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PAGES
PAST GLOBAL CHANGES

NEWS OF THE INTERNATIONAL PALEOSCIENCE COMMUNITY

A CORE PROJECT OF THE INTERNATIONAL GEOSPHERE-BIOSPHERE PROGRAMME **IGBP**

PAGES TIMESTREAM 2 – LONG RECORDS

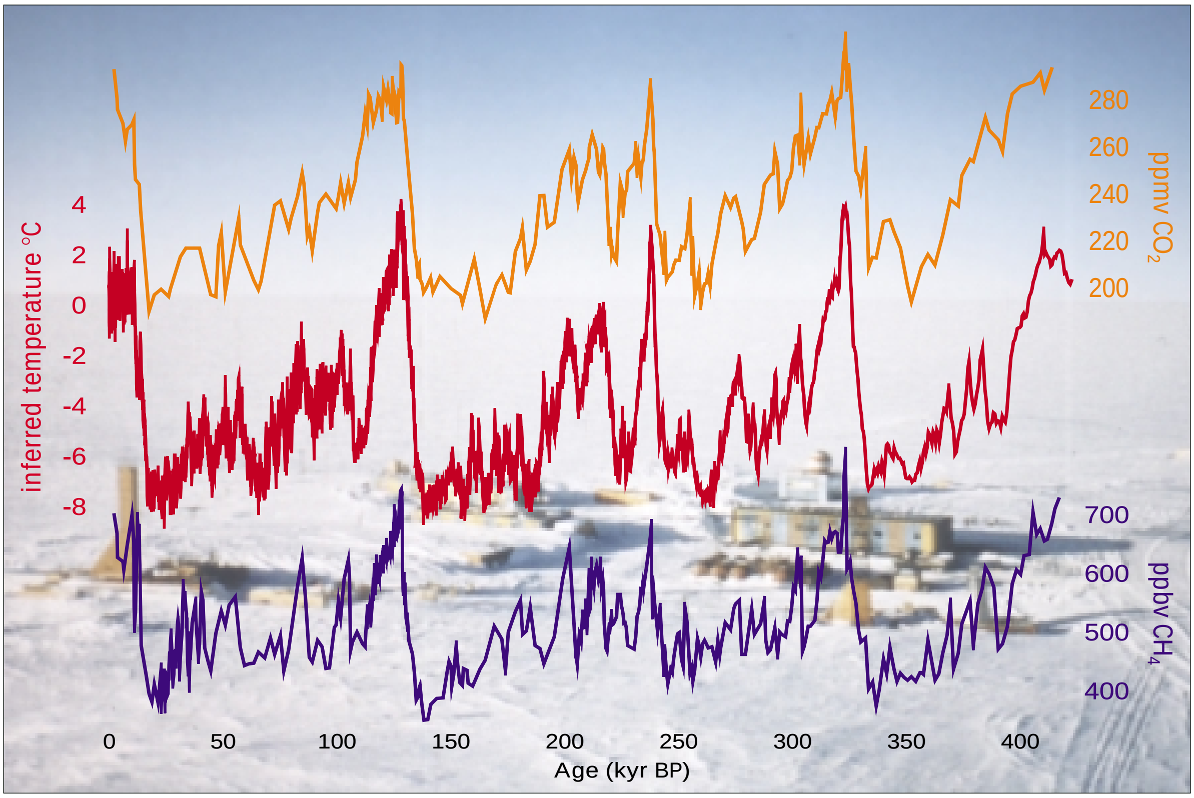

Figure 1: The sequence of changes in atmospheric CO_2, isotopically inferred temperature and CH_4 as recorded in the Vostok ice core. The record is 420,000 years long, comprising nearly 4 complete glacial cycles. Each cycle shows similar structure in terms of its termination as well as glacial period oscillations between relatively stable bounds. The interglacial periods are quite variable in their duration and evolution. The record also shows that modern levels of concentration of the greenhouse gasses CO_2 and CH_4 are unprecedented over the entire record. For a detailed report of these measurements see Petit et al., (Nature, 399, 429–36, 1999). A version of this figure is available in the PAGES transparency set (see last page, "Have You Seen…") The background image shows the Vostok research station in Antarctica (Photo: Todd Sowers).

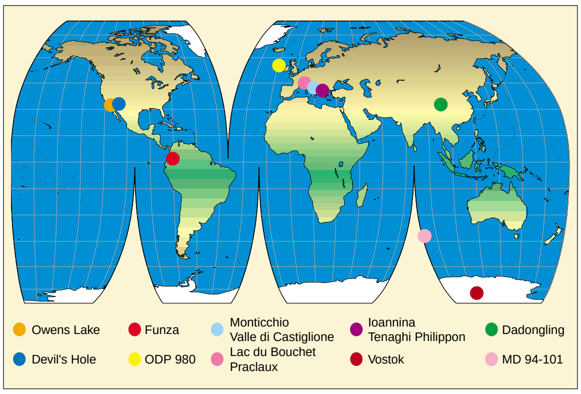

Figure 2: Site map of long records discussed in this issue

The magnificent initial results from the four-cycle Vostok record have prompted us to devote much of the present issue to a variety of long records, each spanning at least one, and usually more than one glacial cycle. The emphasis is perhaps biased towards 'terrestrial' records, partly because they are so diverse in terms of locations, archives and proxies, partly because they reflect the work of a rather dispersed research community, the combined efforts of which are less often gathered together to illustrate their value and interest. The examples chosen (see site map, figure 2) are illustrative and make no claim to be an informed selection of the 'best' records, so we trust those colleagues who feel spurned will both forgive our

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EDITORIAL

National PAGES Meetings

Several countries have organized formal or informal PAGES groups. In some cases, these are linked to the PAGES representative on the national IGBP committee. In other cases, they are less formally linked to the IGBP structure. A recent meeting of the Swedish PAGES community, held near Lund and organized by Barbara Wohlfarth, the PAGES representative on the Swedish national IGBP committee, provided an excellent illustration of the value of such groups and of the kind of meeting that can be organized. Other national meetings are already scheduled:

- as a result of broadly based local initiatives (for example the meeting in Prague, Czech Republic, Sept. 6–9, 2000)
- through the actions of the PAGES representative on the national IGBP Committee (for example the planned UK meeting, March 10, 2000)
- through close collaboration between the PAGES IPO and local organizers (for example that in Pune, India, February 4–5, 2000, linked to a meeting of the PAGES Scientific Steering Committee).

From a personal perspective, based largely on experience of the Lund meeting, I would see as highly desirable elements of any national meeting, at least the following:

- Close involvement of active, young researchers in every aspect of the program
- Liaison in advance with the PAGES Office to ensure the best possible interaction between national initiatives and the PAGES program as a whole
- Enough discussion time during the meeting to allow the airing of new ideas and forward-looking research agendas
- Participation by representatives of the appropriate national funding councils
- Lively, high quality poster sessions

Much funding for PAGES research is obtained at national level so national meetings can help to raise the profile of PAGES-related research and improve the climate of opinion within which judgements on the quality of the research are made – as well as providing a forum for making personal contacts and exchanging views. PAGES welcomes initiatives at national levels and will do all it can to support meetings that arise through such initiatives.

Frank Oldfield

continued from front page

sins of omission and benefit from the demonstration effect of the records that have been included.

We look forward to being able to present comparable long records from Africa as an outcome of the second international symposium of the IDEAL project, 10–13 January, 2000 in Malawi and the PEP III open science meeting “Past Climate Variability in Europe and Africa”, 27–31 August, 2001 in Aix-en-Provence, France. (*www.pages.unibe.ch/calendar/calendar.html*). Similarly, inclusion of long marine and continental records from the Austral-Asian region awaits output from the PEP II meeting, probably to be held in Singapore in September, 2000. One longer term goal must be the refinement of independent chronologies wherever possible (for example Allen and Huntley in this issue, figure 7). Only in this way will it become possible to explore usefully the question of phase lags and response times, the understanding of which is often precluded by our current degree of dependence on ‘tuned’ chronologies.

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WORKSHOP ANNOUNCEMENTS

Paleograssland Research 2000

WESTBROOK, CT, USA, 1–3 JUNE, 2000,

A conference on the reconstruction and modelling of grass-dominated biomes

Paleograssland Research 2000 will bring together international researchers to synthesize an informed multi-proxy approach to the reconstruction of past grasslands. The conference will take place over three days and will involve approximately sixty researchers actively involved in studying the reconstruction, biogeography, ecology and physiology of grasslands. Participating disciplines will include: pollen, stable isotopes, grass cuticles, charcoal, phytoliths and environmental modelling. The emphasis of the conference will be a holistic appreciation of paleo-grassland evidence.

www.wesleyan.edu/~kbeuning/PGR2000
Abstract Deadline: 1. March 2000

Monsoon climate, geomorphologic processes and human activities

NANJING, CHINA 25–29 AUGUST, 2000

The main theme of the conference will be monsoon climate, geomorphologic processes and human activities in Asia and Pacific regions. Further information, including session topics and contact information is available in the first circular, which can be viewed on the PAGES website.

www.pages.unibe.ch/calendar/calextras/IAG.html

INSIDE PAGES

New SSC Members

PAGES SSC welcomes three new members in 2000:

Julie Brigham-Grette is a very active and distinguished geologically-based paleo-scientist whose interests lie mainly within the longer timescales of relevance to PAGES. She brings an expertise in chronology, high latitude paleo-environmental change and both marine and continental archives. Her contacts with Russian scientists are also greatly welcomed.

Daniel Olago, is a young researcher with an excellent academic record reflecting work on both PAGES timescales, as well as strong links with the East African Lakes (IDEAL) project. He will help reinforce PAGES links with African paleo-scientists. His close association with the PAGES/START 'node' in Nairobi is also of great potential value to PAGES and we very much look forward to having him join the PAGES SSC.

Ashok Singhvi's expertise is in the paleo-environmental record from arid and semi-arid lands in India and neighbouring regions. He has also been in the forefront of developing luminescence-based chronologies for sediment sequences from these kinds of challenging environment. He is very active in international co-ordination and promises to enhance PAGES' involvement with scientists in both the Indian subcontinent and nearby areas to the west. Both in terms of scientific expertise and regional interests, he therefore complements the existing representation on the SSC in valuable ways.

At the same time three members rotate off the SSC:

Jonathan Overpeck having finished two terms on the SCC, the later as both Vice-Chair and a member of the executive committee, is stepping down while at the same time assuming a new academic position as director of the Institute for the Study of Planet Earth at the University of Arizona, Tucson. Peck will keep an active profile at PAGES, concentrating his efforts on leadership of the PAGES/CLIVAR Intersection activity.

Govind Pant, steps down from the SSC this December having brought his contribution to PAGES to fruition by agreeing to host the 2001 SSC meeting and workshop on paleoenvironments of South Asia at the Institute of Tropical Meteorology, of which he is director, in Pune, India in February 2000.

Timothy Partridge has finished two terms on the PAGES SSC and steps down after playing an important role both as a representative of PAGES related research in South Africa and also as a link between PAGES and INQUA.

PAGES Workshop Support

PAGES workshops serve to synthesize information, coordinate ongoing research, define new avenues of research, and organize community participation in the implementation of relevant research. Workshops are generally open to broad community participation, though PAGES funding for each is limited. PAGES also sponsors smaller workshops devoted to defining and launching specific projects, as well as topical working groups to advance areas of PAGES-related science. Further details, including proposal guidelines and a list of past and planned PAGES workshops are available on the PAGES website (*www.pages.unibe.ch/workshops/workshops.html*).

The proposal deadline for the 2000 PAGES SSC meeting, at which workshops for the years 2000 and 2001 will be discussed, is January 15, 2000.

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WORKSHOP REPORT

Isotopes in Paleoclimate Research

LEICESTER, UK, 28 APRIL 1999

The Natural Environment Research Council has identified Global Change as one of the five main issues on which its research should be focused in the next 5 to 10 years, and the need to know about natural climate variation over a range of timescales is regarded as a key area for development. Since isotopic techniques are likely to continue to play an important role in gaining this knowledge, the NERC Isotope Geosciences Laboratory organized a forum attended by over 250 delegates from all the major universities and research institutes in Britain, as well as many from overseas.

The first of seven presentations was given by Neil Roberts and comprised an overview on the use of stable isotopes in studies of Quaternary paleoclimate. Nick Shackleton then reviewed his work since the 1960's on isotopes in foraminifera from marine cores. Alayne Street-Perrott described the role of paleoclimate records in the lacustrine environment. Frank McDermott discussed current research on paleoclimate records in speleothems. David Peel's talk centred on the ability of the polar ice sheets to preserve evidence both on past climate, and information about changing atmospheric composition and climate forcing in the past. The final scientific presentation was by Mark Pollard, who gave an overview of research into dendroclimatology. Frank Oldfield and Tom Edwards then outlined briefly the mission of PAGES and the aims and ambitions of the ISOMAP group, concentrating on the opportunities and problems posed by each type of continental archive, the challenges of quantitative calibration, and the most successful results achieved so far.

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A 0.6 Million Year Pollen Record from the Colombian Andes

In the basin of Bogotá, located in the Eastern Cordillera of Colombia, continuous subsidence has been in equilibrium with sediment accumulation since the late Pliocene (1,5). This has resulted in a very thick sequence of lake sediments rich in fossil pollen (3). At site Funza (4°50'N, 75°12'W) deep bore holes were drilled by the Colombian Geological Survey (Ingeominas). The 357 m long core Funza-I represents the last 1.4 million years (Ma), and the 586 m long core Funza-II the last 3.2 Ma. Here we show the pollen record of the upper 140 m of Funza-I core sediments. The originally published time frame of Funza-I (4,5) was revised on the basis of absolute datings of core Funza-II (1). The former lake of Bogotá drained around 25 kyr BP and the present-day high plain at 2550 m altitude in the eastern Cordillera of Colombia represents the floor of this former lake.

The Colombian Andes show a clear altitudinal zonation of the vegetation: lowland forest from 0 to 1000 m, subandean forest (lower montane forest) from 1000 to 2300 m, and Andean forest (upper montane forest) from 2300 to 3200 m. Above the upper forest line, usually around 3200 m and corresponding to the 9.5°C annual isotherm, subparamo occurs from 3200 to 3500 m, grassparamo from 3500 to 4200 m, and superparamo from 4200 m to the perennial snow belt at 4800 m. Each of these vegetation belts is characterized by presence or dominance of a suite of taxa. On the basis of the relative contribution of different vegetation belts to the total pollen spectrum, the altitudinal position of the upper forest line can be estimated. Using a lapse rate of 6°C temperature change for every 1000 m displacement of the upper forest line, the paleotemperature for each period can be calculated. In the tropical mountains this is a relatively reliable method as shifts of vegetation belts occur altitudinally over a short range of maximally 1500 m.

Today the high plain lies in the Andean forest belt, 700 m below the upper forest line, but during colder episodes of the Quaternary, subparamo and even grassparamo surrounded the lake (4). As the altitude of the former lake is halfway between the maximum altitudinal position of the upper forest line (3400 m, during the warmest interglacial) and its lowest position (1900 m, during the coldest Pleistocene glacial), the lake sediments provide a sensitive record of climatic change during the entire Quaternary (6).

Time control is based on a visual match with core Funza-II from the same location, that includes absolute fission-track ages, and a match with the $\delta^{18}O$ record of ODP Site 677 (1). In a recent study 73 fossil taxa, present in >4% of the 409 pollen assemblages were analysed with TWINSPAN (7, 8). We recognized 10 cluster types that form 3 main cluster zones: W (warm), CW (cool), and C (cold). Pollen zones based on previous visual inspection were compared with new cluster types which were graphed as a bar code along the pollen diagram. The use of two pollen sums (standard pollen sum, and a zonal pollen sum) was useful in identifying local effects on the forest composition.

During the period from 650–330 kyr BP *Alnus*, *Hedyosmum*, *Weinmannia*, Melastomataceae, *Myrica*, and *Podocarpus* were the most important taxa of the Andean forest. The time frame published in 1993 (1) indicates that the first scattered presence of *Quercus* started around 478 kyr BP (102 m core depth), the first continuous presence began in 423 kyr BP (92 m), and the presence of zonal *Quercus* forest around 330 kyr BP (72 m). During the period from 330–135 kyr BP zonal Quercus and *Weinmannia* forest developed, replacing partly *Podocarpus*-dominated forest in the uppermost Andean forest belt. As a consequence, during the last 135 kyr BP high representation of *Quercus* on the high plain of Bogotá no longer coincides with warm climatic conditions, but now occurs during cool to cold conditions (7). The pollen record was correlated with the $\delta^{18}O$ record and the temperature drop during OIS 4 and and the very first part of OIS 2 is calculated as minimally 6.6° to 7.8°C. The inferred amplitude of the upper forest line during the last 650 kyr was maximally from ca. 1900 to 3400 m corresponding to a range of ca. +1.2°C to –7.8°C compared to today. Effects of low glacial pCO_2 on the altitudinal vegetation distribution are not fully understood at this moment and, as a consequence, not accounted for in the temperature estimates (2).

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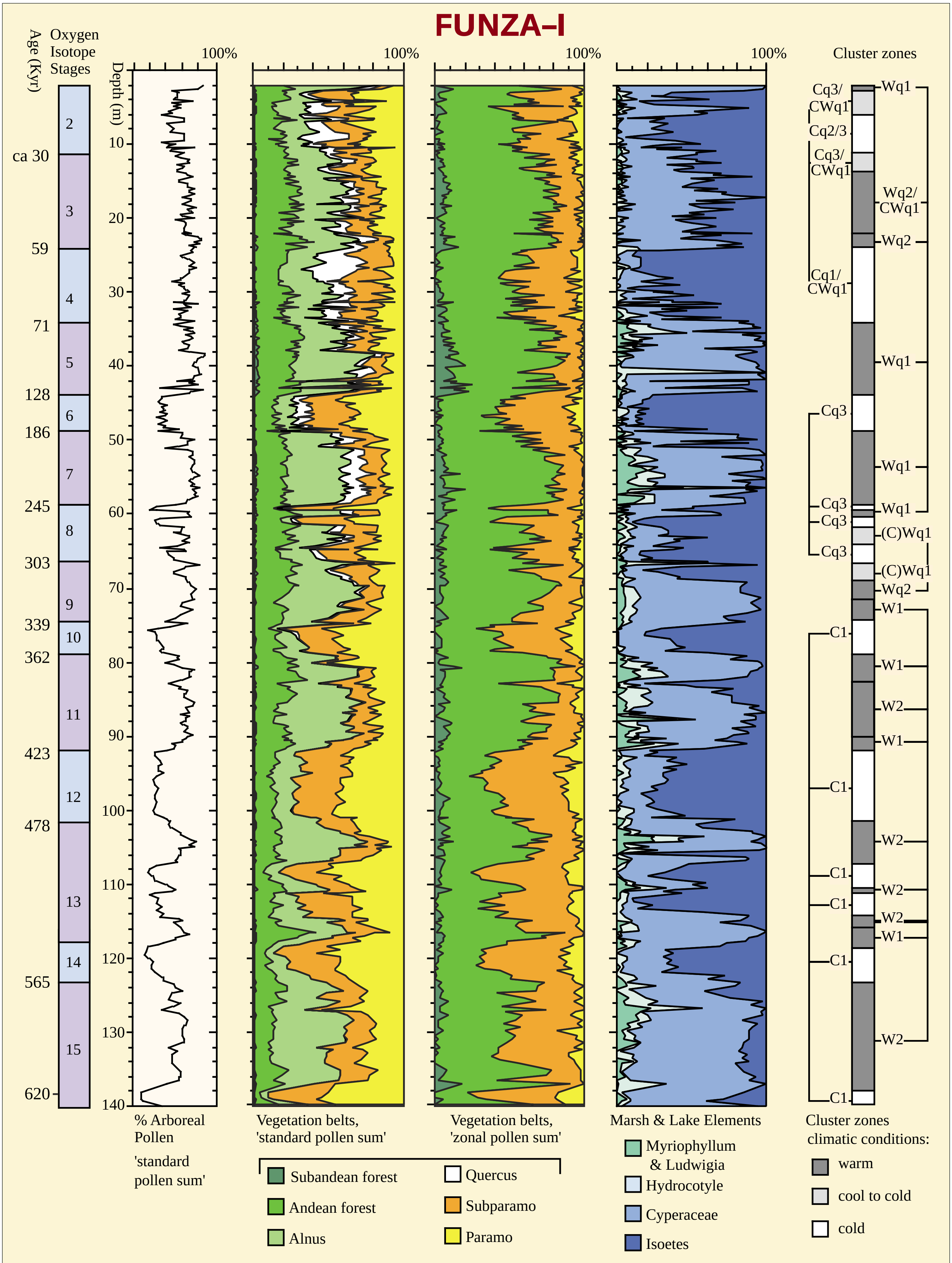
References

(1) Andriessen et al., 1993
(2) Boom et al., submitted
(3) Helmens, 1990
(4) Hooghiemstra, 1984
(5) Hooghiemstra, 1989
(6) Hooghiemstra & Cleef, 1995
(7) Van 't Veer & Hooghiemstra, submitted
(8) Van 't Veer et al., 1995
Full references can be found at *www.pages. unibe.ch/publications/newsletters/ref993.html*

Figure 3: Summary pollen diagram of the core interval 0–140 m from site Funza-I, located at 2550 m altitude in the Eastern Cordillera of Colombia. This site lies in the Andean forest belt at present (green), but in the past the former lake was surrounded by subparamo or grassparamo vegetation. From left to right are shown:
(1) scale of estimated ages (kyr)
(2) correlation with the marine oxygen isotope stages 2 through 15
(3) core depth (m)
(4) arboreal vs. non-arboreal pollen percentages based on 'standard pollen sum'
(5) main pollen diagram based on the 'standard pollen sum' including subandean forest (lower montane forest), andean forest (upper montane forest; Alnus *and* Quercus *have separate curves); subparamo and grassparamo are vegetation belts above the upper forest line. Oak (*Quercus*) is an immigrant from the northern hemisphere and started its record in the study area at 478 kyr BP but continuous presence of zonal oak forest has occurred since 330 kyr BP.*
(6) main pollen diagram based on a pollen sum of taxa from zonal vegetation types only 'zonal pollen sum'). Compositae, with a relatively wide ecological/altitudinal range, are excluded from the subparamo group. For the same reason grasses are excluded from the grassparamo group that consists here of characteristis herbs only.
(7) pollen diagram based on a pollen sum exclusively including marsh and lake taxa. Shallow water taxa are graphed from the left, deep water taxa from the right. Note that lake-level oscillations coincide to a high degree with glacial-interglacial cycles shown in the two vegetation diagrams. In general cold climates coincide with high lake-levels whereas increased evaporation during warm climatic conditions result in low lake-levels.
(8) Cluster zones (pollen assemblage clusters) result from a modified TWINSPAN-classification and reflect vegetation belts in relation to the present-day altitudinal range of the taxa in each cluster zone. Core intervals reflecting warm, cool, and cold climatic conditions.


FUNZA–I
Age (Kyr)
Oxygen Isotope Stages
Depth (m)
100%
Cluster zones
% Arboreal Pollen
'standard pollen sum'
Vegetation belts, 'standard pollen sum'
Vegetation belts, 'zonal pollen sum'
Marsh & Lake Elements
Cluster zones climatic conditions:
Subandean forest
Andean forest
Alnus
Quercus
Subparamo
Paramo
Myriophyllum & Ludwigia
Hydrocotyle
Cyperaceae
Isoetes
warm
cool to cold
cold

The Dadongling Section – a Long High Resolution Record from the West of the Chinese Loess Plateau

The accompanying graphs (figure 4) present a distillation of the results discussed more fully in Chen et al. (1995).

Graph A: Probe readings of magnetic susceptibility at 5cm intervals
The proposed correlations between paleosols (represented by peaks in susceptibility) and interglacial Marine Isotope Stages (MIS) suggest that this part of the section spans at least 5 glacial cycles. The upper shaded areas denote the two parts of the profile for which detailed magnetic measurements and particle size analyses have been carried out on individual subsamples (see Graph B).

Graph B: Two subsections of the magnetic measurements spanning parts of MIS 6 to 5C and 4 to 1. The approximate age of the lower of the two analysed sections is 'pinned' by evidence for the paleomagnetic 'Blake Event' around 110kyr BP. It seems likely that part of the record from Stages 5A and B is missing from the section and a hiatus is tentatively inferred just below 17m depth. The early- to mid-Holocene age of the upper paleosol is confirmed by radiocarbon dates. The 5cm sample interval used in the lower part of the section thus provides a temporal resolution of around 250yr or better; above this, there are intervals where suites of contiguous 1cm thick samples provide a temporal resolution of around 50yr. The record of variations in susceptibility (χ) outlines the changing concentration of magnetic minerals through the profiles. χ_{fd}% and $\chi_{arm/SIRM}$ provide mutually independent estimates of the proportion of magnetic minerals of pedogenic origin. The two sharp, pre-Holocene peaks in all three properties lie within the Late-Glacial period. The coherent and repeated sub-millennial scale oscillations within MIS 5C–D are considered further in the text below relating to Graph E.

Graph C: Magnetic properties measured on particle sized separates
This figure provides a more robust basis for interpreting the magnetic contrast between the loess (Sample 1 – top of MIS 6) and paleosol (Sample 2 – MIS 5E) parts of the record. Maximum magnetic concentrations are much lower in the late MIS 6 loess and peak in the coarse and medium silt fractions. Evidence for fine, pedogenic grains is virtually absent. Concentraions in the MIS 5E palaoesol sample peak in the finest clay fraction and pedogenic grains are dominant. The opposite trends in demagnetisation characteristics (reverse field ratios) versus particle size provide independent reinforcement for this interpretation. Thus, the magnetic grains in the loess represent relatively coarse, wind-transported detrital material; the finer grains (three to four orders of magnitude smaller volume) in the paleosols mainly represent the products of in-situ soil formation.

Graph D: Magnetic property most strongly indicative of pedogenesis (χ_{fd}%) against the mass percentage of particles coarser than 62.5µm
Pedogenic episodes, the strength of which can be, at least qualitatively, differentiated by variations in χ_{fd}%, show consistently low coarse silt percentages; conversely, the main episodes of loess deposition can be differentiated on the basis of the percentage coarse silt contribution, but χ_{fd}% remains consistently low. Less than 5% of the samples plotted contravene this general observation. This indicates that the two proxy signatures show a degree of independence that allows for credible magnetic-proxy-based reconstructions of moisture and temperature regimes during interglacial periods dominated by the summer monsoon (cf. Maher and Thompson, 1999), and of changing wind strength, using particle size variations, during glacial periods dominated by the winter monsoon (cf. Chen et al. 1997). Both lines of inference have their limitations and require further critical evaluation, but the simple bi-plot helps to explain some of the ways in which loess profiles have been used to provide reconstructions of past climatic variations; for example, for the last glacial period, during which links between Heinrich layers in the North Atlantic and coarser granulometry in loess sections have been inferred.

Graph E: high resolution record of magnetic property variations during part of MIS 5C–D
χ_{arm} may be used here as an indicator of the concentration of pedogenic grains, the properties on either side, as mutually independent indicators of their relative importance, as in Graph B. Over this time interval of around 15kyr, there are at least 5 coherent alternations between periods of partial pedogenesis and intervals of loess deposition, each of the latter with little or no indication of soil development. These alternations occur on the same time scales as Dansgaard-Oeschger oscillations. These results suggest that (i) the continuity of eolian aggradation for key time intervals at sites of high accumulation in the western part of the Loess Plateau allows for an extremely high resolution reconstruction of short term climate changes, (ii) the magnetic signatures are essentially syndepositional in such environments and avoid the polygenetic overprinting more typical of paleosols in the classic loess sections further east, and (iii) putative links between North Atlantic variability and the stratigraphy of Chinese Loess sections on Dansgaard-Oeschger time scales are supported not only by granulometric data, but by magnetic measurements, though lack of a good chronology precludes direct correlations.

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Full references for this article can be found at *www.pages.unibe.ch/publications/newsletters/ref993.html*

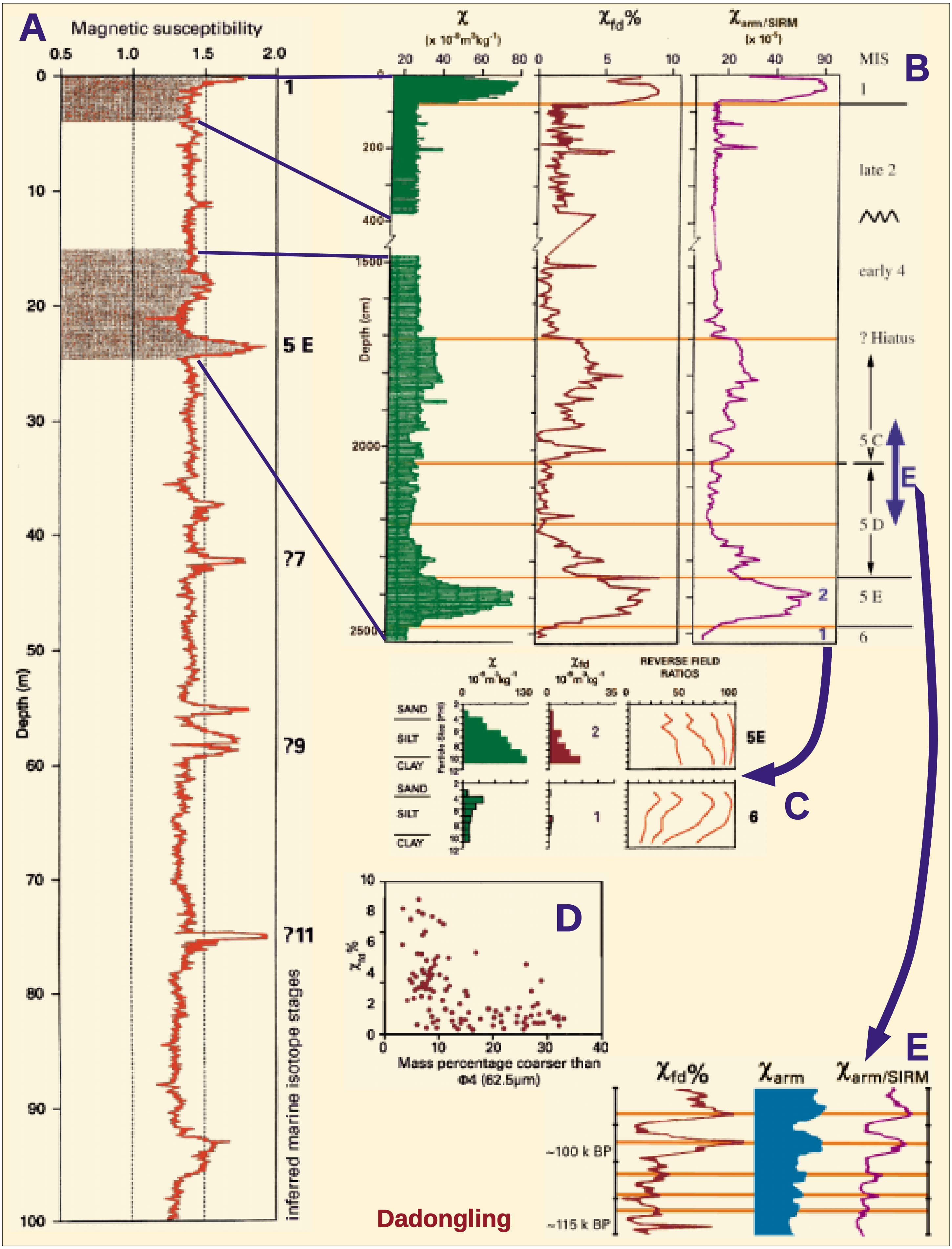

Figure 4: The Dadongling loess section

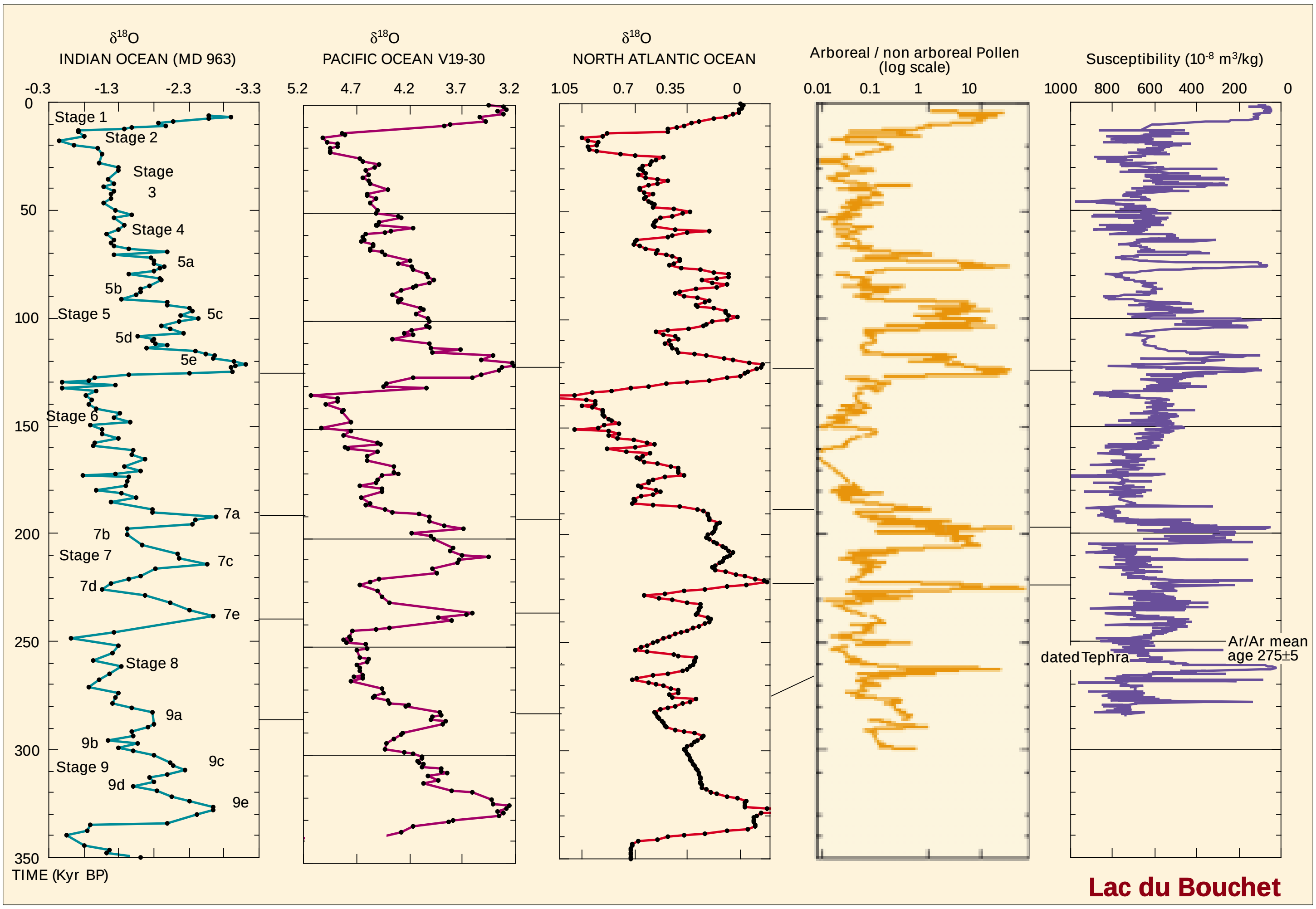

Figure 5: Pollen and magnetic susceptibility from Lac du Bouchet, compared with marine data.

A 300,000 Year Record from Lac du Bouchet, France

Volcanic activity on the Velay plateau (Massif Central, France) generated numerous maar-type explosion craters between the end of the Pliocene and ca. 800 kyr BP. These craters were subsequently occupied by lakes and filled by sediments; maar lakes thus contain thick records of climatic and environmental variations. They also received volcanic ash-fall from neighbouring eruptive centers. The Arboreal Pollen curve of the 40 m long sequence of Lac du Bouchet gives an idea of the alternation of forested and unforested vegetation. The simplified pollen diagram allows identification of five main warm complex units alternating with five cold episodes from the top (Holocene) to the bottom. Provided that authigenic magnetic minerals do not interfere, magnetic susceptibility measures the concentration of inherited titanomagnetite particles and, since dissolution provides a cumulative effect, susceptibility is tightly related to erosion regimes of the catchment area. High mineral/organic ratio during cold periods results in a high magnetic susceptibility, while low mineral/organic ratio during warm period results in low susceptibility. The chronology was established based on ^{14}C dating (Thouveny et al. 1994) and more recently on an Ar/Ar age at 42 m depth (Roger et al., 1999). High resolution oxygen isotope records from the Pacific Ocean (Shackleton, et al. 1985), Indian ocean (Bassinot et al. 1990) and North Atlantic Ocean (Vogelsang, 1995) are presented as reference.

The average age 275±5 kyr BP obtained by Ar/Ar dating coincides with the Amargier interstadial and can be compared with the age of its equivalent in these $\delta^{18}O$ records. Although this substage is marked in the Indian and Pacific Oceans, it is often considered as part of stage 8. In our record, the increase of thermophilous trees, development of soils in the catchment area and deposition of highly organic gyttja suggest that it was rather similar to an interglacial stage. We thus propose to correlate the Amargier interstadial with a low ice volume substage occuring in this time window in the Oceanic records (substage 9a) and dated at 285.7±3.5 in the $\delta^{18}O$ record of the vein of Calcite of Devil's Hole (Winograd et al., 1992, Ludwig et al., 1992, figure 8 this issue).

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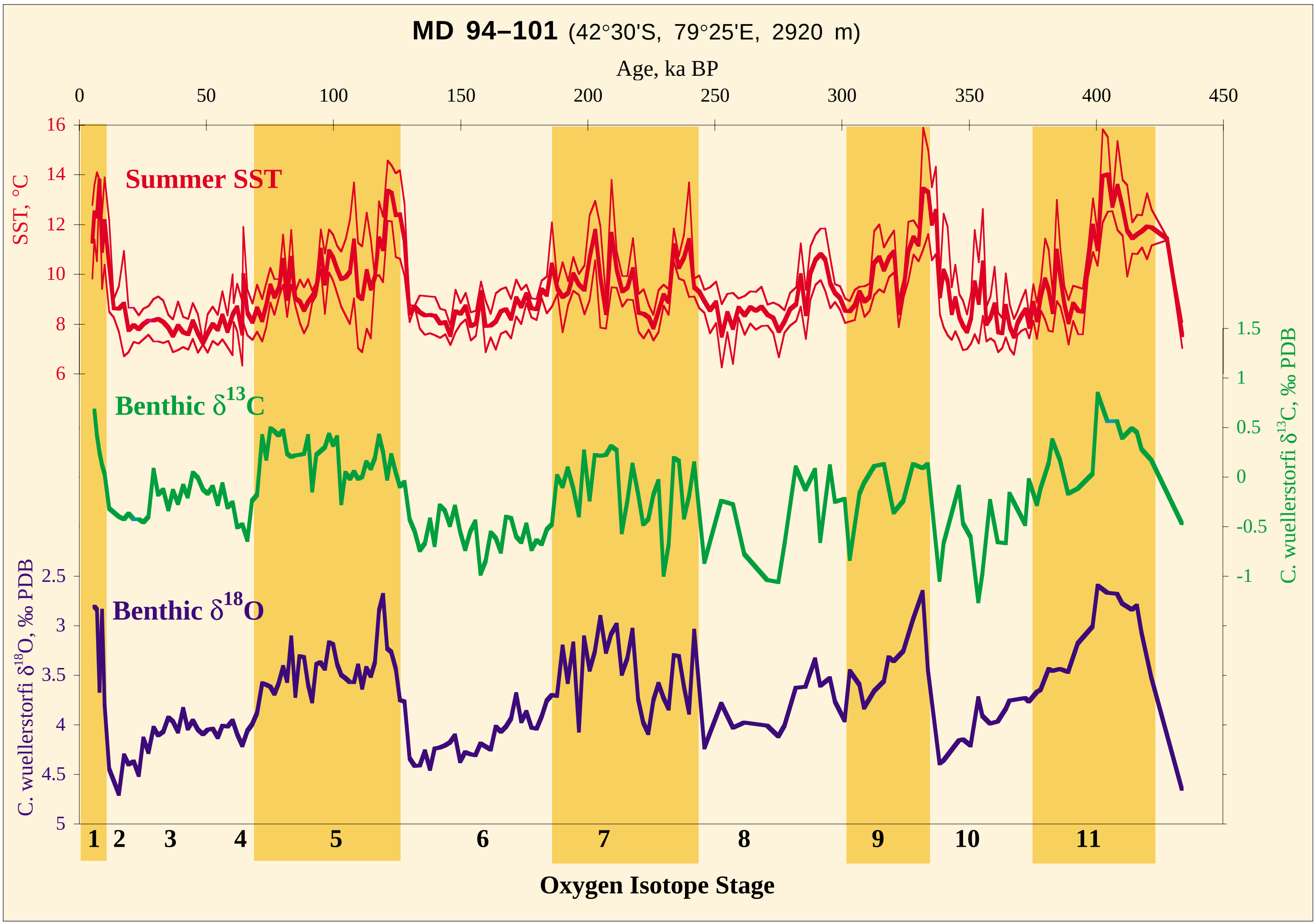

Figure 6: Time series of summer SST and isotopic measurements from marine core MD 94–101.

Southern Ocean Core MD 94–101

This core is located just north of the subtropical convergence, in the Indian sector of the Southern Ocean. SST is reconstructed from planktonic foraminiferal assemblages (Salvignac, 1998) by the revised analog method (Waelbroeck et al., 1998). Benthic foraminifera $\delta^{18}O$ and $\delta^{13}C$ are expressed in per mil versus the Pee Dee Belemnite (PDB) standard. Isotope measurements were made at the LSCE (Gif, France) on a Finnigan MAT 251 mass spectrometer (Lemoine, 1998). The mean external reproducibility (1 s) of carbonate standards is 0.05‰ and 0.02‰ for $\delta^{18}O$ and $\delta^{13}C$, respectively. These records have been dated by correlating the *Cibicides wuellerstorfi* $\delta^{18}O$ with the SPECMAP $\delta^{18}O$ stack of Bassinot et al. (1994). Marine isotope stages are indicated for reference.

C. wuellerstorfi $\delta^{18}O$ reflects variations in global ice volume, whereas its $\delta^{13}C$ is an index of deep water nutrient content (or ventilation): heavy $\delta^{13}C$ values representing well ventilated waters (or nutrient-rich waters), and vice versa. Visual inspection of these three records indicates that, in this region, increases in summer SST lead decreases in global ice volume and increases in deep water ventilation. This is confirmed by spectral analysis: SST leads deep water $\delta^{18}O$ and $\delta^{13}C$ by approximately 3 ky in the precession and obliquity bands, and by 3–7 ky in the 100 ky band. Our records thus show that deep water ventilation in this region is directly related to variations in the global ocean circulation, itself directly linked to variations in the global ice volume on glacial-interglacial time scales. On the other hand, the lead of SST with respect to benthic $\delta^{18}O$ in core MD 94–101 is of the same order as that found in core MD 88–770 (46°01'S, 96°28'E, 3290 m), located further south, in the Subantarctic front area (Labeyrie et al., 1996). Waelbroeck et al. (1995) demonstrated that MD 88–770 SST record is in phase with the Vostok air temperature signal over the two first climatic cycles. Consequently, SSTs from the entire region between the present-day Subantarctic and Subtropical fronts appear to be in phase with Vostok air temperature, suggesting that this latitudinal band could be a source of water vapor for the precipitation falling on Vostok.

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Full references for this article can be found at *www.pages.unibe.ch/publications/newsletters/ref993.html*

The high Resolution Paleoenvironmental Record of the Last 101,800 Years from Lago Grande di Monticchio, Italy

The 101,800 year record from Lago Grande di Monticchio in southern Italy (40°56′40″N, 15°36′30″E; 656 m asl) illustrates the kind of detailed information about environmental changes during the last glacial that can be obtained from lacustrine sediments. This recently published multi-proxy record (Allen et al., 1999, *Nature*, **400**, 740–743.) illustrates the potential of such lacustrine records to provide greater insight into terrestrial environmental conditions than can be obtained from either ice or marine cores. It also makes it clear that terrestrial biota were full participants in last glacial environmental changes.

The principal importance of Monticchio is that it is the first European terrestrial site to provide a continuous and high temporal resolution record of environmental change covering the last glacial with a chronology that is independent of all other records. This calendar year chronology is based upon the measurement of varves and the calculation of sedimentation rates; it is corroborated by radioisotopic dates on organic remains and tephras. This independent chronology enables not only investigation of the regional environmental changes and rates of change during the last glacial on a centennial to millennial scale, but also elucidation of the temporal relationships between terrestrial events and events recorded in ocean sediment cores and ice cores.

The complex paleovegetation record can be summarized in terms of the reconstructed biomes – global vegetation units characterized by a particular combination of dominant plant functional types (Prentice et al., 1992). The records for dry density, magnetic susceptibility and biogenic silica, together

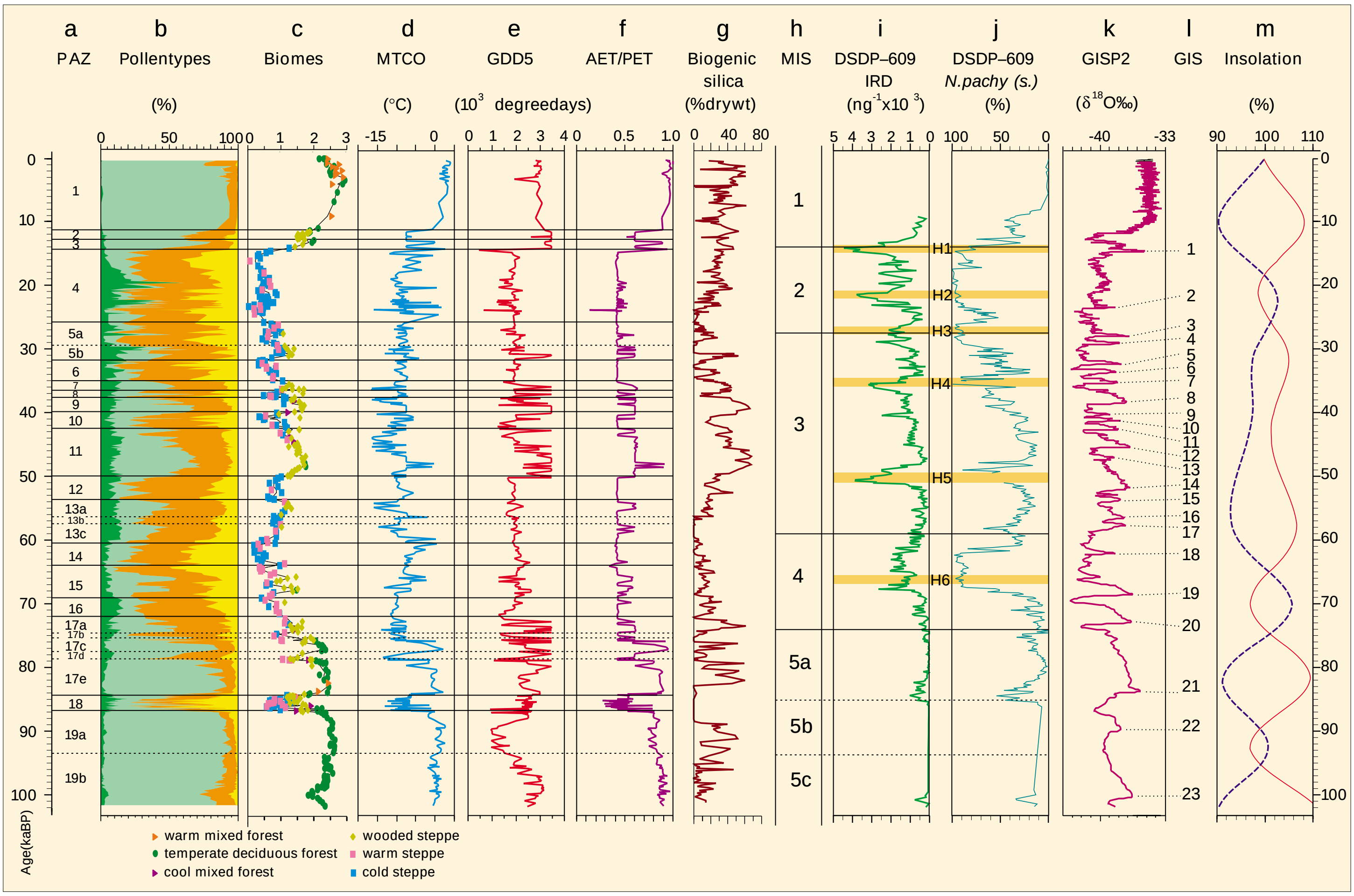

Figure 7: Monticchio pollen assemblage zones (PAZ). b. Relative abundance of pollen of Pinus *subgen. Diploxylon (dark green), other woody taxa (pale green), other herbaceous taxa (orange) and* Artemisia *plus Chenopodiaceae (yellow). c. Reconstructed biomes plotted with respect to sample scores on the 1st axis of a detrended correspondence analysis of the terrestrial pollen data set (eigenvalue 0.39). d. Mean temperature of the coldest month (MTCO), e. annual temperature sum above 5°C (GDD5) and f. estimate of the ratio of actual to potential evapotranspiration (AET/PET) reconstructed from the pollen data using pollen–climate response surfaces. g. Biogenic silica estimated using a normative model based on X-ray fluorescence major element data. h. Marine oxygen isotope stage/sub-stage boundaries (after Martinson et al., 1987). i. Abundance of lithic grains >150 µ (n g-1 x 103) (IRD) and j. relative abundance of* Neogloboquadrina pachyderma *(s.) for North Atlantic core DSDP–609 (Bond et al., 1992; Bond & Lotti, 1995). Shaded bars indicate periods of increased abundance of lithic grains related to Heinrich events (H1–H6). k. Greenland ice-core (GISP2) δ¹⁸O record (Grootes et al., 1993). l. Greenland ice-core interstadials (GIS) (Dansgaard et al., 1993). m. January (blue dashed line) and July (red solid line) insolation at 40°N expressed as percentages of present values (calculated at 250 yr intervals using the program developed by Berger, 1978). Data used to plot i, j and k were obtained from World Data Center A (WDC-A), operated by the National Geophysical Data Center at Boulder (note reversed x-axis scales for i and j).*

with the reconstructed biomes, show that during intervals characterised by forest/woodland biomes the catchment was more stable, there was less erosion of mineral materials and the lake was more productive. In contrast, during intervals dominated by steppe biomes the lake was less productive and the catchment was less stable.

The pollen data have been further utilized to quantitatively reconstruct paleoclimatic conditions using the pollen–climate response surfaces technique. These reconstructions indicate that moisture availability was reduced during cold and warm steppe periods compared to forested periods, with wooded steppe periods being intermediate. For most of the last glacial the reconstructed mean temperature of the coldest month was ca. 12°C less than the present day, with minimum reconstructed values more than 20°C less than present day values. During the early Weichselian forested intervals, the reconstructed coldest month temperature was close to that of the Holocene. Of particular interest in the reconstructed values of the annual temperature sum above 5°C is the reduction during pollen assemblage zone 19b compared to the preceding subzone. This most probably reflects the decreased summer insolation at that time.

Investigations of rates of paleovegetation change show both this, and the underlying environmental changes, were often rapid: for example, increases/decreases of >20% in the total pollen of woody taxa occur in a mean interval of 142±21 yr, whilst increases/decreases of ≥10°C in reconstructed temperature of the coldest month occur in a mean interval of 153±54 yr. Given the average temporal resolution of the pollen data (pre-Holocene: 193±157 yr) these must be regarded as minimum estimates of the actual rates of change.

In the last 101 ka of the GISP2 ice-core record 22 interstadial events have been identified. When the GISP2 record, plotted on the Meese et al. (1994) timescale, is compared with the Monticchio record plotted on its independent timescale, the ice-core interstadials correlate with environmental changes seen in the Monticchio record. Prior to 65 ka, however, the Monticchio record shows greater detail than the ice-core data, pro-

continued on page 12

A 800,000 Year Long Record from Owens Lake, California

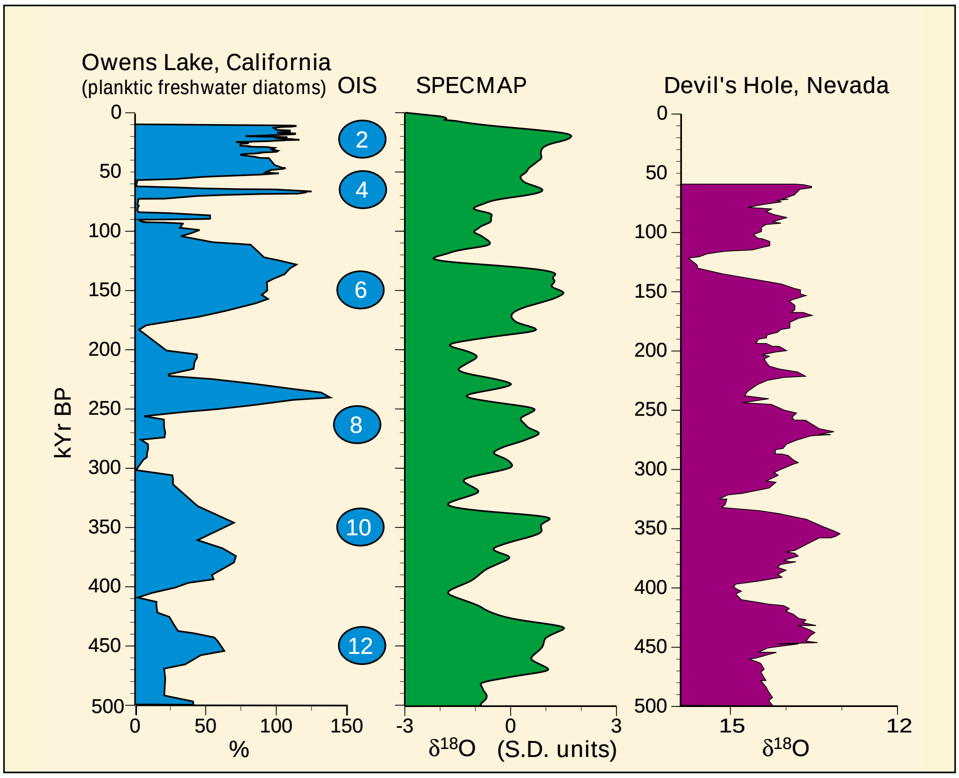

Figure 8: Owens Lake compared to SPECMAP and Devil's hole records

A 323-m (~800 ka) core of lake deposits beneath Owens Lake playa, Inyo County, California contains a nearly continuous paleolimnological record based on diatom assemblages. The core chronology is anchored by the Brunhes/Matuyama boundary and the Bishop ash near the base of the record and by radiocarbon dates near the top. A tentative chronology based on mass accumulation rates appears to reliably date some volcanic ashes of known age and allows this record to be correlated with marine and terrestrial records of climate change (Smith and Bischoff, 1997).

Throughout the past 500 kyr of its history, Owens Lake was characterized by planktic freshwater diatoms, indicating a positive hydrologic input from the Owens River and overflow of the Owens basin to lake systems downstream. Saline diatoms or sediments barren of diatoms occur in the intervals where freshwater planktic diatoms are less common or absent.

According to the Owens Lake chronology, even-numbered isotope stages of SPECMAP, representing glacial conditions, approximately match episodes where freshwater planktic diatoms dominate. The match probably indicates abundant precipitation in the Sierra Nevada in response to a southward shift of storm tracks originating in the North Pacific around the Aleutian Low which was forced to the south by the expanding Laurentide ice sheet.

The correspondence of the freshwater, planktic diatom peaks at Owens Lake to wet climates indicated by isotopes in the independently dated spring-deposited carbonate at Devils Hole, Nevada (Coplen et al., 1994) is less convincing, perhaps as a result of inadequate chronological control of the Owens Lake record. Nevertheless, the strong, approximately 100 kyr pulses indicating cool and wet climates in all these records suggests a common cause related to global climate change. When the chronology becomes independently verified or corrected, the Owens Lake lacustrine diatom record will be important for investigating the relation of lake levels and alpine glaciation in western North America to continental glaciation and global atmospheric circulation.

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Glacial Modulation of Rapid Climate Change During the Last 0.5 Million Years

Two often competing priorities, the temporal length and resolution of paleoenvironmental records, may be simultaneously addressed using long cores from rapidly accumulating deep-sea sediment deposits. Site 980 of the Ocean Drilling Program's Leg 162 (Jansen et al., 1996) was drilled on the Feni Drift in the subpolar North Atlantic (Figure 2), and provides such an opportunity. The uppermost 65 meters of sediment at this site represent the last 0.5 myr, at an average accumulation rate of 13 cm/kyr, easily resolving millennial-scale features while encompassing more than four full glacial-interglacial (G–IG) climate cycles. This combination of length and resolution affords the possibility to evaluate short-term variability in the context of orbital-scale influence. Measurements of regional and global climate proxies from Site 980 reveal persistent patterns of variability, and suggest that the amplitudes of rapid oscillations are influenced by the baseline climate state, particularly the size of continental ice sheets.

Stable oxygen isotope ratios ($\delta^{18}O$) in benthic and planktic foraminifera provide information about the degree of global glaciation and near-surface hydrography, respectively. The $\delta^{18}O$ of the benthic species, *C. wuellerstorfi*, primarily reflects the global ice volume and the temperature of the deep ocean (Emiliani, 1955; Shackleton, 1967), while the $\delta^{18}O$ of the planktic species, dextral-coiling *N. pachyderma*, bears the strong imprint of local hydrography, particularly sea-surface temperature (Keigwin and Jones, 1989; Oppo et al., 1997, 1998). Additional information about the surface ocean and the link to nearby icesheets comes from measurements of ice-rafted debris (IRD). Previous studies of the last G–IG cycle have demonstrated that sediments on Feni faithfully capture a signal of at least regional extent (Ruddiman et al., 1977; Duplessy et al., 1981; Broecker et al., 1988a,b; Bond et al., 1992; 1993; 1999; Lehmann and Keigwin, 1992; McManus et al., 1994; Labeyrie et al., 1995; Bond and Lotti, 1995).

Each of the three proxies varies in a different fashion (Figure 9), and each shares important links with the other two. The benthic $\delta^{18}O$ displays the familiar sequence of glacial and interglacial Marine Isotope Stages (MIS) of the standard orbital chronostratigraphy (Emiliani, 1955; Imbrie et al., 1984; Martinson et al., 1987; Shackleton et al., 1990). By this measure, MIS 1, 5e, 9, and 11 are the most "interglacial" stages, with similarly low $\delta^{18}O$ values. MIS 2, 6, and 10 have similarly high $\delta^{18}O$ values, and are all surpassed by MIS 12, the most extreme glaciation of the last 0.5 Myr. The close agreement of these observations with those based on a compilation that emphasized benthic records from outside the North Atlantic (Shackleton, 1987) underscores the global significance and utility of benthic $\delta^{18}O$. G–IG amplitudes of the benthic $\delta^{18}O$ record at Site 980 are consistently larger (>2.0‰) than those outside the region. These larger amplitudes, combined with the consistent relationships among respective glacial and interglacial extremes, indicate that not only did the deep North Atlantic experience a particularly large temperature change during the last G–IG cycle (Duplessy et al., 1980), but that it must have undergone equivalently large temperature changes relative to the global deep ocean during previous cycles.

IRD varies throughout the record, with a markedly episodic character that contrasts with the more smoothly varying benthic $\delta^{18}O$. The youngest IRD episodes represent the catastrophic discharges that punctuated the last ice age (Heinrich, 1988; Broecker et al., 1992; Bond et al., 1992; cf review by Andrews, 1998), and comparable features occur throughout the record. Each glacial interval contains several IRD events, the last of which (McManus et al., 1994; Venz et al., 1999) is associated with the rapid deglaciation, or termination (Broecker, 1984) that marks the transition to the subsequent interglacial stage. IRD peaks are only associated with benthic $\delta^{18}O$ values above approximately 3.5‰, suggesting a threshold for iceberg discharge.

The $\delta^{18}O$ of dextral-coiling *N. pachyderma* displays large-amplitude variations, with several G–IG cycles of 3.0‰. Although such a range of values is remarkable, it is less than the equivalent range suggested by the broad temperature tolerance of this species (Be and Tolderlund, 1971; Kipp, 1976; Pflaumann et al., 1996), and by measurements of modern specimens (Figure 9). Only MIS 5e slightly surpasses MIS 1 as an interglacial extreme, and is approached by both MIS 9 and MIS 11. MIS11 is by far the longest interglacial, including a warm, IRD free interval of 30–40kyr. MIS 12 is the coldest glacial stage, as well as the most glaciated, followed by MIS 2, 6, and 10. Rapid oscillations of approximately 1.0‰ occur within the glacial stage of each large cycle, whereas peak interglacial variability is limited to less than 0.3‰. As with the IRD discharges, benthic $\delta^{18}O$ values of approximately 3.5‰ mark the transition between more and less variable modes of millennial-scale variability. After correction for the ice volume effect on $\delta^{18}O$ (Labeyrie et al., 1987; Fairbanks, 1989; Schrag, 1996), the planktic isotopic variations represent sea surface temperature (SST) changes of 8–9°C for each G–IG cycle. On shorter timescales, the SST

Monticchio, continued from page 11

viding evidence for additional environmental fluctuations not seen in this part of the ice-core record. From this correlation with GISP2, as well as from correlations with high resolution ocean records such as that from DSDP–609, it is concluded that the Monticchio record clearly demonstrates a link between the closely coupled ocean–atmosphere system of the North Atlantic region and environmental changes in the Mediterranean region.

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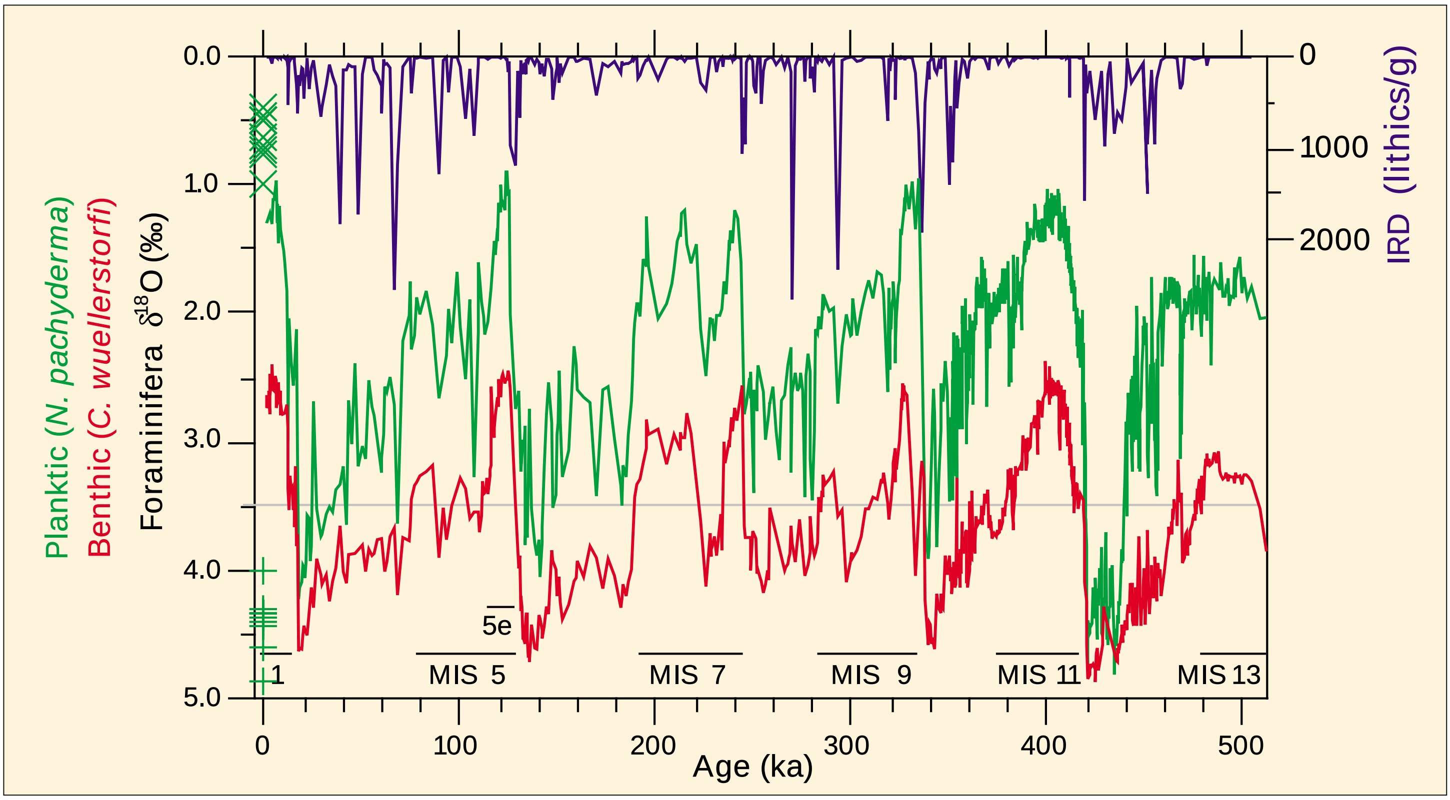

*Figure 9: Oxygen isotope ($\delta^{18}O$) and ice-rafted debris (IRD) measured in sediments from Site 980. IRD index is the number of detrital sediment grains (lithics), larger than 150 mm, per bulk sample weight. Benthic (*C. wuellerstorfi*, red) and planktic (*N. pachyderma d.*, green) foraminifera $\delta^{18}O$ values are calculated relative to the Peedee Belemnite (PDB) standard (Emiliani, 1955), and plotted on the same scale. Data points at 0 kyr are $\delta^{18}O$ measurements on modern* N. pachyderma d. *from Atlantic sediment traps at 47° N (x) and 65°N (+), demonstrating an isotopic range surpassing that of our sedimentary data. The modern data from 65°N are adjusted by +1.0‰ , a minimum estimate of past mean ocean changes (Labeyrie et al., 1987; Fairbanks, 1989; Schrag et al., 1996), for comparison to glacial data. Interglacial marine isotope stages (MIS) and the last peak interglacial substage 5e are indicated for reference. All other intervals represent glacial stages (MIS 2-4, 6, 8, 10, 12). From McManus, J.F., Oppo, D.W., and Cullen, J.L., 1999, A 0.5 million year record of millennial-scale climate variability in the North Atlantic: Science,* **283**, *971–975.*

changes are 1–2°C within the peak interglacial portion and 3–6°C within the glacial portion of each large climate cycle. The most extreme glacial interval, MIS 12, does not have the highest degree of variability, but rather a series of 3°C oscillations. This pattern of climate response is similar to that observed during recent climate cycles in many records, including Greenland ice cores (e. g., Dansgaard and Oeschger, 1989; Johnsen et al., 1992; Grootes et al., 1993).

The benthic $\delta^{18}O$ threshold for amplified variability occurs near the mid point of the range of values observed at Site 980. However, because of the deep ocean temperature changes that are preferentially associated with peak interglacial intervals (Chappell and Shackleton, 1986; Labeyrie et al., 1987, Shackleton, 1987), the threshold value of 3.5‰ may represent as little as a 30m departure from modern sea level. This threshold amount of glaciation modulates the higher-frequency climate response in the North Atlantic and probably beyond, as evidenced by similar records from outside the immediate region (e. g., Tzedakis et al., 1996). Throughout more than four large G–IG cycles, the pattern of climate variability is clear. The Site 980 record of the last 0.5 million years demonstrates that millennial-scale variability is persistent, with a regional, possibly global, amplitude that is modulated by the degree of global glaciation.

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31st International Geological Congress Travel Fellowships

The 31st International Geological Congress, August 6–17, Rio de Janeiro, Brazil, will have a number of sessions organized by, and of interest to PAGES scientists (see PAGES News Vol. 7 No. 2). The Geological Society of America has recently announced (EOS Vol 80 No. 42) fellowships for residents or citizens of the United States, born after August 31, 1960 for grants consisting of a roundtrip airfare to Brazil. Application forms are available from Grants Administrator, GSA Headquarters, 3300 Penrose Place, PO Box 9140, Boulder CO 80301, USA and are due postmarked no later than February 15.

0.5 Million-Year Pollen Records from Southern Europe

Thick lacustrine sequences from southern Europe provide an opportunity to develop complete and high-resolution pollen records spanning multiple glacial-interglacial cycles and showing the response of vegetation to climate variability. The sequences discussed here represent the four longest continuous European pollen records and are located between 39 and 45°N, forming a West-East transect: (i) Lac du Bouchet [1,2] (44°55′N, 3°47′E; 1200 m above sea level [asl]) and Praclaux [3] (44°49′N, 3°50′E; 1100 m asl), Massif Central, France. (ii) Valle di Castiglione [4] (41°53′30″N, 12°45′35″E; 44 m asl), central Italy. (iii) Ioannina [5,6] (39°40′N, 20°51′E; 470 m asl), northwest Greece. (iv) Tenaghi Philippon [7–9] (41°10′N, 24°20′E; 40 m asl) northeast Greece.

The published chronostratigraphical scheme for each pollen sequence was used for broad correlations with the marine sequence and assignments to individual isotopic stages. Each data set was then aligned to a target, the SPECMAP stacked $\delta^{18}O$ record [10] (Fig. 10). 'Glacial-to-deglacial' transitions were used as the tie points on the basis that these transitions have been relatively rapid and the response of vegetation was essentially synchronous within the error estimates for the marine chronology. Given that the sites are located relatively close to glacial tree refugial areas, lags arising from delayed immigration of tree populations were considered to be minimal. This simple step of placing the records on a common timescale, although it eliminates any assessment of leads and lags, greatly facilitates comparison between the different types of proxy evidence in terms of their overall structure and character.

The four pollen sequences display a close similarity to the SPECMAP stack on glacial-interglacial timescales suggesting that the many substages into which the oceanic record is divided are also appropriate for viewing the continental record. It has long been appreciated that the subdivision of Stage 5 is necessary to the understanding of the last interglacial, but the data show a similarly complex structure for earlier deglacial stages, with alternating forest and open vegetation intervals corresponding to the isotopic variations.

While Figure 10 demonstrates the overall similarity between the terrestrial

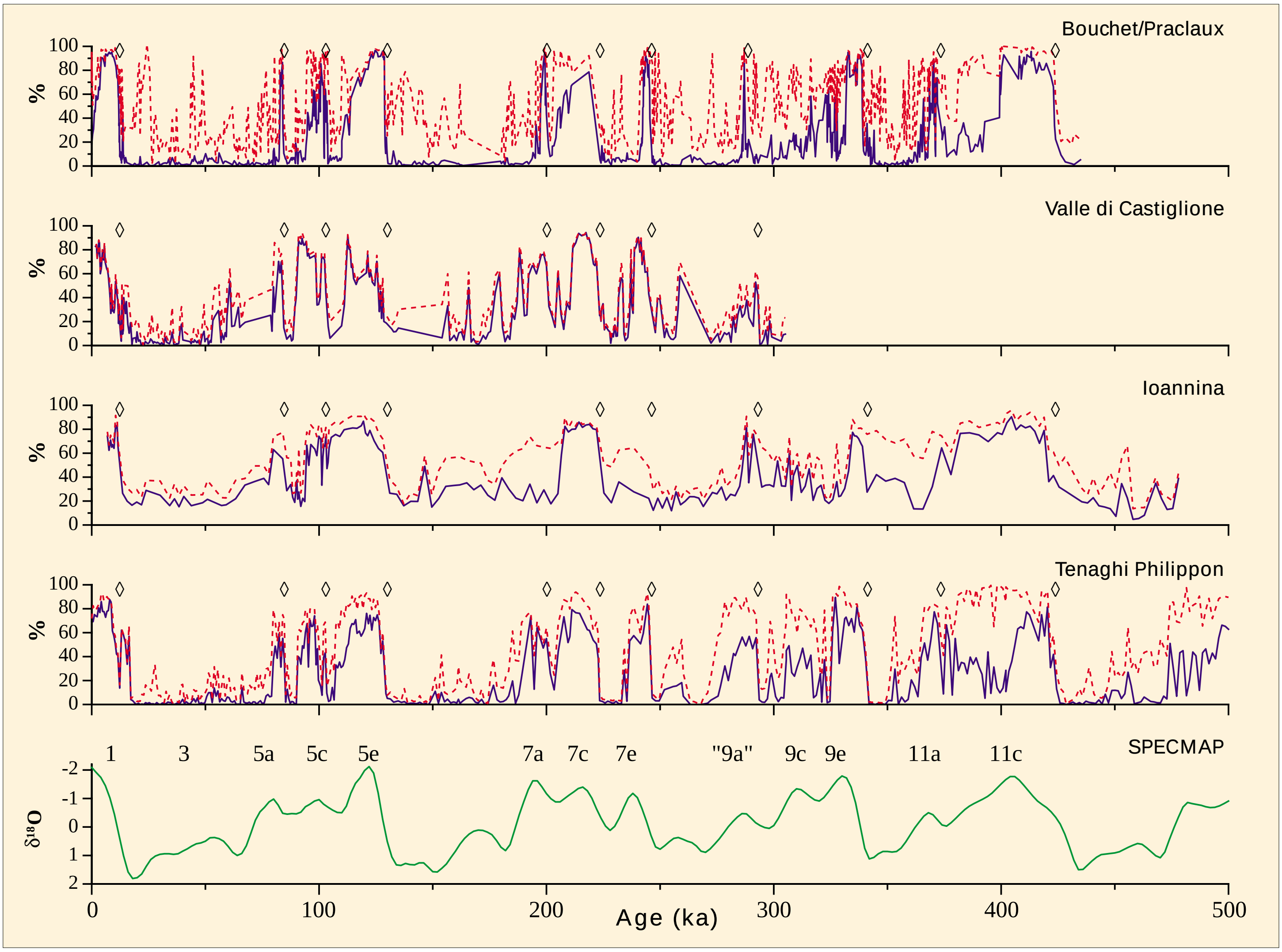

Figure 10: Comparison of terrestrial pollen records and the marine isotope sequence. For the terrestrial records the arboreal (AP) minus Pinus *(solid line) curve has been used for correlations and tuning, but the AP curve including* Pinus *(dotted line) is also shown. Marine isotope stages are indicated. Diamonds show the control points used for tuning. A composite Bouchet / Praclaux record is used here (Bouchet D: 0–110 kyr BP; Bouchet H: 110–287 kyr BP; Praclaux: 287–430 kyr BP). (from Tzedakis, et al. 1997, Earth and Planetary Science Letters* ***150****, 171–176).*

and marine records, it also draws attention to some of the differences between them. One apparent divergence is in the relative amplitude of variation in the indicators used, with Arboreal Pollen (AP) frequencies showing in some cases higher amplitude variations relative to the $\delta^{18}O$ record. This, to a certain extent, may be an artefact arising from the limitations of the AP percentage signal alone, which provides information on the changes in vegetation structure, but does not reflect compositional changes within and between the periods it defines. More in-depth comparisons may thus require a different measure (such as the paleobioclimatic operator [11]) which can incorporate the additional information. Despite such shortcomings, however, comparison with long and detailed marine records such as ODP 980 [12] suggests that over higher frequencies of variability the AP curves show a closer correspondence to the planktic rather than the benthic isotope records. This suggests the occurrence of rapid climate changes which have had an influence on sea surface temperatures and downstream effects on terrestrial ecosystems, but a moderate impact on global ice volumes. What emerges is that long pollen sequences can be used to add detail to our understanding of the extent and nature of climate variability over orbital as well as sub-orbital frequencies.

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WORKSHOP REPORTS

DFG Program

Bonn, Germany, 1–2 July, 1999

A meeting of the participants in the Deutsche Forschungsgemeineschaft (DFG) priority program 'Changes in the Geosphere-Biosphere during the last 15,000 years (see PAGES News Vol 6. No. 1) was held on July 1 and 2 in Bonn, Germany. Over 40 presentations were made summarizing the progress made in each of the projects funded through the program. These focus on continental and near-shore, marine archives of every kind within and around Germany. The outcomes of the program will be of great interest to PAGES through contributions to PEP III, to Focus 3 themes dealing with human impact on environmental systems, and to the improvement of chronological control for key periods of environmental change. The program will conclude with a major colloquium in November 2000 presenting the results through a series of oral reviews and project-specific posters. This meeting will be co-sponsored by PAGES and the joint intention will be to use the occasion to link the research accomplishments of the program more closely to the international scientific community.

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4th Conference on Asian Marine Geology

Qingdao, China, 14–17 October, 1999

More than 100 participants, from 18 nations, presented a range of research based primarily on marine sediment records in the Asia-Pacific region. Much of the research presented fell within the PAGES remit, including regional sea surface temperature and salinity reconstructions (Min-Pen Chen – Taiwan marginal seas, Tdamichi Oba – Japanese coastal waters, Yali Sun et al. – Sr measurements in corals). Other topics which received considerable attention included the reconstruction of changes in the Kuroshio boundary current (Pinxian Wang, Hiroshi Ujiie) and sea level changes during the Holocene (Yong Ahn Park, B. Krishna Rao, Fernando Siringan). The Yellow river deposits an enormous sediment load to coastal waters, some 90% of which is derived from the Chinese Loess Plateau (Yoshiki Saito). It was suggested that high resolution sediment records should be targeted by constraining periods of high sedimentation with accurate dating (Serge Bernier).

The Asian Marine Geology community has grown rapidly since the first meeting in Shanghai in 1988, and is increasingly addressing questions of high resolution, quantitative environmental change of relevance to the PAGES project. The Fifth International Conference on Asian Marine Geology is scheduled to be held in Thailand in 2003.

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PAGES–REDIE Fellowship Week

BERN, SWITZERLAND, 12–16 JULY, 1999

For the first time, seven young scientists from developing countries were able to spend a week at the PAGES office in Bern as part of a PAGES/START fellowship. The aim of the week at the PAGES IPO was to interact, share individual research findings, and establish links with PAGES scientists. The presentations represented a wide diversity of paleoscience, and are presented here within the context of three time periods: the last 500 years, the Holocene and the last 60,000 years.

The last 500 years

Multiproxy records of global climate have shown that the most dramatic warming of at least the last millennium has occurred during the last century. Therefore, high resolution studies covering the last few centuries are important in order to understand and predict global and regional climatic systems. Two case studies were presented which reflect changes during this period using very different techniques and in very different environments. The first case shows direct human interference in regional moisture balance over a specific region in southwest of India. The second shows oceanographic response to warming in the northeastern tropical Pacific.

The transformation of Anantapur (southwest India) from a once humid to a completely arid area in the last two centuries prompted an evaluation of climatic changes in the area. Being located in a rain shadow region of the Western Ghat mountains, this region receives less rainfall than any other location in the whole of South India. Rainfall records in the area show no specific trend, but an increase of 0.8 °C in temperature has been observed over the last 50 years. Studies on sediment samples collected from the area point towards an abrupt change in the sediment deposition pattern in the last 200 years which can be attributed to drastic deforestation (figure a). This data is complemented by an extant historical inscription, dated 1416, which reads “We grant to you the tract of land bounded as follows … in which you may cut down the jungle and form fields …”. The human impact on the local climate has been demonstrated in this study. However, better chronological control, as well as similar studies on sediments from the surroundings, should be carried out to improve understanding of processes involved in local environmental change.

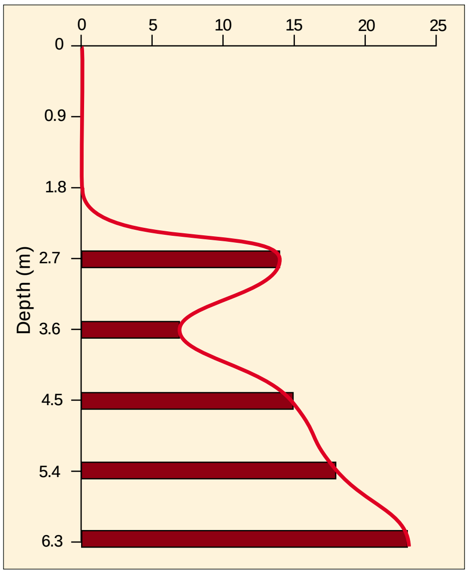

Figure a: Vertical variation of the pollen of tree taxa, as a percent of total pollen, in the Bukkapatnam tank, India. (P.J. Thomas)

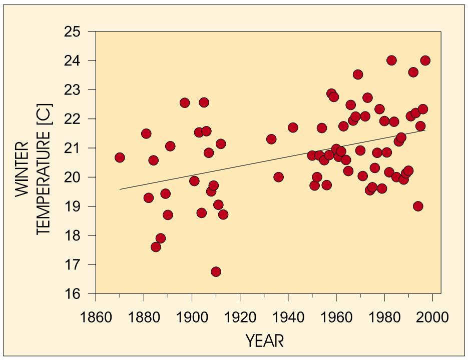

Figure b: Sea surface winter temperatures in La Paz basin, lower Gulf of California, during the last century. (G. Bernal; the authors gratefully acknowledge use of data from Release 1 of the COADS dataset).

In another context, records from laminated sediments from La Paz basin, lower gulf of California, indicate that sedimentation inside the basin has changed during recent centuries favoring accumulation of inorganic over organic Carbon. This could be explained by lower calcite dissolution, higher calcite fluxes or a combination of both in more recent times. During the last century, winter sea surface temperature of the area has increased (figure b). At the same time, the isotopic difference in $\delta^{18}O$ between the foraminifera *Pulleniatina obliquiloculata* and *Globigerina bulloides* has increased, indicating a possible change towards more stratified conditions. This could support the hypothesis of ecological changes leading to more calcitic biogenic production. But benthic and planktonic foraminifera accumulation and a fragmentation index support the idea of changes in calcite dissolution. Other proxies for primary productivity could help improve our understanding of this marine environment.

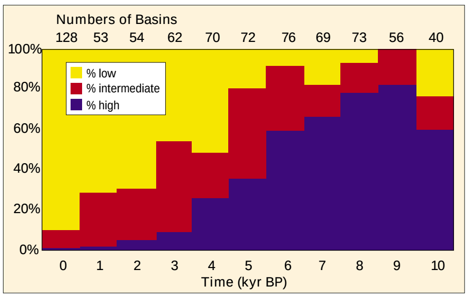

Figure c: Lake status variations during the last 10,000 years BP in Northern Hemisphere Africa. The histogram indicates the relative number of lakes with high, intermediate and low status in this area at each 1000 year interval. Changes in lake status (a measure of relative water depth or lake level) can be reconstructed from stratigraphic, sedimentological, geochemical and paleoecological data. For the Northern Hemisphere Africa, the lake status data show that conditions were generally wetter than today during the early and middle Holocene (the maximum of wetness occurred at about 9,000 yrs B.P); conditions became progressively drier after 5000 years B.P. (B. Damnati et al., in press)

The Holocene

Continental climate records were presented that indicate that the Holocene has been a climatically unstable period. Recent marine records from the SE Arabian Sea supporting this conjecture were also shown, with monsoon related oceanic processes being highly variable. Large scale changes in oceanic processes in this areas occurred even after 6000 years BP. Multi-proxy continental data from Africa (figure c) and the Indian subcontinent clearly indicate that the Holocene monsoon maximum occurred at around 9000 years BP, but recent high resolution investigations from North India suggest that the maximum occurred at around 6000 years BP. Moreover the extent of northward movement of the ITCZ during the mid Holocene is not well defined. Biological productivity proxies within the SE Arabian sea records reveal that the coupling between monsoon wind strength; mixed layer processes and surface productivity may have responded non-linearly in the past (figure d).

For the late Holocene, differentiating the human impact from low amplitude climatic changes has been difficult, mainly due to the lack of disturbance indicators. To overcome this problem in the Ethiopian Rift Valley, charcoal and grass epidermal fragments have been used to show the effect of domestic grazing after 2000 years BP (not shown).

The Last 60,000 years

Preliminary results of terrestrial records from Yunnan (southwestern China) and deep sea records from the Sulu Sea were presented. Both areas are influenced by monsoon systems, primarily the Indian and East Asian monsoons respectively. The Western Pacific Warm Pool influences the atmospheric and hydrological conditions in the Sulu Sea. In Yunnan, terrestrial indicators from lacustrine deposits, e.g. total organic carbon, pollen content, magnetic susceptibility, and percentage calcium carbonate, show several warm/wet and cool/dry episodes in the interval from 58 to 32 ky BP. These climatic changes are also observed in the record of lake level oscillations. The Sulu Sea high-resolution $\delta^{18}O$ and Mg/Ca records document apparently large, previously undetected millennial climate "events" during marine isotope stage (MIS) 3. Preliminary interpretation of $\delta^{18}O$ and Mg/Ca records suggests that these "events" are due in part to sea surface temperature and at least partly the result of changes in sea surface salinity in the Sulu Sea.

The observed terrestrial and marine climatic changes seem to be related in a simple manner with $\delta^{18}O$ depletion maxima and Mg/Ca maxima in marine records correlating with warm/wet episodes in the continental records. Correlation in this sense can be observed not only during the time of MIS 3, but also in the younger records (e.g., Last Glacial Maximum, Younger Dryas). Improvement of chronological control, especially beyond the range of radiocarbon dating is necessary. Further correlation of marine and terrestrial records could help shed light on the mystery of land-ocean linkages, in this case the link between the Indian and the East Asian monsoons and the Western Pacific Warm Pool.

Conclusions and Recommendations

A discussion session was held to provide recommendations for how PAGES can best continue to support the work of young scientists from developing countries. The following recommendations were agreed upon:

- provide access to recent, updated data sets
- maintain a direct e-mail list
- facilitate access to modern equipment through opportunity announcements and by providing access to second hand equipment
- hold more workshops in developing countries
- facilitate submission of international proposals to national funding agencies
- lobby for increased funding of paleoscience, especially in developing countries

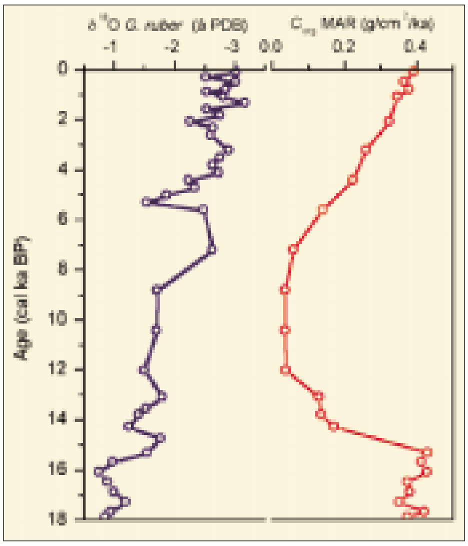

Figure d: Stable isotope record of planktonic foraminifera and mass accumulation rates (MAR) of organic carbon in a sediment core off SE Arabian Sea (M. Thamban et al., in press)

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For full references please consult *www.pages.unibe.ch/publications/newsletters/ref993.html*

PEP III at the XV INQUA Congress

Durban, South Africa, 3–11 August 1999

The PEP III Scientific Steering Group and Secretariat made use of the opportunity to publicize the PEP III programme at the INQUA XV Congress by convening a thematic poster and a workshop session on past climate variability through Europe and Africa. The 90-minute poster session attracted a mix of scientists and PhD students from paleocommunities across the transect whose excellent presentations reflected the highest quality of research. The session highlighted a broad range of climate reconstructions for both timestreams using a variety of archives and proxies in both individual projects and larger collaborative programmes. Following an introductory delivery by Françoise Gasse, presentations of 6 generic posters outlined details of large multinational programmes from across the transect such as EDDI (European Diatom Database Initiative) and GASPAL (Groundwater as a continental indicator of past climatic conditions). The popularity of this session (28 posters were presented) forced us to divide the remaining hour into a series of parallel sessions according to climatic region. The posters received a lot of attention at the Congress, fulfilling our objective to publicize PEP III to a wider audience as well as to spread awareness of related projects amongst those already involved. It also highlighted existing gaps in paleoclimate studies with respect to both climatic region and to methodologies. In particular, paleoclimate science in Eastern Europe was poorly represented.

The workshop and business meetings focused on ways to alleviate problems encountered by African scientists within PEP III. PAGES funded three Africans to attend INQUA: Chiori O.C. Agwu (University of Nigeria), Cheikh Gaye (formerly of Cheikh Anta Diop University, Senegal, now IAEA, Vienna) and Daniel Olago (University of Nairobi, Kenya). PAGES also contributed

continued on page 18

PEP III at INQUA, continued from page 17

towards the costs of three others who were primarily funded by the African Pollen Database: Bisi Sowunmi (University of Ibadan, Nigeria), Immaculate Ssemmanda (Makerere University, Uganda) and M.U. Mohammed (Addis Ababa University, Ethiopia). Several important points of discussion were raised by this group and their national colleagues during these meetings. A lack of adequate national funds for both field and laboratory work, computing facilities, internet access and availability of key publications in libraries is placing African scientists at a serious disadvantage for full participation in paleoclimatic programmes.

There is a need to build on existing networks to further the integration of African and Euro-African communities. PAGES does not fund research, but we can help by funding Africans to attend workshops and summer schools and there are a number of opportunities for national meetings. Also, PEP III strongly encourages the use of it's name and logo to support grant applications to African funding agencies, provided the proposal fits within the PEP III remit and we receive relevant feedback. For the future, PEP III is preparing to meet with African science leaders in Nigeria next year to further discuss these issues. In addition, the next IDEAL meeting sponsored by PAGES, START and IGU, will be held in Malawi, January 10–13, 2000. Several African scientists involved in large lake studies have been invited to attend. A plenary PEP III Conference will be held in Aix-en-Provence, France, 27–31 August, 2001. To register your interest please contact Catherine Stickley. Efforts are being made to find financial support for scientists from developing countries to participate.

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Climate in Historical Times

The project "Natural climate variations from 10,000 years to the present day" (Klima in historischen Zeiten, KIHZ) is a joint effort to analyze the dynamics of natural climate variability. Geoscientists and climate modelers from five German institutions, all members of the Helmholtz Association of National Research Centers (HGF), intend to create a synergy between proxy data and numerical modeling of the ocean-atmosphere system. KIHZ, led by J.W.F. Negendank, H. von Storch and H. Miller, is funded from 1998–2001 through the Strategy Fund of the HGF.

Data from continental and marine climate archives such as ice cores, tree rings, lake and marine sediments from different locations across both hemispheres are systematically combined with dynamic climate modeling and data assimilation. The different archives, to be organized along a consistent synthetic time scale, will be integrated to form a multi-proxy-parameter network. The project thus comprises three main segments, (i) analysis of geological archives, (ii) evaluation of existing paleoclimate data and time series, and (iii) climate modeling. A comparison of "free" climate simulations with integrations driven by data-assimilation aims at time-spatial, continuous climatic reconstructions of the last 10,000 yrs with a temporal resolution of decades to centuries. Selected time windows and simplified models are chosen to simulate regional differences during historical highs and low temperatures.

Project progress is achieved through annual workshops where all project members present their work in progress, and frequent smaller ad-hoc meetings that focus on specific questions being raised by project participants. At the KIHZ'99 workshop, held from 6–9 September at Jülich, Germany, preliminary results were presented and accompanied by vigorous discussions. Many archives show larger amplitude signals than would be expected to result from reconstructed temperature changes alone. Thus, a major portion of climate variability during the Holocene must be attributed to changes in the hydrological cycle. Also all archive data show a strong response to regional climate forcing and local effects. These results raise the following questions: What is the regional pattern of climate variations and anomalies? Which regions, variables and time scales can be realistically simulated by GCM's? Furthermore, climate models show that the internal atmospheric and ocean dynamics are able to produce a strong climate variability signal. Which signals can be attributed to external forcing and which ones to internal dynamics? In addition, increased focus is required on the main problems in data assimilation, with the ultimate question being: Can the trajectory of a climate simulation be driven by assimilation of proxy data? The next ad-hoc meetings will focus on, for example, the synthesis of a consistent time scale, upscaling, and climate variability during the past millennium. Data administration and exchange will be achieved through the information system PANGAEA (see PAGES News Vol 7, No. 1).

Currently, 9 groups from German universities, funded by the federal research and education ministry (BMBF), are preparing to join the project. KIHZ thus provides a platform for interdisciplinary and inter-institutional exchange within the national paleoclimate community and is looking forward to exchanging concepts, data and methods with the international paleoclimate community. For more information about the project, including the scientific background, structure and list of members please visit the KIHZ-homepage at *www.gfz-potsdam.de/pb3/pb33/kihzhome/kihz00/*.

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PAGES has a QUEEN

The European climate has been subject to rapid and dramatic changes during the recent geological past, mainly because of the instability and variability of the regional extension of the temperate climatic zones into very high northern latitudes, in particular over northwestern Europe and the adjacent ocean basin. Because of the difficulties in accessibility the Arctic Ocean, the Eurasian shelf seas and the high latitudes of northern Europe and northern Asia have remained behind in developing an understanding of how they responded to the Late Quaternary climatic changes and how they influenced the climate over northwestern Europe.

Over the past years, numerous bilateral projects have developed between research institutions in western European countries, North America and Russia in an effort to solve various aspects of the paleoclimatic history of northernmost Eurasia and the adjacent Arctic. The program "Quaternary Environments of the Eurasian North (QUEEN)" is sponsored by the European Science Foundation and tries to promote the exchange of information between the many ongoing projects in northern Eurasia and the adjacent Arctic Ocean which try to reconstruct the regional paleoclimate during the last two climatic cycles. QUEEN attempts to correlate well-established and well-dated marine and terrestrial records of the Late Quaternary paleoenvironmental history of the northern and eastern vast regions which were partly covered by one of the large Arctic ice sheets. Adjacent to the Eurasian ice sheets, a periglacial environment developed which was the habitat of mammoth and other now extinct megafauna. The mammoth has been chosen to dominate the QUEEN logo.

While the western European record of this history can be considered relatively well-known, the northern, southern, and eastern extension of these ice sheets during the last glacial maximum and the regional coherence of the individual ice domes is still relatively poorly understood. QUEEN attempts to synthesize the new knowledge gained through the many ongoing efforts in the area of interest and to stimulate new investigations in areas which may hold clues for a better understanding of this history. QUEEN recently published the first compilation of the Eurasian ice sheet distribution during the last glacial maximum, and there is no question that it never extended further to the east than the Taymyr Peninsula and the Central Siberian Uplands. This map (see figure) has been published in the first international volume describing results of the QUEEN project (BOREAS, vol. 28, No 1, 1999) in a summary paper by Svendsen et al. The third QUEEN workshop was conducted in April 1999 in the Hardangerfjord/Norway. The program of the workshop, the list of participants and the abstracts of the scientific presentation, as well as the membership of the QUEEN Steering Committee are accessible via world wide web: *www.geomar.de/~hbauch/king/html/queen.html*.

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Reconstructions of ice-sheet extent during the last glacial maximum as published by Svendsen et al. in 1999.

Have You Seen...

- The Interpretation of Short Climate Records, with Comments on the North Atlantic and Southern Oscillations, C. Wunsch, *Bul. American Met. Soc.*, **80**, 2, 245–255, 1999.
- Forcing of the cold event of 8,200 years ago by catastrophic drainage of Laurentide lakes, Barber et al., *Nature*, **400**, 344–348, 1999.
- Northern Hemisphere Ice-Sheet Influences on Global Climate Change P. U. Clark, R. B. Alley, D. Pollard, *Science*, **286**, 1104–1111.
- 5 new additions to the PAGES overhead collection, including the Vostok ice core record seen on the cover of this newsletter, a transect of lake records from the Americas, new Holocene greenhouse gas records and results from the Paleoclimate Modeling Intercomparison Project (PMIP): *www.pages.unibe.ch/publications/overheads.html*.

Some new books on the PAGES bookshelf:

- *Quaternary Climates, Environments and Magnetism*, B.A. Maher and R. Thompson eds, Cambridge University Press, 390 pp, 1999.
- *Paleoclimatology: Reconstructing Climates of the Quaternary*, 2nd edition, R. Bradley, Academic Press, 613 pp., 1999.
- *Use of Proxies in Paleoceanography: Examples from the South Atlantic*, G. Fischer and G. Wefer eds. Springer verlag, 735 pp., 1999.
- *Past Global Changes and their Significance for the Future*, Alverson, K., F. Oldfield and R. Bradley eds., Quaternary Science Reviews, 19, No's. 1–5, 465pp, 2000. Also available as a hardcover book from Elsevier press: *www.pages.unibe.ch/publications/reports00.html* for more details and to preorder.

PAGES CALENDAR

(* indicates open meetings – all interested scientists are invited to attend)

- ***10–13 January, 2000 "Second International Symposium on the Limnology, Climatology and Paleoclimatology of the East African Lakes". Lake Malawi, Malawi**
  Tom Johnson, tcj@d.umn.edu; Eric Odada, pagesnbo@form-net.com
  http://www.pages.unibe.ch/calendar/calextras/idealcirc.html

- **2–3 February, 2000 "PAGES Scientific Steering Committee meeting". Pune, India**

- ***4–5 February, 2000 "PAGES Workshop on South Asian Paleovironments". Pune, India**
  Rupa Kumar Kolli, Climatology & Hydrometeorology Division, Indian Institute of Tropical Meteorology, Homi Bhabha Road, Pune 411 008, India
  Tel +91-20-589-3600, Fax +91-20-589-3825, kolli@tropmet.ernet.in

- **16–20 February, 2000 "Terminal Millennial Synthesis of Decadal-to-Millenial-Scale Climate Records of the Last 80 ky". Trins, Austria**
  James P. Kennett, Dept. of Geological Sciences, University of California, Santa Barbara, CA 93106, USA. kennett@magic.geol.ucsb.edu

- **20–22 March, 2000 "Land Use and Climate Impacts on Fluvial Systems (LUCIFS)". Bonn, Germany**
  Bob Wasson, Department of Geography, Australian Nat. University, Canberra, ACT, 0200, Australia
  Tel +61-6-249 2745, Fax +61-6-249 3770, robert.wasson@anu.edu.au

- ***27–31 March, 2000 "INQUA Commission of the Holocene". Seville, Spain**
  Ana I. Porras, Dept. Physical Geography, University of Seville, Spain
  Tel +34 954.551.377, Fax +34 954.556.988, anapc@arrakis.es

- ***22–24 April, 2000 "15th Himalaya-Karakoram-Tibet Workshop". Chengdu, China**
  Deng Bin, 15th HKT Affairs Office, Chengdu University of Technology No. 1, Erxianqiao Dongsanlu, Chengdu, 610059, PR China
  Tel +86-28-4079488, Fax +86-28-4077099, 5hkt@cdit.edu.cn
  www.cdit.edu.cn/15hkt/

- ***27–30 April, 2000 "Iceland 2000 – Modern Processes & Past Environments. Special symposium: Modern and Ancient Ice-marginal Landsystems". Keele University, Staffordshire, UK**
  Mike Edge, Keele University, UK
  Tel +44 1782 583169, Fax +44 1782 715261, gga28@keele.ac.uk

- ***6–11 May, 2000 "The Ecological Setting of Europe – From the Past to the Future: European Agriculture on its Way from the Past to the Future". Scania, Sweden**
  www.esf.org/euresco/00/c_cal00.htm

- ***1–3 June, 2000 "Paleograssland Research 2000: A conference on the reconstruction and modelling of grass-dominated biomes". Westbrook, CT, USA**
  Kristina Beuning - Dept of Earth and Environmental Sciences, Wesleyan University, Middletown, CT 06459, USA.Tel +1 860-685-2265, Fax +1 860-685-3651, kbeuning@wesleyan.edu
  www.wesleyan.edu/~kbeuning/PGR2000/

- **2–6 June, 2000 "CAPE 2000: Sea Ice in the Climate System: The Record of the North Atlantic Arctic". Kirkjubaejarklaustur, Iceland**
  Aslaug Geirsdottir, age@rhi.hi.is
  http://instaar.colorado.edu/~duvall/cape/cape2000.html

**The full PAGES calendar is available on our website *(www.pages.unibe.ch/calendar/calendar.html)*.
If you would like to have your meeting announced, please send us the conference details.**