excess heat storage in glacial AAIW would have reduced the energy available for heating the atmosphere in the sub-/polar Southern Hemisphere and consequently attenuated the millennial-scale warm events over Antarctica. Second, by temporarily warming glacial AAIW, the amount of energy/heat available for equilibrating interhemispheric energy imbalances was reduced. This supports the notion that excess heat storage in glacial AAIW might have been instrumental in maintaining cold conditions in the North Atlantic.

The timing of the glacial AAIW warm events seems to point to a specific sensitivity of the climate system as a whole to changes in AAIW formation. It is currently difficult to substantiate the specific role of AAIW in the bipolar seesaw. Given the mounting evidence reflecting the wider significance of Southern Hemisphere climate change, it is increasingly likely that variations in the ocean-atmosphere dynamics in this part of the world exert a profound control on climate change on a global scale. This would contrast with the view of a rather "passive" role of the Southern Hemisphere, i.e., largely responding to climate changes triggered elsewhere.

Data

Data are stored at the National Climate Date Center, Boulder, Colorado (http://www.ncdc.noaa.gov/paleo/data.html).

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For full references please consult:
http://www.pages-igbp.org/products/newsletters/ref2010_1.html

The 2nd PAGES past interglacials workshop

Mytilene, Greece, 24-27 August 2009

Chronis Tzedakis[1,2], D. Raynaud[3] and J.F. McManus[4]

[1]Department of Geography, University College London, UK; p.c.tzedakis@ucl.ac.uk; [2]Department of Environment, University of the Aegean, Mytilene, Greece; [3]Laboratoire de Glaciologie et Géophysique de l'Environnement, Grenoble, France; [4]Lamont-Doherty Earth Observatory, Columbia University, USA

PAST INTERGLACIALS

In the context of future climate change, there is a need to understand the sensitivity of the Earth System to different forcings. Though not strict analogues for an anthropogenic future, past interglacials can be thought of as a series of natural experiments in which boundary conditions varied considerably, with consequent effects on the character of climate change. Their examination, therefore, can provide a more complete view of the range and underlying physics of natural climate variability. Examination of the paleoclimate record reveals a large diversity between interglacials in terms of their intensity, duration and internal variability. This raises fundamental questions about the Earth's climate, but a general theory accounting for the occurrence of interglacials with differing characteristics remains elusive (Tzedakis et al., 2009). This has provided the impetus for a comprehensive comparison of interglacials of the last 800 ka within the context of the PAGES Working Group on Past Interglacials (PIGS).

The first PIGS workshop, held at Bernin, France, 2-4 October 2008, defined specific priority topics, which would form the themes of three subsequent workshops: (1) intra-interglacial variability; (2) magnitude and duration of interglacials; and (3) explaining the structure of interglacials from the forcing. The overall aim is to integrate the various themes emerging from the workshops in order to arrive at an improved understanding of the factors determining interglacial diversity.

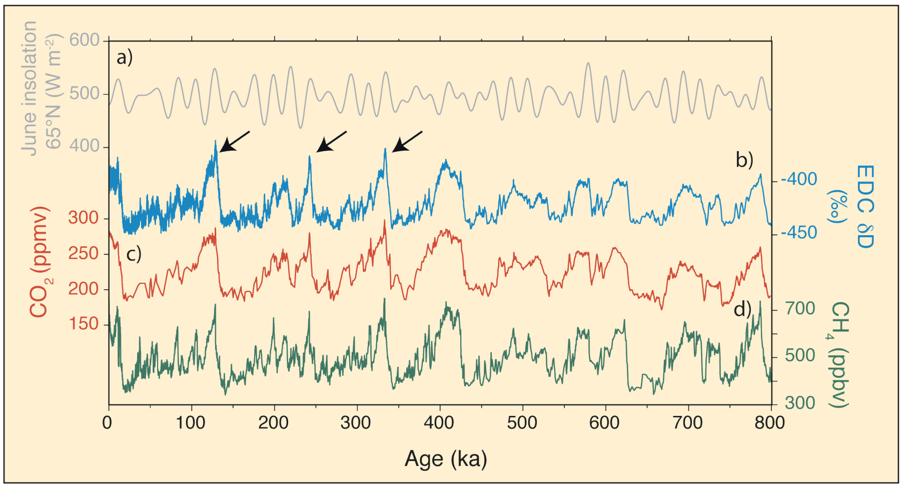

*Figure 1: EPICA Dome C (EDC) ice core records plotted against **a**) June insolation for 65°N (Berger, 1978). EDC records are (**b**) deuterium (δD) composition of the ice (Jouzel et al., 2007); (**c**) atmospheric CO_2 concentration (Lüthi et al., 2008); (**d**) atmospheric CH_4 concentration (Loulergue et al., 2008). Black arrows indicate relatively short-lived maxima in temperature (δD) and greenhouse gas concentrations that were discussed in depth at the meeting.*

At the second PIGS workshop held at the University of the Aegean, on the Island of Lesvos (24 - 27 August, 2009), 25 scientists from 10 countries (including 2 PhD students, 3 young scientists, and 7 newcomers to PIGS), representing the marine, ice core, terrestrial and modeling communities, met to assess our current understanding of the following issues: (i) evidence for intra-interglacial variability; (ii) (relative) timing and local or regional significance of reported events; (iii) transient jumps and declines in temperature and greenhouse gas (GHG) concentrations at the onset of interglacials (Fig. 1); (iv) comparison of interglacial and glacial climate instability.

The first day focused on general considerations of interglacial trends and variability. Ice core data (Antarctic temperatures and GHGs) were examined first, along with atmospheric CO_2 reconstructions beyond 800 ka. This was followed by presentations of modeling results of interglacial climates and simulations of CO_2 concentrations. After a presentation of the potential of specific molecular markers to reconstruct paleofires, the discussion moved to an evaluation of interglacial climate (in)stability and associated mechanisms from paleoceanographic data and reviews from the Mediterranean and the tropical Pacific, as well as sea-level reconstructions.

The presentations of the second day focused on specific case studies: Holocene millennial-scale oscillations in ocean circulation both from data and modeling perspectives were considered first. This was followed by an examination of the role of millennial-scale variability as an intrinsic feature of the past five terminations. Marine and ice core data from MIS 5e and 11 were presented next, along with a general consideration of Antarctic variability within interglacial periods. After a discussion of new simulations of Last Interglacial climates, the presentations ended with an examination of interglacial climate oscillations in speleothem and long pollen records from southern Europe.

Two major themes were identified during discussions, and these will now form the focus of two separate projects. One will emphasize the importance of rigorous statistical treatment of intra-interglacial variability and its relationship to mean global state. The other will examine the role of higher frequency variability in orbital-scale changes such as deglaciations (or interglacial inceptions).

The third PIGS workshop will be hosted by Jerry McManus and take place later this year in the U.S. (exact place and time to be appointed). This workshop will focus on the duration of interglacials.

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Understanding future sea level rise: The challenges of dating past interglacials

PALSEA

PALSEA workshop, Woods Hole, USA, 20-25 September 2009

WILLIAM G. THOMPSON[1], M.B. ANDERSEN[2], A. DUTTON[3] AND M. SIDDALL[2]

[1]Woods Hole Oceanographic Institution, Woods Hole, USA; wthompson@whoi.edu

[2]University of Bristol, UK; [3]The Australia National University, Canberra, Australia

The aim of the joint PAGES-IMAGES Working Group "Paleo-constraints on sea-level rise" (PALSEA; www.climate.unibe.ch/~siddall/working_group.html) is to extract information about ice sheet response to temperature change from the history of sea level over the Quaternary, particularly interglacial periods, within a range of temperatures bracketing the modern. A better understanding of the relationship between global temperature and sea level is crucial for projections of future sea level rise expected from global warming. Currently, substantial uncertainty exists for such projections, primarily due to a lack of understanding about ice sheet dynamics. The 2nd PALSEA workshop focused on challenges in uranium-thorium (U-Th) coral dating, with discussions centered on three themes: technical issues in U-Th mass spectrometry, open-system behavior of U-series nuclides, and development of a Quaternary sea level database.

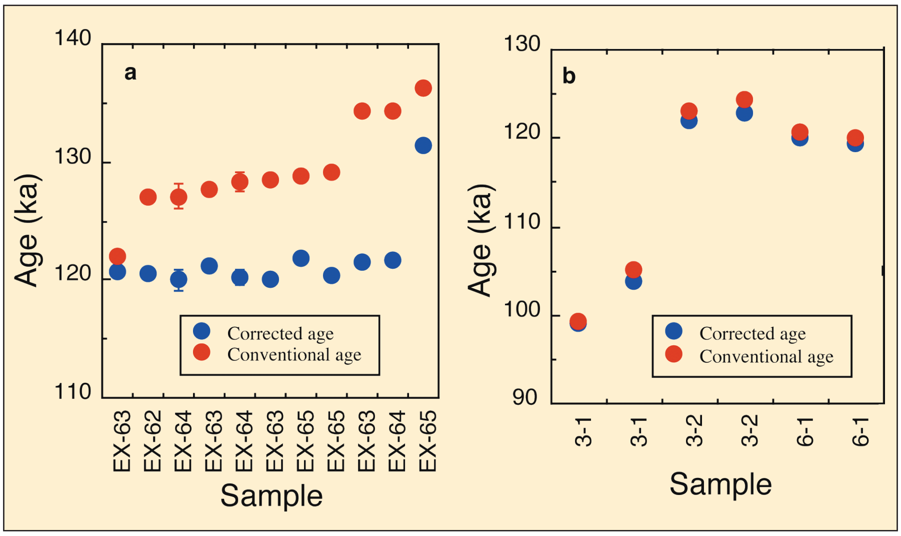

*Figure 1: The impact of open-system processes on coral ages (Thompson, unpublished data): **a**) Discrete sample replicates from a single large Western Australian head coral. Conventional ages range from 122 to 136 ka. Corrected ages cluster tightly at 121 ± 1 ka (mean and 2 SD), with the exception of one age at 131 ka. **b**) Ages from a Caribbean Last Interglacial reef outcrop (3 corals; 2 replicates each). Initial uranium isotope ratios fall between 1.147 and 1.151, satisfying a 'strictly reliable' screening criterion. However, one coral age is ~ 20 ka younger than it should be and reproduces poorly, due to late uranium addition. These two examples illustrate that neither rigorous screening criteria nor correction methods succeed in producing accurate ages in every case, highlighting the importance of replicating ages from discrete pieces of the same coral and comparing ages with stratigraphic observations from the field as an additional means of excluding erroneous ages.*

Analytical developments

Developments in mass spectrometry continue to improve coral age precision and extend the range of the U-Th geochronometer (Andersen et al., 2008). As a result, assuring comparability of ages reported by different labs is crucial. Ideally, all measurements should be traceable to the same set of reference standards. Unfortunately, internationally recognized standards are not currently available. A widely used U/Th uraninite reference standard, HU-1, is now in short supply and may no longer be suitable as a reference standard, as different aliquots have different isotope ratios when measured at current levels of precision and the assumption of radioactive equilibrium no longer appears valid. The time is ripe for the development of new standards. As a result of workshop discussions, a strategy for their production and distribution has been initiated in collaboration with the National Environment Research Council's Geosciences Laboratory, UK, drawing on the experiences of the EARTHTIME project (www.earth-time.org). As part of the workshop, an informal U-Th dating inter-lab comparison involving 14 labs was run. This exercise provided extremely useful information for the participants and a more comprehensive intercomparison is being planned.

Open-system effects

The impact of open-system behavior of U-series isotopes on the quality of coral ages is well documented, and both sample screening (Gallup et al., 1994) and age correction (Thompson et al., 2003) methods are employed to alleviate this problem. While practices for sample screening and/or age correction are still keenly debated, workshop participants agreed on a number of key points: 1) It is clear that many corals yield ages that do not agree within