The University of Oxford Department of Earth Sciences

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Where is the water in the Lunar mantle?

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Key Words	**Planetary science, Moon, petrology, mineralogy,**

Overview

Several recent studies have documented petrological, geochemical, and geophysical evidence for notable H_2O being present within the lunar mantle (Saal et al., 2007; McCubbin et al., 2015), despite it at one time considered 'bone dry'. The hydration state of the bulk-silicate Moon (BSM) controls many of its important petrophysical properties, such as the melting point of the mantle, and the viscosity and ascent dynamics of magma generated from it. However, the mineralogical hosts of this H_2O remain debated (e.g. Liu et al., 2017), as do the absolute concentrations and spatial distribution (Peslier, 2010; Hauri et al., 2015). This research project will focus upon the potential contribution to this BSM water budget made by nominally anhydrous minerals (NAMs) by using a closely integrated analytical, experimental, and thermodynamic modelling approach.

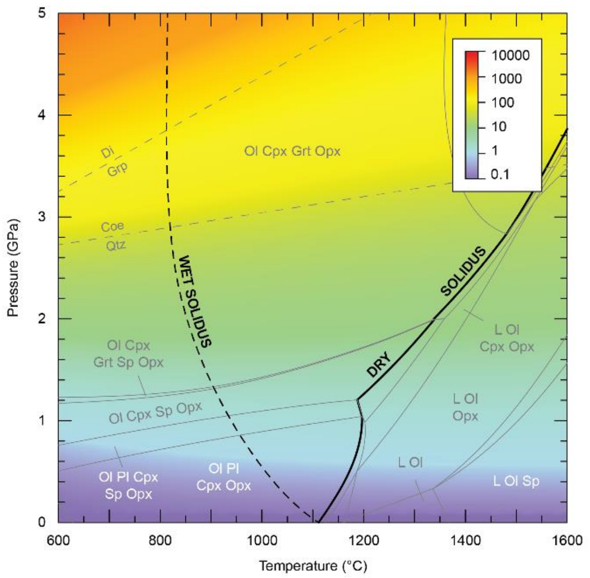

Figure showing modelled variation of H_2O fugacity as a function of pressure and temperature, which is used for model parameterisation.

The outcomes of this research will have far-reaching implications for competing 'hot' and 'cold' models of formation of the Moon and its post-accretion degassing history, alongside the early evolution of other rocky bodies in our solar system.

Methodology

This project will closely combine experimental, analytical, and thermodynamic modelling techniques. Firstly, key NAMs expected to stabilise at various depths within the lunar mantle will be synthesised using a specialised piston cylinder apparatus at relevant pressure, temperature, and oxygen fugacity (fO_2) conditions. Equilibrated run products will then be analysed via in-situ micro-analysis (FTIR/SIMS) to quantify their potential water capacity. Petrological forward modelling of BSM bulk compositions will be used to generate mineralogical profiles through the lunar mantle, and mass balance-based calculations of potential H_2O content with depth will be determined (Perple_X). If progress permits, parameterization of the water solubility in key lunar mantle minerals will be formalised as discrete functions of P, T, $f(H_2O)$, and $f(O_2)$.

Timeline

Year 1: Doctoral training courses, literature review, and laboratory training.

Years 2 and 3: Experimental (piston cylinder) and micro-analytical work (SEM, EPMA), in-situ analysis of H_2O contents of run products (FTIR/SIMS), and petrological modelling (Perple_X). Data compilation and interpretation. Presentation of results at international conferences.

Year 4: Data integration, thesis completion, write papers for international journals, presentation of results at an international conference

Training & Skills

The supervisory team in Oxford and associated collaborators are leaders in petrological modelling and experimental petrology, and applying both techniques to solving geological problems at the micro- to the macro-scale.

An ideal student for this project would have a keen interest in planetary science, petrology, and mineralogy. They will learn how to process and analyse samples in the laboratory and be trained on a range of experimental and micro-analytical equipment. They will be trained in the scientific method, mentored on how to prepare scientific results for presentation at international conferences, and how to write papers for publication in high-profile, international journals.

References & Further Reading

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Further Information

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