PROJECT TITLE: Biogeochemistry of a subterranean estuary and fluxes of solutes and nutrients to coastal waters in the Northern Bahamas.

DTP Research Theme(s): Living World and Changing Planet

Lead Institution: University of Bristol

Lead Supervisor: Prof. Fiona Whitaker, School of Earth Sciences

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Project keywords: subterranean estuaries; submarine groundwater discharge; groundwater biogeochemistry; carbonate island aquifers; Bahamas

Project Background: In areas of permeable bedrock, the subterranean estuary plays a critical role in controlling the discharge of fluid and terrestrial solutes to coastal oceans via submarine groundwater discharge (SGD), with profound impacts on benthic primary productivity, algal blooms and ocean acidity. These coastal aquifers are characterised by steep gradients in salinity and redox that drive a range of reactions and nutrient transformations. Much prior work has considered the physical hydrology of idealised aquifer systems and focused on the effects of density and tides, whilst the effects of aquifer heterogeneity and of episodic and longer-period forces remain poorly understood. Physical studies have remained largely decoupled from geochemical work that is required to understand freshwater contributions to coastal nutrient budgets, and even less is known about the reaction dynamics of marine-derived solutes circulating through the near shore aquifer that return to the ocean.

Project Aims and Methods: This study adopts a multidisciplinary approach to unravel interactions between groundwater flow, biogeochemistry, and reaction dynamics in the coastal carbonate aquifer on North Andros Island in the Bahamas. Below we outline the planned research direction and design, but we are open modifying this on discussion with the student to reflect their own ideas.

The biogeochemistry of groundwaters will be characterised across the northern part of the island using samples from a suite of research wells that penetrate through the fresh-salt water mixing zone into the underlying saline zone. These will be compared to samples of SGD from creeks and caves and via seepage in the offshore sediments, comparing the barrier-reef fringed east coast and the more restricted west coast. This data will be used to parameterise reactive-transport simulations of mixing, organic matter remineralisation and water-rock interaction using TOUGHREACT at a range of scales. Combining these approaches will enable the student to unravel the influences of meteoric and sea water composition, organic matter inputs, and hydrogeological characteristics of the aquifer on biogeochemical processes.
within the subterranean estuary. The resulting understanding of spatial heterogeneities and temporal
dynamics in the magnitude of solute and nutrient fluxes to the coastal ocean will allow upscaling of data to
generate estimates of SGD discharge in tropical coastal carbonate systems and contribute to sustainable
management of coastal water resources under the influence of anthropogenic and climate changes.

Candidate requirements: This project requires an undergraduate degree in environmental science, geology,
chemistry, or a related science discipline. Some experience in the collection and analysis of water samples
and/or the use of coupled models to simulate subsurface flow/geochemistry is beneficial but not essential.

Notwithstanding any mobility issues, the candidate must be prepared to work in fieldwork in physically
challenging conditions in the Bahamas to the best of their ability. We welcome and encourage student
applications from under-represented groups. We value a diverse research environment.

**Project partners:** The British Geological Survey is the UK’s premier provider of objective and authoritative
geoscientific data, information and knowledge to help society to use its natural resources responsibly,
manage environmental change and be resilient to environmental hazards. This project provides the
opportunity to work in the dissolved gases facility, which is unique in the UK and has a world leading
reputation in the field of groundwater dating and tracing. There is also considerable scope to draw on the
knowledge and techniques developed by BGS using nutrient isotopes to understand biogeochemical cycling
in aquatic systems. During periods spent at BGS in Wallingford there will be plenty of time to work
alongside and interact with a range of practising geoscientists which gives an excellent opportunity to see
how research science is undertaken outside of the University sector and provides an insight of future career
possibilities.

**Training:** Training will be provided in the field and laboratory biogeochemical techniques, analysis of
samples and evaluation of resulting datasets, including the use of TOUGHREACT to simulate coupled
subsurface processes. You will undertake fieldwork on North Andros, as part of a team of 3 PhD and 2
Masters students in geology, hydrology, hydrogeophysics and isotope geochemistry.

**Background reading and references**
Cooper et al., 2016, Dissolved organics carbonate transformations and microbial community response to variations in
Robinson et al., 2018. Groundwater dynamics in subterranean estuaries of coastal unconfined aquifers: controls on
submarine groundwater discharge and chemical inputs to the ocean. *Advances in Water Resources* 115, 315-331.

**Useful links**
[http://www.bristol.ac.uk/earthsciences/courses/postgraduate/](http://www.bristol.ac.uk/earthsciences/courses/postgraduate/)

**Bristol NERC GW4+ DTP Prospectus:**
[http://www.bristol.ac.uk/study/postgraduate/2023/doctrnal/phd-great-western-four-dtp/](http://www.bristol.ac.uk/study/postgraduate/2023/doctrnal/phd-great-western-four-dtp/)

**How to apply to the University of Bristol:** [http://www.bristol.ac.uk/study/postgraduate/apply/](http://www.bristol.ac.uk/study/postgraduate/apply/)

**Please note:** If you wish to apply for more than one project, please contact the Bristol NERC GW4+ DTP Administrator to find out the process for doing this.

The application deadline is Monday 9 January 2023 at 2359 GMT.
Interviews will take place during the period 22 February – 8 March 2023.

**NERC GW4+ DTP Website:** for more information about the NERC GW4+ Doctoral Training Partnership
please visit [https://www.nercgw4plus.ac.uk](https://www.nercgw4plus.ac.uk).

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