IGBP - SCOR Fast Track Initiative "Ocean Acidification"

Atmospheric CO_2 and ocean biogeochemistry: modern observations and past experiences

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Organisations involved:
SOLAS, IMBER, LOICZ, GLOBEC, IOCCP, GCP, IMAGES, IGBP, SCOR, PAGES

Overarching Question: What can we learn from past changes in the Earth system to better understand the consequences of ongoing ocean acidification?

Background

The atmospheric concentration of carbon dioxide is now higher than experienced on Earth for at least the last 400,000 years, and presumably the last several million years. Moreover, the current rate of CO_2 rise of 1.1 ppm/year exceeds even the relatively rapid increases at transitions from glacial to interglacial periods by about two orders of magnitude. As a direct effect of rising CO_2, global temperatures are predicted to increase by several degrees during this century. Another, less highlighted consequence will be increased surface ocean pCO_2 and a lowering of the pH of the surface ocean. For example, as atmospheric CO_2-levels will double over their pre-industrial values by the middle of this century, the accompanying surface ocean pH changes are expected to be three times greater than those experienced during glacial to interglacial transitions.

Many questions on the effect of increasing atmospheric CO_2 on ocean chemistry and marine life are unanswered or cannot be answered quantitatively. These include a robust prediction of changes in ocean carbonate chemistry, the buffering effect of carbonate sediments, the effect of weathering rates and fluvial input, the feedback with the plankton community, in particular carbonate producers, the effect on overall marine production, including fish, the tolerance of corals to changing water chemistry, and others. There have

been recent initiatives (e.g. SCOR-IOC symposium "The ocean in a high CO_2 world", Royal Society study on surface ocean acidification, and an NSF/NOAA/USGS sponsored workshop on impacts of increasing CO_2 on marine calcifiers) to approach these questions mainly on the basis of oceanographic observations and modelling. However, modern day observations are fundamentally limited by the small range of CO_2 variations that can be observed naturally. On the other hand, lab experiments and model simulations are limited by the requirement to simplify the complexity of the atmosphere-ocean-biosphere system.

One way around this dilemma is to complement modern observations and modelling results with palaeoenvironmental reconstructions from earth historic periods of major atmospheric CO_2 changes. It is clear that there is no perfect palaeo-analogue to the greenhouse scenario predicted for the next decades and centuries, in terms of absolute CO_2 level and rate and magnitude of CO_2 rise. Nevertheless, the record of Earth's history contains periods of rapidly rising and/or persistently high atmospheric CO_2 levels, which provide opportunities to observe earth system responses in a range of scenarios. Therefore the proposed FTI could address long and short-term changes in past ocean biogeochemistry over the last 100 million years with a focus on particular periods in Earth history; among others for example

(i) The seven glacial-interglacial transitions of the last 650,000 years, where atmospheric CO_2 repeatedly increased by up to 100 ppm (40%), accompanied by a surface ocean pH decrease of the order of 0.15 units.
(ii) The Eocene change in carbonate compensation depth.
(iii) The Paleocene Eocene Thermal Maximum 55 million years ago, where abrupt processes (e.g. massive release and oxidation of methane hydrates) resulted in a transient CO_2 increase of the order of several hundred ppm, presumably at a high rate that approximates the present situation. This event also provides the opportunity to observe recovery times of the earth system to a CO_2 perturbation.
(iv) The middle Cretaceous ~100-80 million years ago as an example of an extreme and lasting Greenhouse world with estimated atmospheric CO_2 concentrations three to ten times higher than present.

Objectives

The main purpose of this cross-disciplinary IGBP-SCOR FTI is to apply insights gained from paleo-environmental reconstruction and analysis to improve our understanding of the potential consequences for the marine environment of the chemical effects of future CO_2 emissions. This FTI will also help those working on paleo-environmental studies to understand what kinds of research would have the greatest potential to improve our understanding of the future. Thus, this FTI will promote communication across disciplinary boundaries, allowing cross-fertilization to occur between those working on paleo-environmental problems and those working on problems associated with effects of human activities.

Timeline

September 28-30, 2006: First workshop to define state of art, burning questions, recommendations, deliverables within following year, and publication outlines
December 2006: EOS report, newsletter reports
Late 2007: Second workshop for synthesis
2008: Publication of special issue and synthesis publication(s)

Planned peer-reviewed products

EOS article(s) on workshop results
Special issue/special section, e.g. in Global Biogeochemical Cycles
Higher profile synthesis publication(s)

Key scientific areas

Marine Biology, Marine Geochemistry, Atmospheric Chemistry, Paleoceanography, Biogeochemistry

First IGBP – SCOR FTI Workshop on
"Ocean Acidification - modern observations and past experiences"

Location: Lamont-Doherty Earth Observatory of Columbia University
Date: 28 September (morning) - 30 September (afternoon) 2006
Participants: Up to 50 researchers working on ocean acidification on present and on past timescales, covering a broad range of expertise on marine biogeochemistry.

Objectives:
The workshop will address specific questions, which break down the overarching general question on the consequences of ongoing ocean acidification (see definition of this FTI) into manageable tasks. The objective will be to define the state of the art answers to these questions, to work out recommendations for the communities, to define deliverables for this particular Fast-Track Initiative within the following year, and to outline group papers.

Scientific themes and questions:
(1) What are the predicted changes (and uncertainties) in marine geochemistry (pH, seawater chemistry, CCD etc.) for various future CO_2 emission scenarios?
(2) What were amounts and rates of change in ocean geochemistry in response to changes in atmospheric CO_2 as inferred from the geological record?
(3) What processes were responsible for past changes in ocean acidification?
(4) What do present-day studies tell us about the response of biota to changes in ocean chemistry (biomineralisation and other biological processes)?
(5) What does the fossil record reveal about the adaptation of marine biota to changes in ocean acidification?

Workshop structure:
Days 1 and 2 – (A) Overview presentations: State of the art of fields related to the above questions. – (B) Breakout into two specialist working groups (according to key questions) consisting of a mix of present-day and paleo-researchers, observationalists and modellers. Groups try to answer the questions, identify the knowledge gaps limiting the answers, and work out what kind of synergetic research could produce better answers.
Day 3 – Presentation and discussion of group results with the entire workshop; synthesis; strategy for publishing, follow-up activities and second workshop.

Publications on this particular workshop:
-- EOS article(s) on workshop results and recommendations.
-- Reports in newsletters of the IGBP and SCOR networks.
(A special issue or special section and higher profile publication are planned as a product of the entire FTI after the second workshop 2007.)

Participation:
The diversity of the approach (paleoclimatology, ocean chemistry, carbon system modelling, physiology, environmental and evolutionary biology, biogeochemistry, etc.) and of time scales will require participation of scientists from various disciplines. The workshop will have 30-50 participants in total with some places being still available. If you are interested to attend the workshop, please send us your brief application by 31 July (email to Thorsten Kiefer, kiefer@pages.unibe.ch).

The application should contain
- a paragraph on your interest in the workshop and
- a paragraph plus references on your expertise on the ocean acidification theme.

Participants will be selected by the Program Committee. There will be no workshop fee but travel and accommodation costs need to be paid for by general participants.

The following people have already confirmed their attendance:
Saber Al-Rousan, David Archer, Steve Barker, Franck Bassinot, Jelle Bijma, Wally Broecker, Ken Caldeira, Harry Elderfield, Jonathan Erez, Kunsan Gao, Jean-Pierre Gattuso, Bärbel Hönisch, Joanie Kleypas, Chris Langdon, Kitack Lee, Bradley Opdyke, Jim Orr, Mark Pagani, Don Potts, Rengaswamy Ramesh, John Raven, Andy Ridgwell, Ulf Riebesell, George Stanley, Ellen Thomas, Rodrigo Torres, Jim Zachos, Richard Zeebe, Ed Urban (SCOR), Beatriz Balino (IGBP), Thorsten Kiefer (PAGES)

If you are confirmed as an attendee and need an invitation letter for your visa application, please email Leah Christen-Witton (leah.christen-witton@pages.unibe.ch).

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