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Investigating the water contents and hydrogen isotopic compositions of lunar apatite

J.J. Barnes¹, M. Anand¹,², I.A. Franchi¹, S.S. Russell¹

¹Planetary and Space Sciences, The Open University, Walton Hall, Milton Keynes, MK7 6AA, UK.
²The Natural History Museum, Cromwell Road, London, SW7 5BD, UK.

The initial studies of Apollo rock samples concluded that the Moon was an anhydrous planetary body [1]. Recently there has been a change of opinion with several research groups detecting copious amounts of water, up to 6050 ppm from a range of lunar glasses, melt inclusions and apatite [2-7]. Here we report results from in situ ion microprobe analysis of apatite grains from Apollo mare basalt 12064 and lunar basaltic meteorite Miller Range MIL 05035.

The $\delta D_{SMOW}$ values for 3 apatite grains in 12064 range from +822 to +998 $\%e$, with the hydroxyl content ranging from ~2800 to 4744 ppm. Five apatite grains were analysed in MIL 05035 with $\delta D$ values ranging from -137 to +830 $\%e$. Hydroxyl content ranges from ~470 to 2690 ppm. The analytical setup for MIL 05035 was such that it yielded relatively low count rates for $^2$H (an order of magnitude less than those obtained for 12064), and this in turn introduced large errors into the analysis.

The results for ilmenite basalt 12064 are among the highest $\delta D$ measured so far from lunar apatites [7] being more tightly constrained in both $\delta D$ and water content. The results plot well outside the range for terrestrial water (+100 $\%e$ to -500 $\%e$) [8, 9], suggesting that the hydrogen isotopic composition measured in these apatites has not been compromised by terrestrial contamination. Cometary material has a high $\delta D$ and therefore, it could be interpreted that at least some lunar hydrogen is of cometary origin [7-9]. The roles of other processes which potentially contribute to elevated D/H ratio in lunar apatites need to be further investigated.

We recorded $\delta D$ values overlapping with terrestrial $\delta D$ values for MIL 05035. However, it is unclear if any of the observed isotopic variation relates to the low, and variable hydroxyl content in this rock.