

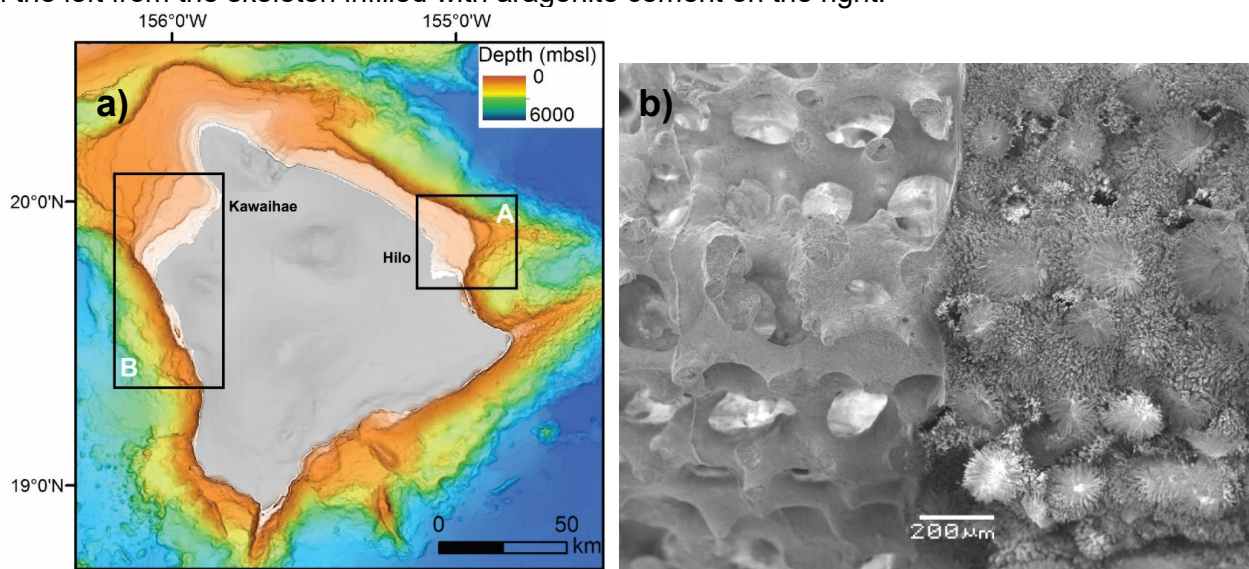
## Environmental change and the coral biomineralisation response in the Central Pacific over the last 500ka

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**Overview:** The aim of this project is to reconstruct environmental change and the coral biomineralisation response in the Central Pacific by analysing *Porites* spp. fossil corals from the Hawaiian Islands. The Hawaiian Islands sit in the North Pacific Subtropical Gyre, at a location which is sensitive to shifts in the Pacific Decadal Oscillation and El Niño Southern Oscillation (Kavanaugh et al. 2018), making them an ideal location to track climate change. The 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 1a). A large suite of fossil *Porites* spp. have been collected from the terraces using a manned submersible, a remote operated vehicle and by rebreather diving. Dating demonstrates that the reefs grew episodically but contain corals that record climate information leading up to, during and after the last five to six glacial cycles. The reefs are a unique resource for reconstruction of environment, sea level (Sanborn et al. 2017) and the biomineralisation response.

The aragonite skeletons of tropical corals record information on the seawater composition, temperature and pH at the time of their deposition (Thompson, 2022). For example, skeletal  $\delta^{18}\text{O}$  indicates seawater temperature and ice volume, Sr/Ca and Sr/U relate to temperature and Ba/Ca reflects freshwater runoff. Massive *Porites* spp. are commonly used for climate reconstruction. They are widespread in tropical and sub-tropical Indo-Pacific reefs and produce robust skeletons which are well preserved in modern and ancient environments. They accrete rapidly and can yield high temporal resolution (sub-annual) climate records which track the frequency and magnitude of climate events e.g. El Niño Southern Oscillation (Jiang et al. 2021). Fossil skeletons can also be used to explore the coral biomineralisation response to environmental change. For example, seawater  $\text{pCO}_2$  affects the biomolecule composition of the skeleton (Kellock et al. 2020), calcification rates (Cole et al. 2018), calcification media pH (Allison et al. 2021) and nanograin skeletal structure (Tan et al.

**Figure 1a).** High-resolution multibeam bathymetry data around the Big Island of Hawaii indicating drowned reefs at Hilo and Kawaihae (after Sanborn et al., 2017). b) Scanning electron micrograph of a coral from the 225-276 ka terrace. A dissepiment, running vertically, divides the pristine skeleton on the left from the skeleton infilled with aragonite cement on the right.



2023) of *Porites* spp. corals. Our recent research is exploring how environmental change affects the material properties of coral skeletons e.g. hardness and resilience to erosion (Tan et al., 2023).

**Methodology:** The student will visit the University of Sydney to select coral samples from the existing Hawaiian coral collection held there and to research the geologic and paleoenvironmental context of the reefs. The student will also have access to additional materials obtained during IODP 389 Hawaiian Drowned Reefs which drilled the reef terraces around the Big Island of Hawaii in 2023. Corals will be examined carefully (XRD, petrography) to identify diagenetic alteration (Figure 1b) which can significantly alter the geochemistry of the primary coral skeleton and overwrite the climate signature (Allison et al., 2007). The student will analyse selected modern and fossil Hawaiian coral specimens for palaeoproxies to reconstruct past seawater temperatures and conditions (Thompson 2022). The data will be used to infer climate utilising recent advances in the interpretation of palaeoproxies (e.g. Cole et al., 2021). The student will also research indicators of biomineralisation response e.g.  $\delta^{11}\text{B}$  as an indicator of calcification media pH, nanograin structure and will measure the material properties of the skeletons e.g. hardness and fracture resistance. The project will generate high resolution palaeoproxy data which are critical for understanding global palaeoclimate and in testing and validating global climate models for predicting 21st century climate change. The project will also answer key questions on the response of biomineralisation to climate change. 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). Do the skeleton material properties suggest that coral reefs in the past were more or less resilient to erosion? 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 sedimentology, 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](http://www.masts.ac.uk)), enabling wider access to training and networking opportunities.

**Applications:** Contact Nicola Allison for further enquires ([na9@st-andrews.ac.uk](mailto:na9@st-andrews.ac.uk)). General information about eligibility, studying at the University of St Andrews, and the online application form 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.

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