NERC IAPETUS 2 DTP PhD studentship (2021)

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Coral osteoporosis: how does seawater phosphate affect the calcification of tropical marine corals?

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Overview: Coral reefs are among the most biologically diverse ecosystems and are of substantial economic importance in terms of fisheries, tourism and coastal protection. Corals are small invertebrate organisms which typically live in colonies and produce aragonite (a form of calcium carbonate) skeletons which form the basis of the reef structure (Figure 1). Eutrophication is a significant pressure on coral reefs and coral coverage is decreased at sites affected by phosphate mining effluents (Martinez-Escobar et al., 2019). However, it is unclear how phosphate supresses coral coverage.

Coral skeletons from high seawater phosphate areas are poorly mineralised (Al-Sawalmih et al., 2017). In culture, increasing seawater phosphate can promote coral growth rates, but this is accompanied by a decrease in the density of the skeleton which may make corals highly susceptible to breakage, e.g from storm events or bioerosion (Dunn et al., 2012). Orthophosphate rapidly adsorbs onto aragonite crystals precipitated in vitro and then suppresses subsequent crystal growth (Tadier et al., 2017, Iijima et al., 2019). Adsorption of orthophosphate into the growing coral aragonite may therefore be responsible for the reduction in coral skeletal density at high seawater phosphate.

The aims of this project are to identify how orthophosphate affects the formation and structure of the coral skeleton. By combining a multidisciplinary approach of coral culturing, fieldwork and laboratory experiments, the student will identify how increasing seawater orthophosphate affects the formation and strength of the aragonite skeleton in tropical marine corals. This mechanistic understanding is needed to improve coral reef management in areas adversely affected by nutrient inputs and eutrophication.

Methodology: The student will explore the impact of seawater orthophosphate on the structures of coral skeletons by collecting coral skeleton samples from along a gradient of seawater phosphate concentrations in the Gulf of Aqaba, Jordan (SCUBA diving possible but not essential, Figure 1a). The student will also culture corals over a range of seawater orthophosphate concentrations in the coral research aquarium facility at St Andrews (Figure 1b) to explore seawater orthophosphate in isolation. The aragonite skeletal structure will be

Figure 1a) Reef site in the Red Sea, b) Heads of massive Porites spp. corals cultured at the University of St. Andrews (Allison et al., 2018)

analysed using electron microscopy techniques (e.g. energy dispersive x-ray spectroscopy and scanning electron microscopy), Raman spectroscopy and strength testing methods e.g. compressive strength and elastic modulus. Coral skeleton growth rates will be measured by identifying the annual coral growth bands visible in X-ray radiographs or under UV light in the field specimens or by using the alkalinity anomaly technique in cultured corals. Skeletal density will be calculated from skeletal mass and volume.

To identify how orthophosphate affects the precipitation process, the student will conduct state-of-the-art aragonite precipitation experiments. The student will use a pH stat titrator linked to a gas apparatus (Figure 3) to precipitate aragonites from seawater under conditions analogous to those of the coral calcification site. Manipulation of environmental conditions (e.g. temperature, salinity, dissolved inorganic carbon, pH) will enable the student to establish a mechanistic model of phosphate-driven coral calcification.

This project will determine if seawater phosphate adversely affects both the production of coral aragonite skeletons and the properties which allow them to persist successfully as reef structures. The student will identify if a predictable relationship exists between seawater orthophosphate concentration and skeletal properties, or if there is a critical concentration above which skeletal structure is compromised. The results of this work will be highly relevant for the management of coral reefs, with the potential for incorporation into policy and conservation actions. Application to other marine calcareous organisms will further widen this impact.

Training and Skills: The student will develop a multidisciplinary skillset in coral culturing, tropical coral reef field sampling and in the preparation and analysis of synthetic and coral carbonates. Analytical methods include the Brunauer-Emmett-Teller (BET) adsorption technique, XRD, electron microscopy, Raman spectroscopy and strength tests. The student will also develop a thorough understanding of the behaviour and analysis of the seawater carbonate system and orthophosphate. The student will receive full training in all required techniques. We will consider applicants from a range of environmental, marine and geological backgrounds.

The student will present results at national & international workshops and conferences and will be assisted in preparing scientific manuscripts to be published in international peer-reviewed journals. The student will join a NERC-funded team studying biomineralisation in the School of Earth and Environmental Sciences at the University of St Andrews and will be a member of the Marine Alliance for Science and Technology for Scotland (www.masts.ac.uk), enabling wider access to training and networking opportunities. All project supervisors are highly research-active across the ecological, environmental and geoscience disciplines; the student will have opportunities to learn other techniques and research areas which may be applicable to their interests. Active participation in their research groups will provide the opportunity to discuss cutting-edge topics in the field, review recent papers and to present current research plans to academics with a common research interest in an informal and supportive atmosphere.

Applications: General information about eligibility, studying at the University of St Andrews, and the online application form can be found at http://www.st-andrews.ac.uk/study/pg/apply/. This project is eligible for funding from NERC IAPETUS 2. Contact Nicola Allison for further enquires (na9@st-andrews.ac.uk).

References:

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