Biomineralization in Corals and the The Hunt for New Tracers of the Past Ocean

JESS F. ADKINS[1]* AND ALEX GAGNON[2]

[1]Dept. of Geology and Planetary Sciences, Caltech, Pasadena, CA, USA, jess@gps.caltech.edu
[2]Earth Science Division, LBNL, Berkeley, CA, USA, acgagnon@lbnl.net

Geochemical records from biogenic carbonates are a mainstay of our understanding of past climates. Isotopic and elemental abundances are often correlated with aspects of the modern water column to 'calibrate' a tracer. Even in light of large offsets from chemical equilibrium, this approach has served the field very well. Emiliani demonstrated that there were donzens (not four) major glaciations in the past few million years. Yet the $\delta^{18}O$ tracer he used is still debated today for what part of its signal is climate and what part is 'vital effect'. In light of both these sucesses and challenges, it is our hope to show how the study of disequilibrium effects can lead to better paleo tracers.

We have been using deep-sea corals as a natural laboratory for studying these vital effects because they grow in modern seawater with relatively constant conditions. Our approach has been to first demonstrate that corals use seawater as the basis for their calcifying fluid which is then modified by specific biological processes before deposition in the skeleton. This direction was first outlined by McConnaughey over 20 years ago and while the details of his models have been challenged his basic approach is still important today. We will review work on the stable isotopes of carbon and oxygen, Mg/Ca, Sr/Ca, U/Ca, and several other tracers in an attempt to build a better understanding of how corals calcify and how this affects the record of past climate. Using a Rayleigh model of Me/Ca uptake into the skeletons we propose a new thermometer based on the trend of data from a single individual in Mg/Ca versus Sr/Ca space. In general, the use of simple models, while ignoring important concepts like organic membrane mediation of tracer incorporation, can both guide the development of new tracers and inform the variance already found for more established proxies.

Reduced Mixing Between Two Deep Ocean Cells During the LGM and a Theory for the Cold Phase of Glacials Cycles

JESS F. ADKINS[1]*

[1]Dept. of Geology and Planetary Sciences, Caltech, Pasadena, CA, USA, jess@gps.caltech.edu

In the mid-80s the three so called 'Harvarton Bears' box models emphasized the role of the Southern Ocean in setting past pCO_2 values. This seminal work has sparked a large data collection effort, many related theories of glacial CO_2 cycles, and intense debate. The core message is that a combination of lower Southern Ocean overturning and increased biological nutrient utilization efficiency (phrased at the time as increased biological production) in the polar Antarctic can lower pCO_2 to the LGM value. It is widely accepted that neither process on its own can give rise to the full glacial to interglacial change, and that carbonate compensation also plays an important role in any scenario of pCO_2 lowering. In this work I would like to explore the role of deep ocean mixing as another important process in setting the LGM pCO_2.

There is evidence from casting d18O as a conservative tracer that the ratio of transport to mixing in the deep Southern Ocean was much larger during the LGM. I interpret this measurement as indicating vertical mixing was lower during the glacial and explore two possible ways this could have come about. Both shoaling of the interface between northern and southern sourced deep waters to lie above the rough topography of the mid-ocean ridges, and the filling of the ocean with cold-salty bottom water can lead to much lower values of deep ocean mixing. With a simple box model I will explore the effects of reduced mixing on pCO_2 in the atmosphere and the carbonate ion content of the deep-sea. Finally, I will propose a hypothesis for how a deep ocean teleconnection around Antarctica, that mechanistically links the density contrast between the northern and southern deep ocean cells, can follow a northern high latitute summer time pace maker and lead from interglacials to glacials. The new theory, however, does not explicitly give rise to terminations.