WATER IN THE EARLY SOLAR SYSTEM AND MANTLE MELTING IN TERRESTRIAL PLANETS. A. D. Bravenec¹, G. D. Bromiley¹, and S. C. Kohn², School of GeoSciences, University of Edinburgh, Edinburgh, UK (a.d.bravenec@sms.ed.ac.uk), ²School of Earth Sciences, University of Bristol, Bristol, UK.

Introduction: Determining the origin and distribution of water in planetary interiors has important implications for understanding the formation and evolution of terrestrial planets and the emergence of life, both in the solar system and beyond. Despite the shared origin of the Earth and Moon, the Moon has remained comparatively unchanged over the past several billion years, while the Earth has experienced large scale geodynamics, resulting in the loss of evidence of Earth’s original post-accretionary composition. Therefore the Moon offers a unique opportunity to gain insight into the role volatile compounds play in planetary formation and early evolution in the Earth-Moon system. Since the discovery of water in lunar glass beads [1], melt inclusions [2], and minerals [3-4], constraining the exact water content in a range of lunar and Martian materials is an active area of interest [e.g. 5]. Because the Moon lacks plate tectonic processes to flux water into the deep interior, the presence of water in lunar magmas implies a hydrous interior in the Earth-Moon system inherited from initial accretionary processes and not completely lost during magma ocean formation or late accretion events.

However, our understanding of volatile incorporation in planetary interiors is largely based on experiments performed under the relatively oxidizing conditions of the modern terrestrial interior. Current estimates of lunar and Martian mantle water contents are based on partitioning data from experiments performed under terrestrial (more oxidized) conditions, as well as observed water contents of magmas, and models of mantle melting processes. Constraining interior water contents of these bodies from measured volatiles in surface materials is also highly questionable. The Martian mantle, lunar mantle, and early terrestrial magma ocean would have experienced reducing conditions [6-9]. Preliminary research suggests /O₂ has a significant influence on water partitioning and speciation in model lunar systems, implying that our understanding of how water is incorporated in the interiors of primitive terrestrial bodies is far from complete.

Experiments and Future Work: Experiments are being conducted in an end-loaded piston cylinder using a double-capsule technique to vary /O₂ with a simplified starting composition representative of the primitive terrestrial, lunar, and Martian mantle compositions respectively. Experiments with various /O₂ buffers (QIF, IW, FMQ, NNO, MH, graphite) will be conducted at varying P (1-4 GPa) and T (~1000-1700 °C). These experiments will determine 1) how H₂O speciation (OH, H₂O, H₂) varies as a function of oxygen fugacity and 2) the determination and quantitation of the effect of varying /O₂ on hydrogen species partitioning between mantle minerals and silicate melt. SIMS (secondary ion mass spectrometry), FTIR (Fourier transform infrared spectroscopy), and Raman spectroscopy will be used to analyze H₂O/H₂/OH contents of minerals and melts. Data from these varied /O₂ experiments will be used to investigate the incorporation mechanisms of different water species in various mineral phases as a proxy for planetary interiors. Results will inform modelling the water content of lunar and Martian interiors, compare the modelled water content of the Earth, Moon, and Mars, and investigate the timing and sources of water in the early solar system.

Figure 1. Backscattered electron image of experiment E6 (2 GPa, 1000 °C, 5 hours. Scale bar is 1 mm).