Improving our understanding of the marine biotic response to anthropogenic CO₂ emissions

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During recent years, ocean acidification (OA) has rushed onto the global change agenda as a global-scale consequence of rising atmospheric CO₂ levels. Biotic responses to changing ocean carbonate chemistry are expected to impact ecosystems, feedback on global climate, and eventually affect socioeconomies. However, our knowledge about the nature of biotic responses to OA is still too limited to quantify their impacts (see also report on IGBP-SCOR Fast Track Initiative workshop in Lamont, 2006; PAGES News, 14:3, 29-30). Therefore, the European Science Foundation (ESF) EuroCLIMATE program, with co-sponsoring from PAGES, organized the Barcelona workshop to bring together a diverse range of experts to review knowledge of the likely effects of OA on planktonic calcifying organisms and marine biogeochemistry. Five sessions addressed 1) Biocalcification mechanisms, 2) Genetics and physiology, 3) Ecology and biogeography, 4) Lessons from the fossil record, and 5) OA in the Mediterranean.

Here, we focus on the fossil record and what can be learned from it about responses and effects of marine biota and ecological systems. More comprehensive reports are published in The Eggs (Ziveri et al., 2007) and Eos (Ziveri et al., 2008). Case studies, ranging from the onset of the Cenozoic era to the recent past, featured a range of perturbations of the carbon system:

Daniela Schmidt (University of Bristol) presented data from the Cretaceous/Paleogene (K-Pg) Boundary (~65 Myr ago), and suggested that the major environmental and climatic changes included abrupt OA (Fig. 1). A drop in average foraminiferal test size and a shift of the carbonate production from coccolithophore- to foraminifera-domination demonstrate profound changes in plankton composition. A decrease in carbonate accumulation at this time is related to a reduction in calcification rather than increased dissolution at the sea floor. Recovery of the carbonate production took several million years.

The Paleocene-Eocene Thermal Maximum (PETM), a rapid OA event ~55 Myr ago, was the subject of presentations by Jim Zachos (University of Santa Cruz) in a public lecture and by Heather Stoll (University of Oviedo). Stoll showed new evidence from the Southern Ocean (a region particularly sensitive to the effects of OA) of distinct shifts in plankton assemblage at the PETM, with an increase in the presence of species generally more suited to warmer conditions and less susceptible to dissolution (Fig. 2). Furthermore, coccolith Sr/Ca data provide some evidence that coccolithophore production may have peaked during the PETM in the Southern Ocean.

Significant deepening of the calcite lysocline and carbonate compensation depth during the Eocene-Oligocene (E-O) boundary (~34 Myr) reveals a whole ocean ‘reverse’ acidification event associated with the first major growth of ice sheets on Antarctica. Based on tests with a biogeochemical ocean box model, Toby Tyrrell (University of Southampton) discussed sea-level fall due to the ice sheet growth and a consequent shift of carbonate deposition from shallow shelf reef areas to the deep sea as the favored explanation of these changes in carbonate chemistry.

Figure 1: The Cretaceous/Paleogene (K-Pg) boundary at Walvis Ridge Ocean Drilling PAEGRAM Site 1262. The boundary is characterized by a drop in carbonate accumulation and an increase in clay, iron oxide and volcanic ash accumulation, which produced distinctive increases in magnetic susceptibility and color reflectance (lightness L*). A percentage increase of the coarse fraction reflects the shift in dominant carbonate producers from coccolithophores to foraminifera. Figures after

Figure 2: Color reflectance (L*) and carbonate accumulation (mm/kyr) at Walvis Ridge Ocean Drilling PAEGRAM Site 1262. The PETM (~55 Myr ago) is marked by a drop in carbonate accumulation and a shift in plankton assemblage to species better suited to warmer conditions and less susceptible to dissolution.
Oceanography and Climate Change: Past, present and future scenarios

Austral Summer Institute VIII, Dichato, Chile, 7-14 January 2008

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The Austral Summer Institute VIII on “Oceanography and Climate Change: Past, present and future scenarios” was held in Dichato, Chile, from 7 – 14th January 2008. Twenty students were selected from 92 applicants to participate in the workshop, which also involved the participation of word-class lecturers.

The first week focused on two key topics:

1) El Niño Southern Oscillation, theory, observations and predictions was lectured by Dr. Axel Timmerman, from the University of Hawaii. Lectures were complemented with computer-based exercises and homework, including ocean and atmosphere data analyses and simple model runs for ENSO predictions.

2) The role of the thermohaline circulation on the Earth’s climate was lectured by Dr. Andrey Ganopolsky from the Potsdam Institute for Climate Impact Research. This included a discussion of climate consequences in modern times.