NLSI Workshop Without Walls: Lunar Volatiles (Part 1)- Abstract

Investigating the Distribution and Source(s) of Volatiles on the Lunar Surface

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In recent years, the search for lunar volatiles (including water), has attracted renewed interest; new analyses of lunar glasses and apatite crystals suggest initial magma volatile contents (prior to degassing) many times higher than previously reported [1], with some possibly reaching terrestrial-like volatile abundances [2].

Alongside these discoveries, several spacecraft have carried out remote experiments on the lunar surface, with equally encouraging results. The Moon Mineralogy Mapper (M^3) spectrometer on-board Chandrayaan-1 detected absorptions of wavelengths associated with the presence of either OH or H_2O groups within the upper layers of the lunar regolith [3]. Most recently, the LCROSS mission documented water and other hydrocarbons and volatiles within impact ejecta near the lunar south pole [4].

But in what form do these surficial volatile compounds exist? And where did these volatiles at the lunar surface come from? Are they indigenous (coming from the original regolith-forming bedrock), or are they exotic, introduced to the lunar surface by comet/meteorite impacts, or by the solar wind? And finally, is there any heterogeneity in volatile abundance across the lunar surface, or are they evenly distributed?

This study applies a geochemical perspective to the search for answers to these fundamental questions about the lunar surface and its volatile budget. The Open University's custom-built high-sensitivity mass spectrometer system ('Finesse') is capable of analysing mg-sized samples, and measuring the isotopic composition of ng-amounts of released gases. In this linked series of dedicated mass spectrometers, 5 mg samples of powdered lunar basalts and soils undergo an online stepped combustion, and stable isotope data for carbon, nitrogen, and noble gases are collected for each combustion step, giving a detailed view of any volatiles released. It is then possible to 'fingerprint' the likely sources of any volatiles found, using these isotopic signatures.

Preliminary results from Apollo 11 and 12 basalt powders indicate very heavy C and N isotope compositions being released at high temperatures, suggesting spallation processes are important for volatiles on the lunar surface.

It is hoped that better constraints on the nature of lunar surface volatiles will complement the ongoing research into lunar mantle volatiles also being conducted at the Open University, to build up a coherent, holistic overview of the Moon and its resource potential.

References:

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[2] Boyce, J.W., et al., *Lunar apatite with terrestrial volatile abundances.* Nature, 2010. **466**(7305): p. 466-469.

[3] Pieters, C.M., et al., *Character and Spatial Distribution of OH/H2O on the Surface of the Moon Seen by M3 on Chandrayaan-1.* Science, 2009. **326**(5952): p. 568-572.

[4] Colaprete, A., et al., *Detection of Water in the LCROSS Ejecta Plume.* Science, 2010. **330**: p. 463-468.