

rainfall reconstruction from *Callitris* tree-rings. After the presentations, there was an open discussion of common themes and the challenges facing the groups working in the region. Key issues raised during this session included the strategic sampling of key lake sequences before they are lost to the current drought in Australia, proposed development of sub-regional reconstructions, determining the stability of teleconnections over time, clarifying the seasonality of the signal preserved within different proxies, the challenge of calibration against contemporary climate given recent land use changes, and the extension of records both forwards and backwards in time. Furthermore, several presentations reported asynchronous temporal and spatial temperature and precipitation trends when compared to those in the Northern Hemisphere over much of the past 2 ka, raising the question of whether the use of such terms as the "Medieval Warm Period/Anomaly" and the "Little Ice Age" are appropriate when referring to the Australasian region. Further work is needed to gain a consensus on this issue. Presentations also highlighted that more effort is needed to develop proxies from this region if we are to get good enough resolution to comment on the past millennium with adequate spatial coverage.

On the second day, presentations and posters focusing on multiproxy reconstructions and modeling work across the region were given and their policy relevance discussed. A broader discussion then took place on how the data might be most effectively collected. After exploring a range of options, it was agreed that the community would collate only published (or directly publishable) data (using both raw and quantified analyses) from each of the different archives, with a full estimate of the uncertainties included and an agreement that objective criteria for the final selection of records must be developed prior to the generation of final reconstructions (in consultation with other regional 2k groups). Qualitative, lower resolution data will also be utilized as an independent check on reconstructed high resolution variability. On the third day, these issues were explored in greater detail and individuals were identified who would lead the collection of data from each proxy group by mid April 2011.

As a starting point, the group was encouraged to develop an Aus2k metadata-base hosted on the PAGES Aus2k website (<http://www.pages.unibe.ch/science/2k/aus2k/index.html>), to develop an inventory of records that are currently available and/or being actively developed in the Australasian region. Following the meeting, a small-scale proposal was submitted

to the Australian Government to fund a research fellow, who will develop a quantitative database of the records listed on the website. This will allow all members of Aus2k to access the database and develop the suite of climate reconstructions needed for the region. Qualitative, lower resolution data will also be utilized as an independent check on reconstructed high resolution variability (Fig 1).

The second Aus2k workshop will be hosted by Pauline Grierson and take place in the first half of 2011 (most likely in Perth). This workshop will focus on combining the collated datasets to generate reconstructions of different climate variables for the Australasian region and identify future reconstruction needs to capture the full 2k period.

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The nitrogen cycle in the ocean, past and present

1st NICOPP Workshop, Montreal, Canada, 14-16 May 2010

ERIC GALBRAITH¹, M. KIENAST² AND T. KIEFER³

¹Earth and Planetary Sciences, McGill University, Montreal, Canada; eric.galbraith@mcgill.ca

²Department of Oceanography, Dalhousie University, Halifax, Canada; ³PAGES International Project Office, Bern, Switzerland

Some three decades after the first measurements of nitrogen isotopes ($\delta^{15}\text{N}$) were made in the marine environment, 27 nitrogen enthusiasts from nine nations congregated on the verdant flanks of Mount Royal, in Montreal. This meeting represented the first for the PAGES Working Group "Nitrogen cycle in the ocean, past and present" (NICOPP). Over three days, this group discussed recent findings, summarized the state of knowledge, and highlighted outstanding challenges related to the use of sedimentary $\delta^{15}\text{N}$ as a tracer of the marine nitrogen cycle. From a series of stimulating talks and enthusiastic discussions, three overarching topics emerged.

Seeing the big picture

While some areas of the ocean are dominated by either water column denitrification, nitrate utilization, or N_2 fixation (Fig.

1), overlap between these processes can produce complex spatial patterns in nitrogen isotopes, apparent in simulations with coupled ocean-biogeochemistry models. As a result, isolated sediment records can be deceiving, as any one is likely to be a time-varying amalgam of all three processes. However, when assembled, records show coherent changes over time even in complex regions, with clear relationships to their oceanographic contexts, allowing the multiple processes to be disentangled. Accordingly, it was resolved by the NICOPP Working Group to amass a global database of all available bulk sediment N isotope measurements, to help move beyond the ambiguity of isolated wiggly lines.

The devil's in the details

There has been considerable concern, over the decades, regarding just what N

isotopes in marine sediments represent. The hopeful interpretation is that bulk combustible nitrogen, an easily measured quantity, represents the isotopic composition of the integrated marine organic export flux. However, isotopic alteration during sinking and burial, and contributions from terrestrial nitrogen, have been shown to modify the bulk isotope record in some environments. To account for these secondary influences, measurements are being made in a growing number of sedimentary fractions and specific compounds. These include the organic nitrogen trapped within microfossils, corals, chlorophyll and amino acids, as well as inorganic nitrogen. The results, so far, reveal new dimensions of complexity, as these individual components can vary with species assemblages, growth conditions, and trophic structures; yet, they often parallel



the bulk sediment $\delta^{15}\text{N}$ records. These observations point to the potential of these targeted measurements to complement the bulk N isotope records: where the two agree, the story is straightforward for both (Fig. 1b). Where they don't agree, the specific measurements can reveal changes in the surface ecosystem, alteration of the bulk record, or both. The emerging picture is that bulk organic records are more representative of the export flux than was thought a few years ago. Given the relative ease of measuring bulk sediment $\delta^{15}\text{N}$, this is good news.

Taking inventory

A primary motivation behind sedimentary nitrogen isotope research is to understand the coupling between the marine N inventory and climate. A lot of progress has been made, most notably in developing the notion of enhanced water column denitrification and N_2 fixation during warm periods (Fig. 1). However, newly identified issues complicate the translation of sedimentary nitrogen isotope records into quantitative constraints on the marine N inventory. At the forefront of these is the anaerobic oxidation of ammonium by nitrite to yield N_2 (anammox). New measurements from culture experiments show that the anammox isotope effect is distinct from that of canonical (i.e., heterotrophic) denitrification. Problems aside, perhaps the most useful single quantity to track through time would be the isotopic composition of mean ocean nitrate. Although the availability of such a record remains elusive, efforts toward a global synthesis should prove a step in the right direction.

The second NICOPP workshop will include a broader range of nitrogen cycling processes and will be held in Halifax, Canada in 2011. In the meantime, a catalog of published bulk sediment $\delta^{15}\text{N}$ records has

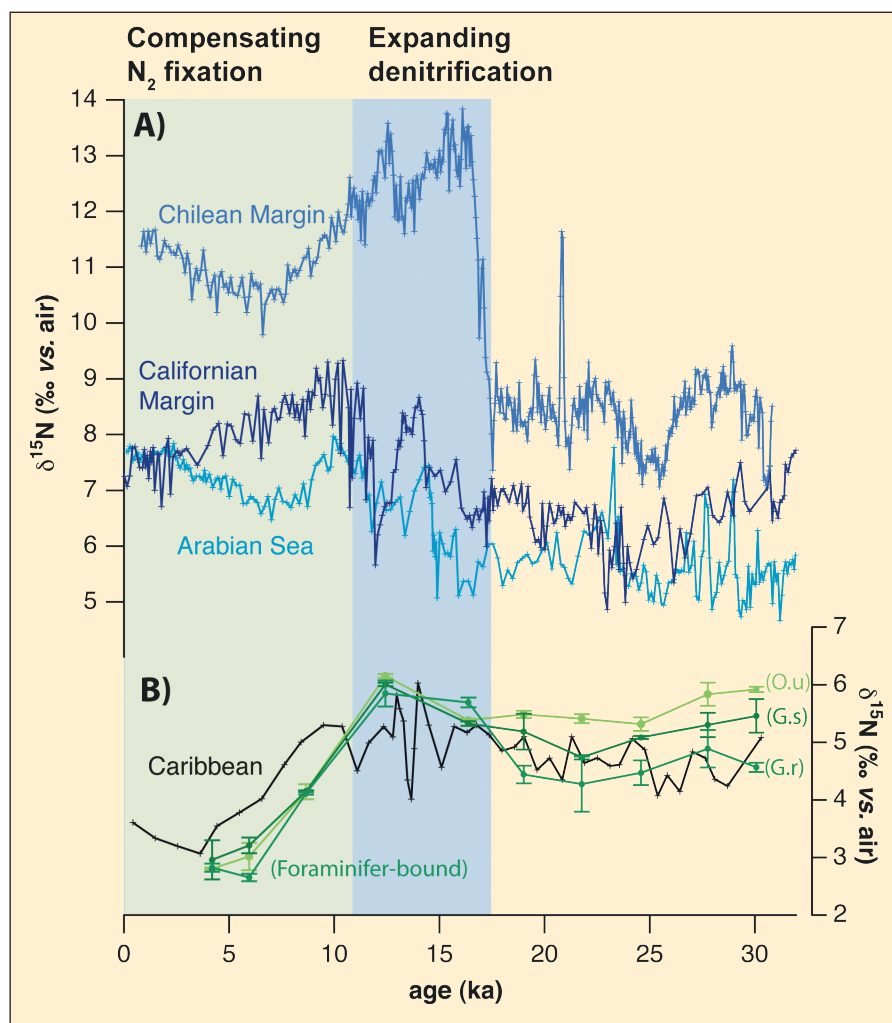


Figure 1: Sedimentary records of bulk and microfossil-bound $\delta^{15}\text{N}$ since the last glacial maximum (after Ren et al., 2009). **A)** Bulk sediment $\delta^{15}\text{N}$ records from each of the three major oceanic denitrification zones (Chilean Margin, Californian Margin, Arabian Sea) increased between 12–18 ka, although with local nuances. **B)** Bulk sediment record (black) from the Caribbean Cariaco Basin and three foraminifera-bound $\delta^{15}\text{N}$ records (O.u = *Orbulina universa*, G.s = *Globigerinoides sacculifer*, G.r = *G. ruber*) from the open Caribbean. N_2 -fixation is very active in both Caribbean regions today. The bulk and microfossil-bound records of the Caribbean reveal an opposite sense of change to that of the oxygen-minimum zones in panel A, consistent with the notion that deglacial warming drove an increase of denitrification that was then compensated by a delayed increase of N_2 fixation.

been developed: <http://www.pages-igbp.org/cgi-bin/WebObjects/metadb.woa/wa/map?group=nitrogen>. All investigators with relevant data are encouraged to contact eric.galbraith@mcgill.ca for inclusion in the global database, which will ul-

timately be available as a data product in multiple formats.

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The first Africa 2k regional workshop

Ghent, Belgium, 11–14 May 2010

MOHAMMED UMER¹ AND DIRK VERSCHUREN²

¹Department of Earth Sciences, College of Natural Sciences, Addis Ababa University, Ethiopia; moha_umer@yahoo.com

²Limnology Unit, Department of Biology, Ghent University, Belgium

The first workshop of the PAGES Africa 2k Working Group was a small, focused workshop, hosted by Dirk Verschuren in Ghent and attended by all Working Group members (see <http://www.pages.unibe.ch/science/2k/africa2k/people.html>). May 12 was dedicated to presentations and May 13 was for discussions. The workshop was opened by Louise Newman (PAGES IPO) who presented the PAGES Regional

2k Network, as well as issues relating to the geographical boundaries of each focal region, critical time intervals, deadlines on expected outcomes and the development of metadatasets. The first formal presentation, by Sharon Nicholson, dealt with the spatial patterns of African climate anomalies associated with important drivers of tropical climate variability. The ensuing presentations dealt with sets of paleodata

currently available from various regions of sub-Saharan Africa. These included precipitation patterns from documentary and gauge station data (Sharon Nicholson); 19th century documentary evidence of precipitation variability in South Africa (David Nash); a regional synthesis of records spanning the West African monsoon domain (Tim Shanahan); anthropogenic versus climatic impacts on paleoenviron-