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News

# Rocky hint of a waterless Moon

**Isotope analysis of lunar samples contradicts recent research.**

Lucas Laursen

Chlorine isotope ratios discovered in a range of lunar samples could suggest the Moon is nearly hydrogen-free.

*Galileo Project/JPL/NASA*

Another twist has emerged in the debate over whether there is water inside the Moon. Researchers studying lunar samples from the Apollo missions have used chlorine isotope measurements to conclude that the Moon is bone dry after all — corroborating scientists' original assumptions from the 1970s, but contradicting more recent studies of the Moon's water content.

The original analysis of Apollo's samples showed that the rocks contained virtually no hydrogen — and thus no water. But in recent years, scientists have found hydrogen atoms in samples of lunar volcanic glass — an indication that the Moon once harboured deeply buried traces of water[1,2]. That discovery was celebrated this spring by researchers at the Lunar and Planetary Science Conference near Houston, Texas (see **'Old rocks drown dry Moon theory'**), where they began discussing the implications of the find. How did the element make it to the depths of the newly formed Moon, and what did this tell us about its origin?

According to the leading theory, the Moon was born from molten debris after a Mars-sized object struck Earth. Understanding the chemistry of the Moon's rocks could, for example, help to work out whether the Moon is mostly made of material from Earth, or from the impactor that hit it.

Zachary Sharp of the University of New Mexico, Albuquerque, and his colleagues have now tried to clear up the questions over lunar hydrogen by looking at a different element — chlorine — which can reveal how much hydrogen existed on the Moon when it was still molten.

## Isotopic signatures

Chlorine has two main isotopes: chlorine-35, and its heavier cousin chlorine-37, which contains two extra neutrons. In rocks all over Earth, the lighter isotope is roughly three times as abundant as the heavier one.

But this reliable 3:1 ratio was not found in the Moon rocks studied by Sharp and his team. Instead, they found a huge variation in the ratio of chlorine isotopes from one sample to the next. Sharp says that this proves there was virtually no hydrogen around when the molten Moon was cooling and solidifying.

He argues that on the young molten Earth, chlorine atoms in the molten rocks would grab hydrogen atoms from water to make hydrogen chloride (HCl) gas. If the gas contained chlorine-35, it would drift away from Earth and escape into space more easily than if it was weighed down by chlorine-37. This process would have left a higher proportion of chlorine-37 in the rock — except for the fact that chlorine-37 forms HCl gas much more readily than its lighter cousin, allowing more of it to escape from the planet.

Overall, these two effects cancel each other out. Both isotopes are lost at about the same rate, which keeps the 3:1 chlorine isotope ratios pretty constant in the rocks left behind on Earth.

When there is no water available, chlorine atoms bond instead to metal atoms to make metal chlorides. Both light and heavy isotopes of chlorine form these bonds equally well — but metal chlorides containing chlorine-35 escape into space more easily, because they are lighter. Losing more of the lighter isotope tends to increase the proportion of chlorine-37 left behind, with the precise amount depending on which metal the chlorine atoms bond with. This creates a wide variation in the ratio of chlorine-35 to chlorine-37 left behind in rocks at different sites — exactly what Sharp and his colleagues found in their analysis of samples from the Moon.

Working from the amount of chlorine they detected, Sharp's team estimates an upper limit of no more than 10 parts per billion of hydrogen in their lunar samples — between 10,000 and 100,000 times less than others have estimated from their lunar glass studies. Sharp and his co-workers report their findings online in *Science*[3].

However, Erik Hauri of the Carnegie Institution of Washington DC, who was part of a team that found hydrogen in lunar glass samples[1], is not yet convinced. He notes that in a vacuum, hydrogen would escape magmatic gases faster than chlorine does on Earth. "In that sense, the behaviour of water and chlorine are decoupled from each other," he says. Geochemist James Webster, of the American Museum of Natural History in New York, adds that the team's assumptions about chlorine and hydrogen interaction in vapour and magma probably only apply at very shallow depths below the Moon's surface.

Geophysicist Francis McCubbin of the Carnegie Institution points out that resolving these debates will require broader studies: "The number of samples we've looked at in total has been fairly limited. The next step is applying these methods ... to a wider range of the lunar samples."

Sharp aims to conduct laboratory experiments mimicking the lunar degassing process to test his interpretation of the chlorine signature. "Looking at the Moon gives us a picture of early Solar System history," he explains, adding that, ultimately, knowing how small planetary bodies interact with volatile elements such as hydrogen could help to guide astronomers' surveys of other planetary systems.

### References


1. Saal, A. E. *et al. Nature* **454,** 192-195 (2008). | Article | ChemPort |
2. Boyce, J. W. *et al. Nature* **466,** 466-469 (2010). | Article | ChemPort |
3. Sharp, Z. D., Shearer, C. K., McKeegan, K. D., Barnes, J. D. & Wang, Y. Q. *Science* advance online publication doi:10.1126/science.1192606 (2010).


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