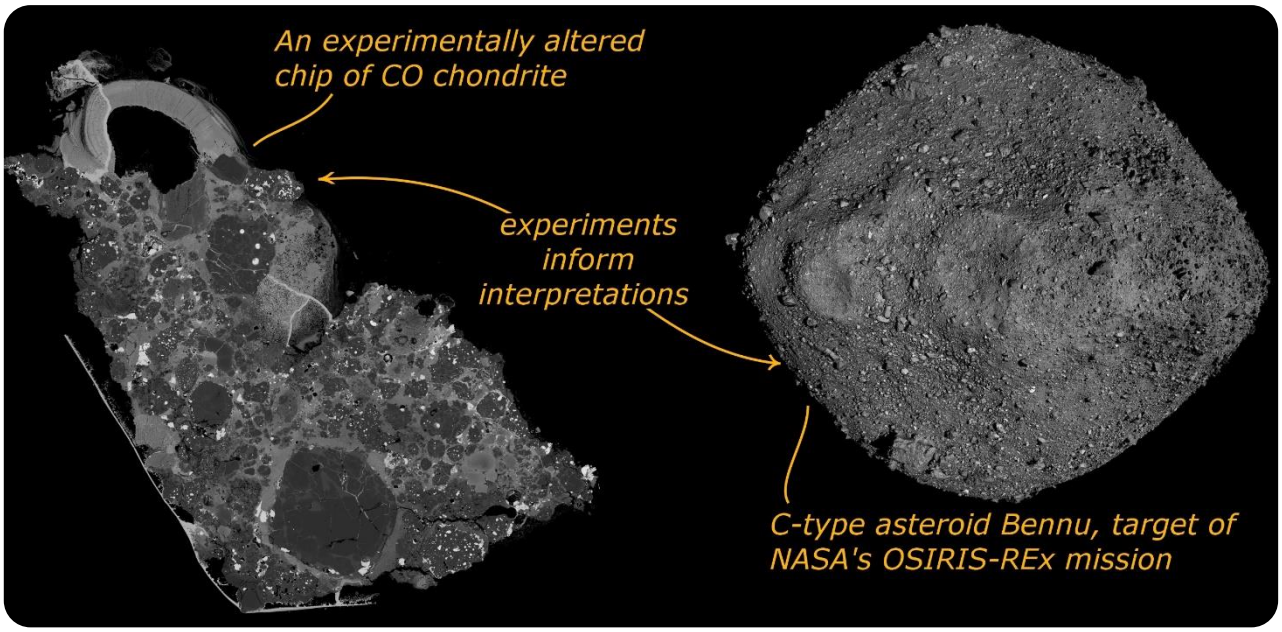
Low temperature geochemistry on water-rich asteroids explored through hydrothermal alteration experiments



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Project highlights:

- Combining experiments with numerical modelling to investigate aqueous alteration on carbonaceous chondrites.
- Exploring factors that controlled the geological evolution of carbonaceous asteroids.
- Results will be compared against naturally altered meteorites and potentially materials returned by the OSIRIS-REx mission from asteroid Bennu.

Summary: Using hydrothermal experiments to alter meteorites this project will recreate the conditions on water-rich asteroids in the early solar system. Experiments will explore how environmental variables affected mineral speciation and growth. This project focuses on two high priority science questions: *what factors controlled the style and extent of aqueous alteration on carbonaceous chondrites?* And *how did the composition of ices accreted by chondrites affect their alteration histories?* Results will aid the interpretation of Ryugu & Bennu samples acquired by recent sample return space missions whilst also contributing to our overarching mission to understand the role of water in the planet building process.

This project is a collaboration between the Open University (OU) and the Natural History Museum (NHM), London. The candidate will work at both institutions developing skills and acquiring data. This project is fully funded by the Science and Technology Facilities Council (STFC).

Background: This project investigates hydrated carbonaceous chondrites and the geological activity that operated on their parent bodies – C-type asteroids. They formed in the outer reaches of the early solar system and are suspected to have been a critical source of water (and other volatiles) for the early Earth.

Today the study of alteration minerals and their isotopic composition is a large and active field. However, most research takes the form of descriptive analysis on naturally altered meteorites. By contrast there are very few studies which employ an experimental approach despite the huge advantages of testing hypotheses through controlled and repeatable conditions. This PhD project will provide a crucial empirical perspective and is therefore likely to lead to significant advances in our understanding of hydrothermal systems on asteroids.

Workplan: This project will perform long duration aqueous alteration experiments, exposing meteorite chips (CO chondrites) to isotopically doped water and varying temperature (T: 25-300°C), water-to-rock ratio (W/R: 0.1-1.0) and reaction duration (t: 10-365 days). There is potential to include variable initial fluid compositions (e.g. ammoniated water) as well. Experiments will simulate different C-type asteroid environments (e.g. the CM., CR and CV parent bodies), ensuring wide-reaching high-impact findings. Experimental products will be analysed with microanalysis techniques (SEM, EMPA, XRD, TGA, nanoSIMS, laser fluorination mass spectrometry, Finesse mass spectrometer and Raman/IR spectroscopy) and results interpreted with the aid of geochemical modelling software.

Career development: The successful candidate will develop an extensive knowledge base in planetary science with transferable skills in stable isotope geochemistry, mineralogy, and numerical modelling. The candidate will perform all experiments, learning to independently operate a wide range of quantitative analytical techniques. This project provides opportunities to work with the UK's national meteorite collection (held at the NHM). A STEM PhD is a good stepping stone for a career in academia, government policy, industrial research, science communication, publishing, or the UK space sector.

Related reading

1. Vacher, L.G., Truche, L., Faure, F., Tissandier, L., Mosser-Ruck, R. and Marrocchi, Y., 2019. Deciphering the conditions of tochilinite and cronstedtite formation in CM chondrites from low temperature hydrothermal experiments. *MAPS*, 54:1870-1889.
2. Suttle, M.D., King, A.J., Schofield, P.F., Bates, H. and Russell, S.S., 2021. The aqueous alteration of CM chondrites, a review. *GCA*, 299:219-256.

Qualifications required:

A minimum of 2:1 BSc or a MSc in physics or a related discipline, e.g. geology, earth sciences, chemistry, geochemistry, natural sciences.