserve University, was one of the team members who wrote the numerical model. "We looked at many factors over a wide range of cooling rates that would affect all the volatiles simultaneously and came up with the right mix. A droplet cooling at a rate of about 3° F to 6° F per second over 2 to 5 minutes between the time of eruption and when the material was quenched or rapidly cooled matched the profiles for all the volatiles, including the loss of about 95% of the water," he said.

The researchers estimated that there was originally about 750 ppm of water in the magma at the time of eruption. "Since the Moon was thought to be perfectly dehydrated, this is a giant leap from previous estimates," continued Hauri. "It suggests the intriguing possibility that the Moon's interior might have had as much water as the Earth's upper mantle. But even more intriguing: If the Moon's volcanoes released 95% of their water, where did all that water go?"

Since the Moon's gravity is too feeble to retain an atmosphere, the researchers speculate that some of the water vapor from the eruptions was probably forced into space, but some may also have drifted toward the cold poles of the Moon where ice may be present in permanently shadowed craters. Several previous lunar missions have suggested the presence of ice at both poles. Unless it is very deep, lunar groundwater is unlikely to exist since the Sun heats most of the Moon's surface to over 200°F (100°C).

Lead author of the study, Alberto Saal of Brown University remarked: "Beyond the evidence for the presence of water in the interior of the Moon, which I found extremely exciting, I learned that the contributions from scientists from other disciplines has the potential to produce unexpected results. Such a scientist is able not only to ask questions that no one has asked before, but also can challenge hypotheses that are embedded in the thinking of the scientists working in the field for many years. Our case is a typical example. When I suggested we measure volatiles in lunar material, everyone I talked to thought that such proposal was a futile endeavor. We 'knew' the Moon was dry."

Many scientists have believed the Moon's polar ice, if there, originated from impacts of water-rich meteoroids and comets that struck the Moon's surface over its history. The new study suggests that some of this water could have come from lunar volcanic eruptions. Verifying that water is at the Moon's poles is one goal of the NASA Lunar Reconnaissance Orbiter mission, due to launch later this year. And it is the primary objective of the Lunar Crater Observation and Sensing Satellite with a 2009 launch date. Verification of water on the Moon's surface is an important step in progress toward an eventual manned lunar outpost.

Source: Carnegie Institution