WATER IN THE MOON: SAMPLING THE PYROCLASTIC DEPOSITS. H. Hui and C. R. Neal, Department of Civil Engineering and Geological Sciences, University of Notre Dame, Notre Dame, IN 46556 (hhui@nd.edu, neal.1@nd.edu).

Introduction: The Moon has been thought to have lost its water during the catastrophic proto-planet collision (believed to have created the Moon) and during the production and crystallization of the lunar magma ocean. However, recent studies have challenged this view of a "dry" lunar interior with the detection of hydroxyl ions in lunar volcanic glass beads [1] and lunar apatites [2,3]. These studies indicate that parental magmatic water contents in these lunar basalts can be as high as 850 ppm (Table 1), which is similar to water contents (700-4800 ppm) measured in undegassed mid-ocean ridge basalts [4], though another study shows that lunar mantle is essentially anhydrous with as little as ~10 ppb water inferred from Cl isotopic ratios in various lunar samples [5]. Dissolved water can alter the structures of silicates, and hence influence mantle melting temperature, magma crystallization temperature and the style of volcanic eruption. Hence, the discoveries of indigenous water in different pyroclastic and mare deposits by several independent groups not only raise the possibility that the Moon were never fully outgassed, but may also revolutionize our understanding of lunar formation and evolution. Due to these reasons, additional samples from other areas of the Moon are needed to further evaluate indigenous water contents within the Moon.

Table 1: Water contents in parental melts inferred from those in apatites (95% crystallization) and glass beads.

Sample	Water (ppm)	Method	Age (Ga)	Ref.
14053,241 High-Al basalt	100~200	SIMS, Apatite	3.92	1,6
15404,51 Soil	10~140	SIMS, Apatite	-	2
NWA 2977 Meteorite	360~850	SIMS, Apatite	2.86	2,7
15427,41 Volcanic glass	~745	SIMS, Glass beads	3.41	3,8

Sample Requirements: To determine indigenous water content in the Moon, we need

- Volcanic rocks not disturbed by the impacts.
- Volcanic rocks that do not contain hydrogen implanted by solar wind.
- Volcanic rocks that contain grains (e.g., glass, apatite), which can be prepared for water measurements using current technology (e.g., SIMS, FTIR).

To evaluate water distribution in the lunar interior and evolution in the lunar history, we need

- Volcanic rocks that crystallized at different ages, especially pre-Nectarian basalt [9].
- Volcanic rocks that are from different locations.

Potential sample sites: Pyroclastic flows exist all over the Moon. This gives us potential to sample the Moon at different ages and different locations. Cryptomare deposits are mare basalts that represent the earliest mare volcanism [10]. Candidate targets include the Langemak (3.92-4.1 Ga, [11]), Australe (3.8-4.0 Ga, [11]). Using the temporal and spatial distributions of mare basalts determined by remote sensing data [12,13,14], Oceanus Procellarum (1.2-3.93 Ga, [12]), Mare Imbrium (2.01-3.57 Ga, [13]), Antoniadi crater (2.58 Ga, [14]), and Mare Moscoviense (2.57-3.55 Ga, [14]) are recommended for younger mare basalts.

KREEP basalts are thought to represent the late stage melts of magma ocean crystallization [15] and are enriched in incompatible elements. Water is incompatible during magmatic processes. Hence KREEP can potentially have high water content. However, only limited mass of pristine KREEP basalt is left in Apollo collection. It is critical to have more pristine KREEP basalts for this (and other) study. Candidate targets are Mare Imbrium (2.01-3.57 Ga, [13]), Dewar Crater (3.2-3.85 Ga, [16]) based on Th abundance maps [17].

Scientific Merits: In addition to give more accurate constraints on water contents in parent melt and further in the source region, these new samples can be used to (i) estimate the water budget of the Moon after lunar magma ocean solidification, (ii) constrain magmatic evolution on the Moon, (iii) compare to surface water contents measured by recent spacecraft missions, (iv) evaluate the indigenous water content over an extended period of lunar evolution. Once indigenous lunar water contents are better constrained, they can then be evaluated as a potential resource to support human return to the Moon.

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