OXYGEN ISOTOPIC COMPOSITION OF WATER IN SELECTED LUNAR SAMPLES.

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Introduction: Characterization of the oxygen isotopic composition of water bound in lunar rocks could shed light on the major source(s) of water to the Earth-Moon system. To that end, we extracted water from eight lunar samples (10049, 10057, 10060, 12021, 12039, 14163, 14305, 79035) and measured the oxygen isotopic composition of that water using a high precision technique developed specifically for the analysis of small (sub-micromolar) quantities of extraterrestrial water. We present here results of these analyses and a discussion of the implications of these results on potential source(s) of lunar water.

Methods: Samples analyzed represent the range of geographic locations on the lunar surface sampled by the Apollo program (as they were collected on the Apollo 11, 12, 14, and 17 missions) and the range of surface exposure ages seen in Apollo samples (21m.y. to 2.75b.y.) [1, 2]. Each lunar sample is heated stepwise to 50, 150, and 1000°C while collecting all evolved species in a liquid nitrogen cold trap. Stepwise heating enables water in different forms (physisorbed water, structural water, water in hydrous glasses, etc.) to be liberated, collected, and analyzed separately. The temperature at which water in a particular phase is liberated is directly proportional to the strength with which it is bound and, hence, the requisite energy to exchange oxygen with surrounding reservoirs. The oxidizer bromine pentafluoride (BrF_5) is used to selectively convert evolved water to molecular oxygen, the oxygen isotopic composition ($^{18}O/^{16}O$ and $^{17}O/^{16}O$) of which is then measured on a dual inlet isotope ratio mass spectrometer (IRMS) (detailed methods can be found in [3]).

Results: Water bound in different phases of lunar samples is isotopically distinct and reflects contributions from at least three isotopically distinct oxygen bearing reservoirs. Deviation from perfectly mass-dependent fractionation, as measured by the $\Delta^{17}O$ value, confirms water extracted is extraterrestrial in origin. Heating some of the samples with the longest surface exposure ages at the highest temperature step (1000°C) released nitrogen. The amount and isotopic composition of some of these fractions of nitrogen suggest its origin is in the solar wind, and our results are consistent with previous findings of solar wind nitrogen implantation on the lunar surface [4, 5]. The amount of water liberated in each stepped heating experiment on each lunar sample and the oxygen isotopic composition of each of these fractions of water will be discussed in the context of differential surface exposure ages, petrology, mineralogy, and potential contributions from solar wind implanted species and comet/meteorite impacts.

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