Enstatite Chondrites – An Inner Solar System Source of Volatiles for the Terrestrial Planets?

Supervision team:

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Description:

The origin of the Earth's oceans and other volatile elements remains an unresolved problem. It is generally understood that the Earth formed in a region of the protoplanetary disk where temperatures prevented the ready condensation and accretion of volatiles, particularly water ice and other elements primarily present as gases in the inner disk. Previously, late delivery of water-/ice-rich asteroids or comets from the outer regions of the disk beyond the snow line were considered the most likely source. However, isotopic measurements of the Earth-Moon system and comets in recent years are forcing a re-evaluation of the plausibility of these sources, and investigation of alternative mechanisms. There is now growing evidence that the Earth accreted with a significant portion of its volatile inventory [e.g. 1] – but that then leaves the problem of how such volatiles were delivered to the Earth as it was forming.

This project looks to investigate the volatile inventory of enstatite chondrites. These primitive meteorites formed under very reducing conditions, and widely believed to have formed in the inner most regions of the proto planetary disk, and the most representative materials from which the Earth formed. These meteorites are enriched in some volatile species – particularly halogens and nitrogen [e.g. 2], and most recently some new results indicate they may also contain surprising amounts of hydrogen [3].

The successful candidate will use our NanoSIMS 50L to investigate the abundance, distribution and isotopic composition of key elements such as H, Cl and N in these meteorites at the micron scale to understand how these volatiles were incorporated into different phases in the protoplanetary disk. A suite of meteorites with different thermal metamorphism histories will also permit investigation of the effects of how processes on the asteroidal parent bodies further modified the primordial volatile inventory and how volatiles may have behaved in the early stages of planet formation. These two strands feed directly into a new understanding of the origin of the Earth's oceans, and more broadly as to how habitable environments in exoplanetary systems may be created.

This work builds upon our extensive expertise in studying these species in lunar samples [e.g. 4,5], and will be complemented with additional bulk measurements using our in house FINESSE mass spectrometer system. As well as using the NanoSIMS, the project will also involve extensive use of analytical electron microscope, electron microprobe, and Raman microscopy.

References:

1. Greenwood, R. C., Barrat, J. A., Miller, M. F., Anand, M., Dauphas, N., Franchi, I. A., Sillard, P. & Starkey, N. A. Oxygen isotopic evidence for accretion of Earth's water before a high-energy Moon-forming giant impact. *Science Advances* **4,** 1–8 (2018).
2. Rubin, A. E. & Choi, B.-G. Origin of Halogens and Nitrogen in Enstatite Chondrites. *Earth Moon Planets* **105,** 41–53 (2009).
3. Piani, L., Marrocchi, Y., Rigaudier, T., Vacher, L. G.2020. Earth's water may have been inherited from material similar to enstatite chondrite meteorites. science.sciencemag.org
4. Barnes, J. J., Kring, D. A., Tartèse, R., Franchi, I. A., Anand, M. & Russell, S. S. An asteroidal origin for water in the Moon. *Nature Communications* **7,** 11684–10 (2016).
5. Stephant, A., Anand, M., Zhao, X., Chan, Q. H. S., Bonifacie, M. & Franchi, I. A. The chlorine isotopic composition of the Moon: Insights from melt inclusions. *Earth and Planetary Science Letters* **523,** 115715–12 (2019).

Qualifications required:

BSc (hons) in Geosciences, 2:1 or higher (a good Master's degree in Geosciences or equivalent with some independent research experience would be preferred)