Moon whets appetite for water

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The Moon. Credit: NASA

Scientists at the Carnegie Institution's Geophysical Laboratory, with colleagues, have discovered a much higher water content in the Moon's interior than previous studies. Their research suggests that the water was preserved from the hot magma that was present when the Moon began to form some 4.5 billion years ago, and that it is likely widespread in the Moon's interior. The research is published in the on-line early edition of the *Proceedings of the National Academy of Sciences* the week of June 14.

"For over 40 years we thought the Moon was dry," remarked lead author Francis McCubbin. "Recently, scientists detected water from Apollo samples on the order of 46 parts per million. We studied two other

Apollo samples and a lunar meteorite using secondary ion mass spectrometry (SIMS), which can detect elements in the parts per million range. We combined the measurements with models that characterize how the material crystallized as the Moon cooled. We found that the minimum water content ranged from 64 parts per billion to 5 parts per million—at least two orders of magnitude greater than previous results."

The prevailing belief is that the Moon came from a giant-impact event, when a Mars-sized object hit the Earth and the ejected material coalesced into the Moon. From two of the samples, the Carnegie scientists determined that water was likely present very early in the formation history as the hot magma started to cool and crystallize. This result means that water is native to the Moon.

The previous studies showing water on the Moon analyzed volcanic glasses. These researchers looked within KREEP-rich rocks. KREEP comes from the last stages of crystallization. KREEP, rocks contain more potassium (K), rare Earth elements (REE), phosphorus (P), and other heat-producing elements such as uranium and thorium. "Since water is insoluble in the main silicates that crystallized, we believed that it should have concentrated in the KREEP," explained coauthor Andrew Steele. "That's why we selected it to analyze."

The researchers specifically studied hydroxyl, a compound with an oxygen atom bound with hydrogen, in the mineral apatite—the only water-bearing mineral in the assemblage. After initial analyses, the scientists excluded one of the Apollo samples from further study because it was unlikely to yield good information about magmatic water content. They concentrated on the other Apollo sample and the lunar meteorite to determine water in the lunar interior.

"It is gratifying to see this proof of the OH contents in lunar apatite," remarked lunar scientist Bradley Jolliff of Washington University in St.

Louis. "The concentrations are very low and, accordingly, they have been until recently nearly impossible to detect. We can now finally begin to consider the implications—and the origin—of water in the interior of the Moon."

Provided by Carnegie Institution