Creating the Critical Zone: Microbe –Mineral Feedbacks at the Rock-Soil Interface

Supervisors

Main supervisor: Doctor Heather Buss, School of Earth Sciences (University of Bristol)
Co-supervisor: Professor Alexandre Anesio, School of Geographical Sciences (University of Bristol)

Project enquiries - Email: h.buss@bristol.ac.uk **Contact number:** +44 (0) +441173314751

Host Institution: University of Bristol

Project description

Co-supervised by Dr. Heather L. Buss and Prof. Alexandre M. Anesio.

Microbial communities at the rock-soil interface are key players in soil formation and nutrient cycles. In many soil environments, nutrients and energy substrate (e.g., organic carbon) are recycled by organisms living in the upper 50-100 cm of the soil, leaving little, if any, to infiltrate to depths below the rooting zone. In such environments, microbial communities at depth are highly dependent on chemolithoautotrophic primary producers: microorganisms that utilise energy derived from inorganic geological sources to produce biomass. Effectively, these are rock-eating bacteria. The biomass produced by these microorganisms becomes an energy source for organisms that utilise other metabolic processes. The production of essential mineral nutrients (e.g., P, Mg, Ca, K) and micronutrients (e.g., Zn, Cu, Mo, Cr) and the creation of new soil fundamentally depends on the physical and chemical breakdown of bedrock by weathering.

In addition to exploiting the energy and nutrients provided by weathering minerals, subsurface soil microorganisms also chemically alter environments they inhabit, impacting subsequent geochemical weathering reactions. Thus, perturbations to the diversity or functioning of the microbial community at depth have major implications for soil production, fertility, and the ecosystem services provided by soils. Predicting the impacts of environmental change (be they natural or anthropogenic) on the sustainability of soil resources and ecosystem services will require quantitative understanding of the coupled biogeochemical processes that produce and transform soil and soil nutrients. Despite this need, only a few attempts (e.g., Buss et al., 2005) have been made to quantitatively describe the coupled geochemical and biological processes at the "nexus of weathering and biology": the rock-soil interface. This PhD studentship research project will work directly at this nexus.

In collaboration with the Czech Geological Survey and international critical zone observatory networks (www.czen.org, criticalzone.org, www.soiltrec.eu) we will collect and analyse microbiological and geochemical data from the rock-soil interface of 3 different bedrock types at the Slavkov Critical Zone Observatory (Slavkov CZO) in the Czech Republic. We will use these data to estimate energy transfer and biomass production of the different microbial groups and communities based on the different energy sources available and the microbial growth rates (estimated as functions of mineral weathering rates). This project will enable a quantitative assessment of geomicrobiological processes in soils and their vulnerabilities to environmental

change, providing fundamental new insights into the role of microorganisms in the earliest stages of chemical weathering and soil development.

Collaboration

The project will be led by the main supervisor (Buss) with significant input from the co-supervisor (Anesio). Dr. Buss will directly supervise the field work, the geochemical analyses and interpretation, the day to day activity of the student, and will have the primary responsibility for the student's progress and development. Prof. Anesio will train and supervise the microbiological components of the project and will collaborate on data analysis and interpretation. Analytical work will be performed in both Schools, although the student will be based within the School of Earth Sciences. From the start of the project, the student will attend regular group meetings with both the Buss and Anesio research groups and will also meet individually with Dr. Buss at least every 2 weeks. The School of Earth Sciences requires annual progress review meetings (held without the supervisors after year 1) for all postgraduates to evaluate that adequate progress is being made and that the student is receiving proper supervision.

Training Opportunities

This project is inherently interdisciplinary, fusing aspects of earth sciences: geology, chemical weathering and soil formation with biology: microbiology, molecular biology and biodiversity. The student will further benefit from conducting field work abroad and interacting with the Czech Geological Survey and the global Critical Zone Exploration Network. The PhD student will work closely with both supervisors to gain the training and knowledge required for this project, regardless of the student's academic background. Required facilities are available at the University of Bristol in the School of Earth Sciences: (1) electron microscopy facility, (2) the Bristol Isotope Group laboratories, (3) Environmental Geosciences teaching laboratory; in the School of Geographical Sciences: (4) LowTex and Microbiology Facilities; and in the School of Biological Sciences: (5) Genomics Facility.

The student will benefit from training in electron microscopy (1), chemical analysis by ICP-MS (2) or ICP-OES (3), basic techniques in microbiology such as culturing, fluorescence and confocal microscopy and measurements of activity (4) and molecular techniques (4, 5). Laboratory training and work in microbiology and molecular biology will be supervised by Prof. Anesio, who specialises in biogeochemical microbiology. Field work, chemical analyses, petrology, electron microscopy, soils analyses and data synthesis will be overseen by the primary supervisor, Dr. Buss, who specialises in chemical weathering and geomicrobiology.

In addition to individual training within the supervisors' respective research groups, the student will have the opportunity for additional training through seminars and short courses at the University of Bristol and across the GW4+DTP. For example, within the School of Earth Sciences, training workshops are offered annually to postgraduate students in computer programming (e.g., Matlab, Python) and electron microscopy (SEM, EPMA), among other scientific and transferable skills. The student would be able to choose from relevant courses provided by the GW4+DTP such as mass spectrometry, phylogenetic methods, bioinformatics and data management, characterisation and modelling of organic matter transformations, and statistics for environmental sciences.

Reference:

Buss H.L., Bruns M.A., Schultz M.J., Moore J., Mathur C.F., and Brantley S.L. (2005) The coupling of biological iron cycling and mineral weathering during saprolite formation, Luquillo Mountains, Puerto Rico. Geobiology, 3, 247-260.