PhD opportunity for self-funded students

PROJECT TITLE: Impacts of weathering, redox cycling and microbial activity on the formation of kaolinite (china clay)

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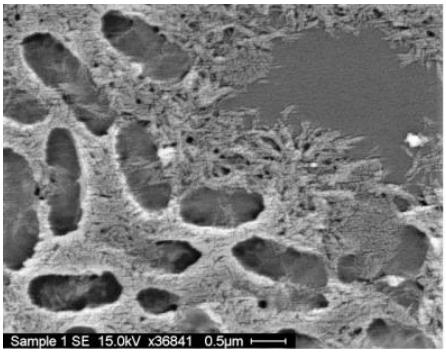
Project keywords: mineralogy, geomicrobiology, weathering, redox cycling, geochemistry, economic geology, mineral resources

Mining of the St Austell china clay deposit on a kilometre scale (© Imerys)



Micron scale microbe-mineral interactions using Scanning Electron Microscopy (© L. Newsome)

Project Background

Do microbes help make china clay? Kaolin minerals are very important economic resources; so much so that china clay has sometimes been referred to as “white gold”. Understanding how kaolin minerals form and behave in the environment is important because not only are they valuable economically, they also transport metals and nutrients to the ocean, can be used to remediate pollutants, and have been identified on the surface of Mars. Large kaolin deposits form from granites, either by hydrothermal alteration or by surface weathering in areas with temperate climates and high rainfall. Kaolin minerals also form in soils in intensely weathering environments. Kaolinization is thought to be triggered by the oxidation of iron(II) in biotite, and this has been linked to the activity of iron(II)-oxidising microorganisms. However, microbial iron(II) oxidation at neutral pH tends to occur in relatively narrow zones of redox interfaces rather than over tens of metres, which raises questions about its significance in economic kaolin deposits. This project will test the hypothesis that microbial redox cycling of iron contributes to kaolin formation in near surface environments, and therefore stimulating microbial redox cycling will increase the rate of kaolinization.

Project Aims and Methods

This project will characterise the conditions under which kaolinite forms during surface weathering of granites, investigate the role of microbial iron cycling and how this influences the rate of reaction, and consider how these processes can be enhanced to improve the kaolinization of low-grade materials by:

- Studying the composition of microbial communities in kaolin deposits (including those currently mined by Imerys at St Austell) using high throughput DNA sequencing.
- Observing the role of microorganisms in kaolinite formation and weathering by performing laboratory experiments with pure mineral phases and cultures of iron-reducing and iron-oxidising bacteria.

- Simulating weathering by performing sediment microcosm redox cycling experiments to observe the behaviour of kaolinite during biogeochemical cycling.

There will be the potential for fieldwork to collect samples from different kaolin deposits beyond the UK. Flexibilities exist for the student to be involved in experimental design and in decisions regarding choice of analytical techniques. We envisage the student will characterise samples using X-ray diffraction, scanning electron microscopy and synchrotron X-ray techniques (www.diamond.ac.uk/Home/About.html).

Overall this interdisciplinary research project links geology and biology to provide fundamental insights into the role of microbes in the formation of a highly important mineral resource. It will provide the student with a deep understanding of biogeochemical cycling, weathering, and environmental mineralogy, as well as providing skills for pursuing careers in academia, environmental consulting, industry or the public sector.

Candidate Requirements

The ideal candidate will have a strong background (preferably MSc-level) in a relevant discipline, such as Geoscience, Geology, Microbiology, Molecular Biology, Environmental Chemistry, or Biology, with a particular interest in environmental geomicrobiology and geochemistry.

Industry Partner

Imerys is the world leader in mineral-based specialities and operates various kaolinite mines including at St Austell. Their support would enhance this project by providing access to samples of kaolin minerals and mineral waste and liaison with industry contacts. The student would be able to interact with Imerys during the project to get an industry perspective, and there is the potential for a summer secondment.

Training

The student will be supervised by experts in geomicrobiology and environmental mineralogy (Newsome), biogeochemical weathering (Buss), and clay mineralogy and geochemistry (Cuadros). This interdisciplinary research project will involve training in laboratory techniques such as mineralogical characterisation, microbiological work and geochemical monitoring. The student will have access to a wealth of training opportunities from the University of Exeter's Researcher Development Programme, which offers a wide range of workshops, seminars, and online resources covering topics such as project management, writing, resilience and wellbeing, public engagement, research ethics, IT skills, careers prep, data sharing, and teaching.

Background reading

Cuadros J., Afsin B., Jadubansa P., Ardakani M., Ascaso C. and Wierzchos J. (2013) Microbial and inorganic control on the composition of clay from volcanic glass alteration experiments. *Am. Mineral*. 98, 319-334. http://dx.doi.org/10.2138/am.2013.4272

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Minyard M. L., Bruns M. A., Liermann L. J., Buss H. L. and Brantley S. L. (2012) Bacterial associations with weathering minerals at the regolith-bedrock interface, Luquillo Experimental Forest, Puerto Rico. *Geomicrobiol. J.* **29**, 792–803. http://dx.doi.org/10.1080/01490451.2011.619640