NERC IAPETUS 2 DTP PhD studentship (2026-27entry)

The coral biomineralisation response to temperature and pH change in the Central Pacific over the last 500ka

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Overview: Tropical corals produce the aragonite skeletons which underpin coral reefs and have a substantial value as resources for fisheries, tourism and land protection. Coral biomineralization is influenced by multiple factors. The aragonite skeletons of tropical corals form at specialist calcification sites. The calcification media at the sites are sourced from seawater but the corals increases the media pH, shifting the dissolved inorganic carbon (DIC) equilibrium in favour of CO_3^{2-} and promoting the formation of aragonite. Calcification is influenced by both temperature and seawater pCO_2 (influencing seawater pH). In addition, coral skeletons contain biomolecules e.g. proteins and lipids, which influence the formation and structure of aragonite.

The aim of this project is to reconstruct environmental change and the coral biomineralisation response to change in the Central Pacific by analysing fossil corals from the Hawaiian Islands. Tropical corals record information on the seawater composition, temperature and pH in their skeletons at the time of their deposition[1]. The Hawai'ian islands are shield volcanos that formed over a volcanic hotspot and then subsided as they move away from the hotspot. Fringing coral reefs formed around the islands and accreted rapidly to keep pace with the change in relative sea level (as the island subsided). During periods of rapid relative sea level rise the reefs gave up and drowned, forming multiple terraces that are preserved at depths from ~150m to >1000m below present sea level (Figure 1). A large suite of fossil *Porites* spp. have been collected from the terraces around the Big Island of Hawaii during previous research and during a recent IODP expedition (IODP 389: Hawaiian Drowned Reefs https://www.ecord.org/expedition389/). Dating demonstrates that the reefs grew episodically but contain corals which grew over the last five glacial cycles. Global sea level and atmospheric CO_2 display cyclical variations over this period (Figure 2). The reefs are a unique resource to explore changes in coral biomineralisation in response to climate variations.

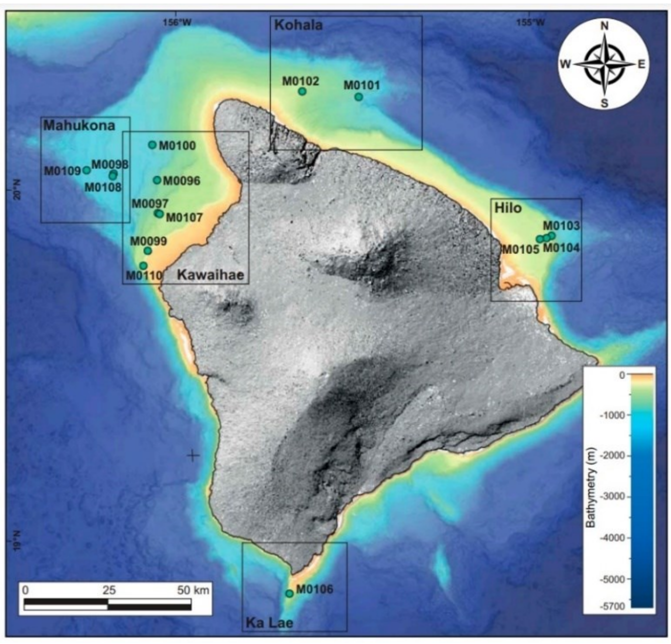


Figure 1. Expedition 389 final site locations from five regions around the island, overlaid on the bathymetric map for offshore Hawai'i.

Figure 2. Plots of a) relative sea level (RSL), m below present day, over the last 500 kyr[2] and b) atmospheric pCO_2 from the Vostok ice core record[3].

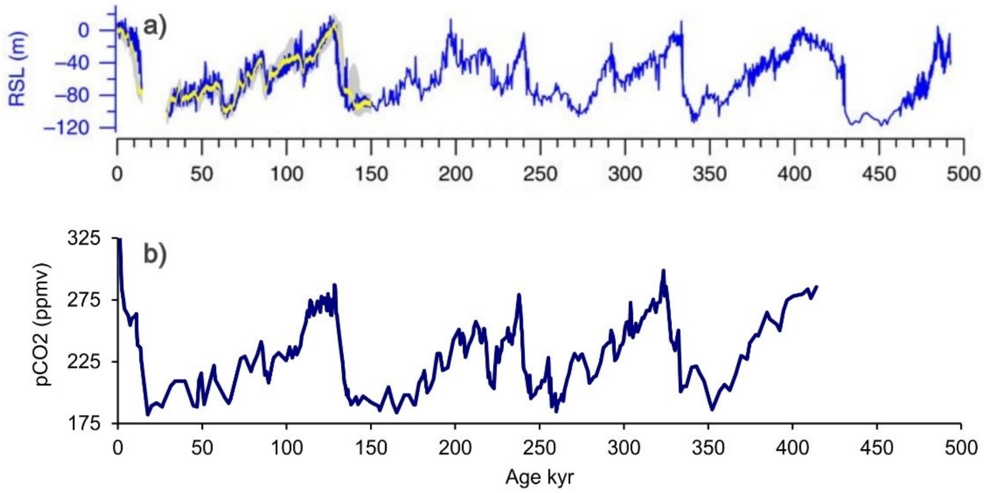
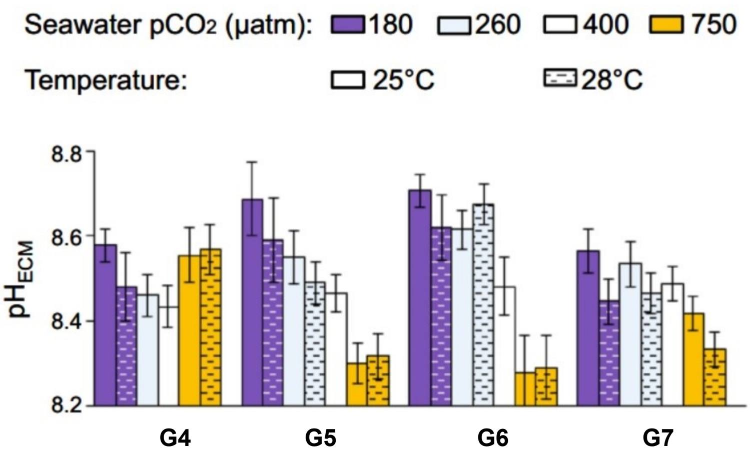


Figure 3. pH of coral calcification media pH_{ECM} (pH total scale) in 4 different *Porites* coral genotypes (G4 to G7) cultured at varying seawater pCO_2 and temperature (Allison et al., 2021). Hatched bars indicate results at 28°C, and unhatched bars are 25°C. Seawater pCO_2 was approximately 180 and 260 µatm in the last Glacial maximum and in the interglacial respectively. Present day seawater pCO_2 is ~400 µatm while the 750 µatm treatment represents a future scenario.



Methodology: The student will investigate relationships between coral biomineralisation and climate and seawater pH in the IODP 389 corals using a series of geochemical tools. Coral aragonite $\delta^{11}B$ is used as a proxy of coral calcification media pH (see ref 4 for a review) and is influenced by external seawater pH (Figure 3). $\delta^{11}B$ analysis of coral skeletons has been used to track regional changes in ocean pH[5] and to explore the response of different coral genotypes to ocean acidification[6]. The student will analyse modern and fossil Hawaiian coral specimens for $\delta^{11}B$ to estimate coral calcification media pH. The student will also apply other palaeoproxies e.g. Sr/Ca, Li/Mg, to reconstruct past seawater temperatures and conditions[1,11]. The student will estimate calcification rates in the corals from the core x-radiographs which record the annual skeletal density changes in the corals. Recent research by our groups shows that seawater pCO_2 and/or temperature also influence the biomolecule compositions of coral skeletons[7], their nanograin structure[8] and the aragonite lattice[9]. The student will have access to these techniques to fully explore the biomineralisation response to CO_2. Corals will be examined carefully (XRD, petrography) to identify diagenetic alteration which can significantly alter the geochemistry of the primary coral skeleton and overwrite the climate signature[10].

This research will indicate how variations in atmospheric CO_2 (reconstructed from ice cores, Figure 2b) influence the calcification media pH of massive corals in the central Pacific and will identify how changes in coral calcification media pH relate to coral calcification rate. The PhD research will demonstrate how coral biomineralisation responds to changes in atmospheric CO_2 and temperature and will answer key questions. For example, was the response of coral calcification to seawater temperature and pH change different in the past (when change was relatively slow) compared to the present day (when change is rapid). This information is critical in predicting the future of coral reefs in a changing climate.

Training and Skills: The student will develop a multidisciplinary skillset gain in geochemical laboratory techniques as well as training and expertise in coral biomineralisation, isotope geochemistry and palaeoclimate reconstruction. The student will join a NERC-funded team studying coral biomineralisation and carbonate palaeoproxy development in the School of Earth and Environmental Sciences at the University of St Andrews. In addition, the student will gain transferable skills in scientific writing, data analysis, statistics, problem solving and presenting. The student 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.

Applications: Contact Nicola Allison for further enquires (na9@st-andrews.ac.uk). General information about eligibility and studying at the University of St Andrews can be found at Postgraduate. This project is eligible for full funding (fees, stipend and research training grant) for 3.5 years from NERC IAPETUS 2. Up to 30% of the studentships can be awarded to international (non-UK) applicants. See NERC IAPETUS 2 for details of how to apply.

References:

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