# *Water in the Oldest Lunar Rocks: Moon is "Wetter" Than Previously Thought*

*Hejiu Hui (University of Notre Dame), Anne Peslier*
*Youxue Zhang (University of Michigan), Clive Neal (University of Notre Dame)*

The recent detection of water in Mare basaltic glass beads and on the lunar surface has revolutionized our knowledge and understanding of the Moon. Until now, the Moon was thought to have lost its volatiles during the cataclysmic collision of two proto-planets that is believed to have led to its creation and during the evolution of a lunar magma ocean. In 2012, scientists in the ARES Directorate at JSC completed an analysis of the water in the oldest of the Moon rock samples collected during the Apollo Program. The rocks, which were brought back by astronauts during the Apollo 15 and 16 missions (figure 1), are pieces of the Moon's oldest crust (>4.4 x $10^9$ years old) and are called ferroan anorthosites. These are thought to have crystallized from a Moon-wide magma ocean at the beginning of the Moon's history. The rocks are composed mainly of the mineral plagioclase and were analyzed for water using Fourier transform infrared (FTIR) spectrometry. These measurements were challenging because of the fragility of the samples (figure 2) and the fact that they are very precious and the water contents measured were low.

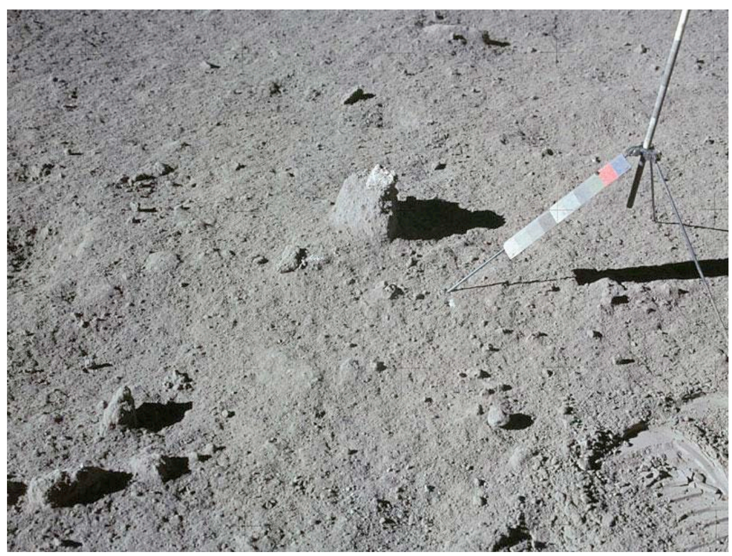
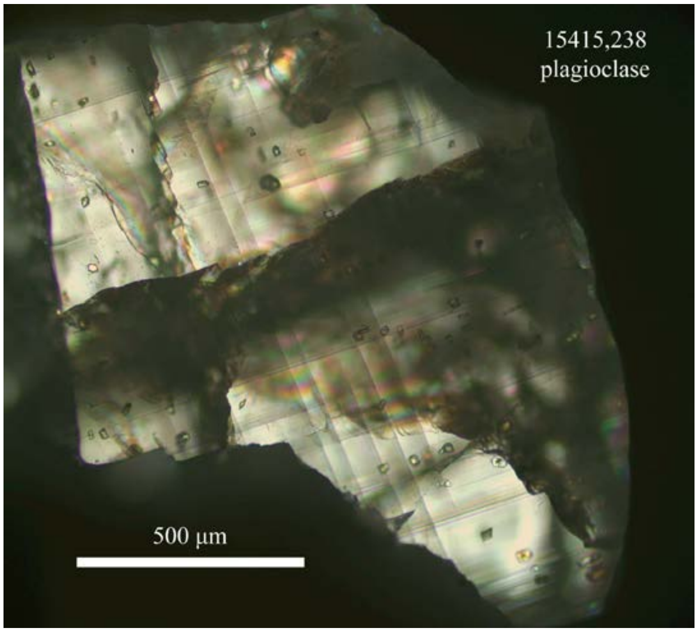


*Figure 1.– Sample 15415 before it was sampled by the Apollo 15 astronauts on the lunar surface. This ferroan anorthosite is one of the best known rocks of the Apollo collection, and is popularly called the "Genesis Rock" because the astronauts thought they had a piece of the Moon's primordial crust.*

Analysis of the ferroan anorthosites found about 6 ppm $H_2O$ in the plagioclases (figure 3). Analysis also found up to 2 ppm $H_2O$ in the plagioclases of another type of Moon rock, troctolite, that is thought to be part of the old lunar crust. Although these may seem like trivial amounts, finding water in rocks from the oldest lunar crust has profound implications. For example, there is a debate about whether the origin of the water measured in Moon rocks was brought later by impacts (of comets, for example) or was present all along from the beginning of the Moon's history. Results from the ARES analysis support the latter hypothesis.




Moreover, knowing the amount of water in the earliest Moon rocks has implications for the modeling of the Moon's formation event. Finally, part of the water measured by spacecraft orbiting the Moon may be from indigenous water in crustal rocks, such as those analyzed in this study.

*Figure 2.– A plagioclase grain analyzed for water in this study.*

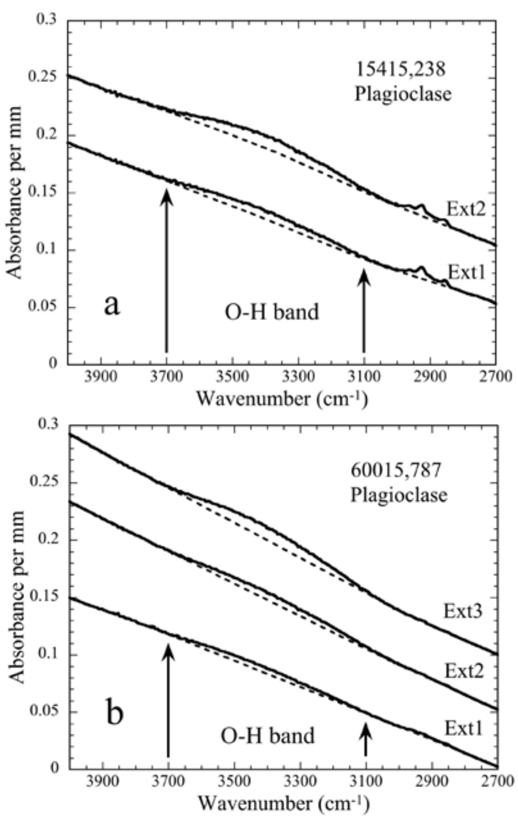



*Figure 3.– An example of FTIR spectra of lunar plagioclases in the water band region. The "bump" in the spectrum above the dotted line (the baseline) is caused by absorption of the infrared light by O-H bonds in the plagioclase.*

Analysis results and findings were published in the journal *Nature Geoscience* and were presented at the Lunar and Planetary Science Conference in March 2013.

Hui, H., Peslier, A. H., Zhang, Y., and Neal, C. R. (2013). Water in Lunar Anorthosites and Evidence for a Wet Early Moon. *Nature Geosci.* 6 (3), pp. 177-180, DOI: 10.1038/ngeo1735