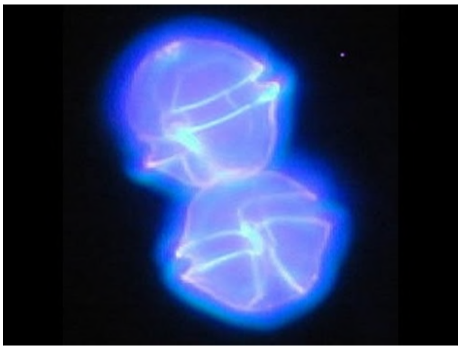
Project EARTH-17-RR4: Assessing the biological response to changes in ocean chemistry from increased weathering

Supervisors: Ros Rickaby, Gideon Henderson

The PhD studentship is funded through the NERC-led Greenhouse Gas Removal programme. Our Consortium will establish the potential of enhanced weathering as a means of CO_2 sequestration. No modification of the Earth's surface can occur without consequence for other parts of the Earth system. One of the key aims is to establish the envelope of marine calcification response to the raised alkalinity associated with enhanced weathering. If marine calcification can keep pace with the additional alkalinity inputs then much of the net sequestration of CO_2 will be undone.

The student will establish the calcification response of the dominant marine biocalcifiers, the foraminifera and the corals, through field experiments with project partners in Israel and Australia to provide additional data constraints on the range of calcification rate responses expected across the marine biota. Through these collaborations we have the opportunity to perform bottle manipulations of alkalinity in the field by suspending organisms within tightly controlled chemical environments in the Gulf of Eilat, and in manipulated reef environments on the Great Barrier Reef. We will use novel techniques, including calcein and ^{135}Ba as tracers of new growth to allow determination of the rate of change of calcification for both planktonic and benthic foraminifera in response to alkalinity addition.



The second objective of the studentship is to investigate the growth optima of different groups of phytoplankton (coccolithophores, diatoms, dinoflagellates and cyanobacteria) to alkalinity addition. It has been shown that dinoflagellates (see Fig) are particularly successful at higher pH, which has important implications for alteration of ecosystems (e.g. red tides) in response to major perturbations of the oceans carbonate chemistry

In addition to changes in carbonate production, input of alkalinity from weathering of minerals will impact ecosystems due to the metals and contaminants that will inevitably accompany the alkalinity. The addition of certain elements will either stimulate growth and carbon fixation or act as a toxin to the biota depending on the rate and magnitude of input to the ocean. The impact of these metal/nutrient additions will also be considered in the life-time of the project.

The student will be trained in clean laboratory techniques, laboratory culture of organisms, field-based biological manipulations, fundamental controls of seawater chemistry using computer packages such as visual MINTEQ, and a range of analytical techniques from Quadrupole to MC ICPMS.

The student will benefit from multiple research group meetings in Oxford, and will be heavily embedded into this project framework, so will benefit from working in an interdisciplinary project tackling the challenge of reducing greenhouse gases. The consortium will also give them direct access to variety of departments within Oxford, including the interdisciplinary Oxford Martin School which has a specific focus on taking research into policy.

Background Reading:

Hinga, K. R., Effects of pH on coastal marine phytoplankton, Mar. Ecol. Prog. Ser., 238, 281-300, 2002.

Muller., M. et al., Phytoplankton calcification as an effective mechanism to prevent cellular calcium poisoning, DOI: 10.5194/bgd-12-12691-2015

Flynn, K. J. et al., The role of coccolithophore calcification in bioengineering their environment; DOI: 10.1098/rspb.2016.1099

Silverman et al., Effect of aragonite saturation, temperature, and nutrients on the community calcification rate of a coral reef, JGR, VOL. 112, C05004, doi:10.1029/2006JC003770, 2007