Water on the Moon: A geochemical approach

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- **Rare opportunity to work with Apollo lunar samples**
- **Training and application of state-of-the-art analytical instruments and techniques**
- **Constrain the abundance, nature and source of lunar water**

Since the Apollo era, the Moon has been considered to be an anhydrous body, therefore, amongst the most exciting recent advances in planetary science has been the discovery by a number of spacecraft missions (India's Chandrayaan-1 and NASA's LRO) of the presence of significant quantities of water on the lunar surface at lower latitudes [1]. These findings have been corroborated by recent, earth-based, laboratory analysis of lunar samples which suggest significant quantities of indigenous water in lunar magmas [2-4]. These findings are complemented by measurements of the deuterium/hydrogen (D/H) ratio in Apollo samples which yield cometary signatures [5], suggesting that comets may have played a more important part in delivering water to the Moon than researchers had previously thought. However, how and when these cometary signatures were acquired by lunar samples remains poorly understood.

In this novel project the student will perform a systematic mineralogical and geochemical investigation, using state-of-the-art analytical instrumentation such as a NanoSIMS, of the main water-bearing mineral phase, apatite, from a range of lunar samples to constrain the amount, nature and source of lunar water. High-precision oxygen isotope measurements on mineral separates will yield key information about mineral equilibration temperatures, which will aid the interpretation of D/H data in the context of sub-solidus igneous processes.

The aims of the project are:

1) Characterize a range of lunar samples (Apollo as well as lunar meteorites) for their primary mineralogy and identify suitable apatite grains for ion-probe investigation.
2) Prepare a range of apatite standards for measuring water content and D/H ratio of water in lunar apatites using NanoSIMS.
3) Quantify the water content and measure D/H ratio in apatites from selected lunar samples.
4) Conduct high-precision oxygen isotope measurements of mineral separates for geothermometry
5) Model and interpret the geochemical dataset in terms of lunar accretion and differentiation and develop testable hypotheses for the origin and evolution of the Moon.

This project will provide an excellent opportunity for the student to work as a part of a lunar team at the OU. The student will also receive intensive training on the state-of-the-art geochemical laboratories at the Open University and the Natural History Museum. Initial measurements of D/H in lunar apatites have been successfully made at the OU using NanoSIMS.

The proposed research is topical and timely in light of a surge in global efforts in lunar science and exploration. Among other international space agencies the European Space Agency (ESA) is currently planning a mission to the Moon (Lunar Lander) and results from the proposed study may feed into mission development, providing an ideal opportunity for the student to be involved in this mission.

Key References: [1] M. Anand (2011) Earth Moon Planets, DOI 10.1007/s11038-010-9377-9 (2011) [2] A. E. Saal et al. (2008) Nature 454, 192 [3] J. W. Boyce et al. (2010) Nature, doi:10.1038/nature09274 [4] F. M. McCubbin et al. (2010) www.pnas.org/cgi/doi/10.1073/pnas.1006677107 [5] J.P. Greenwood et al. (2011) Nature Geoscience, DOI: 10.1038/NGEO1050.