

**REDIE**

*The PAGES/START fellows during their stay in Bern (left to right): P.J. Thomas, M.U. Mohammed, B. Damnati, S. Dannenmann (US-NSF fellow), A. Mulock-Houwer, G. Bernal, M. Thamban, Y. Yin. In the background the remnants of the 1999 spring flood, a magnitude last observed in 1566.*

**EDITORIAL****Ready for REDIE**

One of the named Activities in the PAGES Implementation Plan focuses on 'Regional, Educational and Infrastructure Efforts' (REDIE). This reflects a foresighted view among the founders of PAGES that our future legacy should include not only data and scientific understanding, but also human development. The urgent need to establish scientific priorities and devise ways of realizing and coordinating them has taken precedence and REDIE has taken second place – until now. This summer (July 17–24), a formidable group of leading paleo-scientists from around the world will give a summer school entitled "The Dynamics of the Earth System: Processes and Records of Past Climate Change" (see <http://phkup0.unibe.ch/summer/>). One outcome of discussions between the PAGES IPO and the organizers of the summer school, Thomas Stocker and Andy Lotter, has been a scheme to fund attendance by young scientists from developing countries. START, the 'Global Change System for Analysis, Research and Training', that has responsibilities for capacity building

across the range of themes embraced by IGBP, IHDP and WCRP, has joined PAGES to finance participation in the course by researchers from China, Ethiopia, India, Mexico, Morocco and South Africa (see announcement on page 2). Those attending the course will also spend a week in Bern organized by the PAGES IPO. In selecting from the many promising applications received, we asked ourselves the following questions:

1. Can we offer scholarships to at least one candidate linked to each of the PEP transects and thus ensure the best regional coverage? (happily, the answer to this was 'yes'; we received high quality applicants from researchers working within each transect)
2. Is the candidate likely to feed his/her knowledge and experience back into the region?
3. Do the motivation, experience and goals of the candidate indicate an ability to connect with and benefit from the course as planned?

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REDIE, continued from front page

We hope to build on the experience gained from this first PAGES-initiated REDIE activity and thereby develop an ongoing program of capacity building within the PAGES research community. The PAGES Scientific Steering Committee has agreed that up to \$10k should be devoted to REDIE each year, at the discretion of the Executive Committee and in response to carefully developed proposals. In order to make the best possible use of this for future generations of young scientists from developing countries, we shall need the feedback and advice from our

first group of funded summer school participants. We also invite ideas and advice from the wider PAGES community, especially those working in developing countries whose experience is relevant to our initiative. We look forward to receiving your suggestions. A sustained and well conceived investment in the next generation of researchers is our goal. Without that the PAGES past has no future.

**FRANK OLDFIELD**

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## Winners of Swiss Summer School Fellowships

PAGES and START are pleased to announce fellowship awards to 8 scientists from developing countries to attend the Swiss Summer School "The Dynamics of the Earth System: Processes and Records of Past Climate Change." The names and poster titles of the winners, as well as three runner-up finalists are listed below.

### Winners

*G. Bernal, Mexico*

Oceanic variability and biogenic sediment accumulation patterns in the subtropics for the last 4 centuries: records from laminated sediments in the lower Gulf of California.

*B. Damnati, Morocco*

Palaeoclimatic reconstructions for the last 30 ka in Africa.

*M. Thamban, India*

Sedimentological investigation along the western continental margin of India: Inferences on palaeoceanography during the late Quaternary.

*M.U. Mohammed, Ethiopia*

Pollen and charcoal indicators of recent land-use change in the Ethiopian rift valley.

*A. Mulock-Houwer, South Africa*

Late Quaternary environmental reconstruction and climate modeling in the winter rainfall region of the Western Cape, South Africa.

*P.J. Thomas, India*

Climatic changes in the Anantapur arid zone observed in the last 500 years – an integrated study.

*A. Yeshanew, Ethiopia*

Signals of atmospheric dynamics in Africa.

*Y. Yin, China*

Evolution and variability of the Indian monsoon, climatic records from lacustrine and deep sea deposits and coupling with the East Asian monsoon during the last 60 ka.

### Finalists

*I.O. Adelekan, Nigeria*

Spatio-temporal variations in the synoptic origin of rainfall over Nigeria.

*C. Gray, South Africa*

A record of terrestrial environmental change from marine cores of the Namaqualand mudbelt in southern Africa.

*F. Mwaura, Kenya*

The geographical characteristics of past lacustrine surfaces in the Eastern Rift Valley, Kenya.



## Educational Opportunities

This is a new feature in our newsletter which supports the PAGES REDIE task discussed in the editorial in this issue. It is aimed at alerting PAGES readers to educational opportunities around the world in paleoenvironmental science. Further details, including internet links are maintained on the PAGES website (<http://www.pages.unibe.ch/activities/redie.html>). Comments and suggestions for material to be included should be sent to Keith Alverson (alverson@pages.unibe.ch).

### MSc in Paleoecology

School of Archeology & Paleoecology  
Queen's University of Belfast, UK  
<http://www.qub.ac.uk/arcpal/>

### MSc Recent Environmental Change

Department of Geography  
University of Liverpool, UK  
[http://www.liv.ac.uk/Geography/Html\\_use/pgcourse3/rec.html](http://www.liv.ac.uk/Geography/Html_use/pgcourse3/rec.html)

### M.Res in Aquatic Environmental Change

Environmental Change Research Centre  
University College London, UK  
<http://www.geog.ucl.ac.uk/ecrc/mres.htm>

### MSc in Quaternary Science

Centre for Quaternary Research  
Royal Holloway University of London  
and  
Environmental Change Research Centre  
University College London, UK  
<http://glacier.gg.rhbnc.ac.uk/mscdegree.html>

### PAGES Newsletter 99-2

Editors: Keith Alverson and Frank Oldfield

Layout: Niklaus Schranz

Circulation: 3000

The PAGES International Project Office and its publications are supported by the Swiss and US National Science Foundations

Printed on recycled paper

## Linking Continental and Ocean Paleo-Records: the PEP Transects

FALL AGU, SAN FRANCISCO, USA, 13-17 DECEMBER, 1999

This Union Session has been accepted for the upcoming AGU meeting. We plan to organize both a half-day of oral presentations and a very full poster session. Oral or poster presentations focusing on linkages between continental and marine records and poster presentations concerned with specific archives, either marine or continental, will be welcome. The proposed themes of the session are outlined below. We strongly encourage all interested in participating to contact one of the convenors as soon as possible, but before August 18. AGU abstract deadline is September 2 (mail) or 9 (web).

One of the most urgent challenges for those seeking to understand the dynamics of the Earth System on time-scales ranging from decades to millennia is to improve the linkage between paleo-records from continental and marine archives. Traditionally, these have been the concern of separate research communities, though the IGBP Past Global Changes (PAGES) project is now succeeding in uniting these at both regional and global level through the Pole-Equator-Pole (PEP) Transects and the IMAGES (International Marine Global Change Study) Program, the latter co-sponsored with SCOR. The session will draw on the expertise of participants in the PAGES program, notably those involved in PEP I, the transect of the Americas. Topics will include:

- comparing and synchronizing detailed marine and continental records of climate change for key time intervals and in key locations;
- the use of both types of archive to improve our understanding of teleconnections in the climate system on a range of temporal scales;
- the implications of synchronous marine and continental changes for modeling past changes in the global carbon cycle;
- comparisons between marine and continental evidence for the amplitude of climate change, eg. between the Last Glacial Maximum and the present day;
- improving the basis for reconstructing and modeling feedbacks to the climate system from changes in the oceans and the terrestrial biosphere;
- the role of past changes in terrestrial dust flux for both climate and marine productivity
- the use of near-shore marine sediment archives, eg. from corals and major estuaries, as high-resolution records of continental changes.

### CO-CONVENORS:

Geoffrey O. Seltzer (goseltze@syr.edu), Keith Alverson (alverson@pages.unibe.ch), Donald Rodbell (rodbell@union.edu), Frank Oldfield (oldfield@pages.unibe.ch)

## IDEAL – 2<sup>nd</sup> International Symposium

ARUSHA, TANZANIA, 10-13 JANUARY, 2000



This is a first call for papers/poster abstracts for the forthcoming meeting on the limnology, climatology and paleoclimatology of the East African Lakes which will be centered around seven themes as indicated below:

- Theme 1: Geological and structural setting of the East African lakes.
- Theme 2: Climate dynamics and climate variability in the East African lakes region.
- Theme 3: Hydrology and Physical Limnology.
- Theme 4: Aquatic Chemistry: Physical and Biological Aspects.
- Theme 5: Food Webs and Fisheries
- Theme 6: Sedimentary Processes, Paleoclimate and Paleoenvironment
- Theme 7: Anthropogenic and Natural Impact

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## 31<sup>st</sup> International Geological Congress



RIO DE JANEIRO, BRAZIL, 6-17 AUGUST, 2000

The Congress will include a Special Symposium on Global Changes and Future Environments. Within this, there will be 2 special sessions of potential interest to PAGES scientists: "Quaternary Climates" and "Past Climatic Changes and the Geological Record". International convenor for the first is Eric Odada and for the second, Frank Oldfield. The sessions will be organised so as to complement and reinforce each other. In accordance with the overall conference instructions, the final program will comprise invited papers. In order to plan

each session, we would especially welcome offers of contributions on new paleoenvironmental proxies, quantitative calibration and related methodological issues, case studies of climate reconstruction from marine, ice core and continental records, especially from low latitudes, reconstructions of rates of change and of system response during rapid transitions, syntheses of paleoenvironmental reconstructions from several archives and global timeslice reconstructions. The deadline for submission of abstracts is September 1, 1999, and

Workshop announcements continued on page 17

further details on the Congress can be obtained from the organizers. PAGES scientists interested in participating are welcome to contact either convenor.

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# Environmental Change and Nonlinearity – A Summary of a new Cross-cutting and Integrative Initiative within Focus 3

## Forcing-Response Mechanisms and Focus 3 Activities

A key IGBP objective is to understand the relationships between forcings, by human actions and climate variability, and responses by processes within the Earth system. In contemporary process studies, there is often the opportunity to make direct measurement of these relationships (or transfer functions). Thus for a variety of modern impacts, such as the effects of deforestation or extreme precipitation events on soil erosion, there are data available that may be used to produce transfer functions for input into predictive process models. Process studies often show that the transfer functions are nonlinear - a forcing input is disproportionately related to the output response, usually because of the mediating effects of thresholds and feedbacks. The Focus 3 Activities, examining sedimentary archival records of change in fluvial environments (LUCIFS), aquatic environments (LIMPACS) and the terrestrial environment (HITE), together represent the natural methodological extension of contemporary process studies that are constrained by short timescales. Bridging the gap between studies of modern processes

and paleo-processes is now a major challenge for the PAGES community and linked core projects, not least where the objective is to reconstruct the nonlinear nature of past or long term environmental change.

## Sediments and System Dynamics

Focus 3 Activities utilize cascading systems as their major frameworks for study. Such systems normally provide delimited, and usually coupled, spatial entities (lake, floodplain and catchment) in which synergistic and independent impacts of human actions and climate on a wide range of ecological, biogeochemical, hydrological and geomorphological processes may be recorded in a sedimentary archive. Focusing on a sedimentary archive as a sequence of outputs from an aquatic, fluvial or terrestrial system highlights a need to appreciate that the behavior of a whole system may be different from the additive behavior of component parts – the ‘reductionism versus holism’ debate that brings into play a variety of theories arising from the mathematical treatment of model systems over the past few decades. There are extremely important implications for our explanation

and understanding of forcing-response mechanisms if it can be demonstrated that changes in reconstructed environments are best described by nonlinear system behaviors. For example, our preconceptions of forcing-response mechanisms may require modification; the effects of perturbations may be highly dependent on spatial scale; the successful application of paleoecological transfer functions may be conditioned by system states; and some types of environmental change may be essentially unpredictable.

## Mechanisms of Environmental Change

A classification of mechanisms which drive environmental change is problematic because they are likely to coexist, often synergistically, and vary across different temporal and spatial scales. But three categories serve to illustrate common concepts of change. First, extrinsic apparently *linear* mechanisms exist where responses *are* proportional to outputs and where relatively small intrinsic thresholds give rise to short or unmeasurable time-lags. Second, extrinsic *nonlinear* mechanisms exist where responses are disproportionate to forcings and where there may be long or measurable time lags because of significant intrinsic thresholds and feedback within the system (Figure 1). A component of these mechanisms may be deterministic chaos, where small differences in initial conditions determine the responses to a particular magnitude of forcing. Third, intrinsic ‘*nonlinear*’ mechanisms exist where systems display non-random changes which are independent of external forcings. Evidence for emergent complexity and self-organized criticality, two of the terms from systems theory which apply to this category, has been found in a recent study of laminated sediments at Holzmaar, Germany. Frequency distributions of sediment accumulation rate data (Figure 2) suggest that the catchment’s sediment system in the mid-Holocene, before major human impact, may have reached the state of self-organized criticality. In this state, the magnitude of sediment loss from the catchment may have been extremely

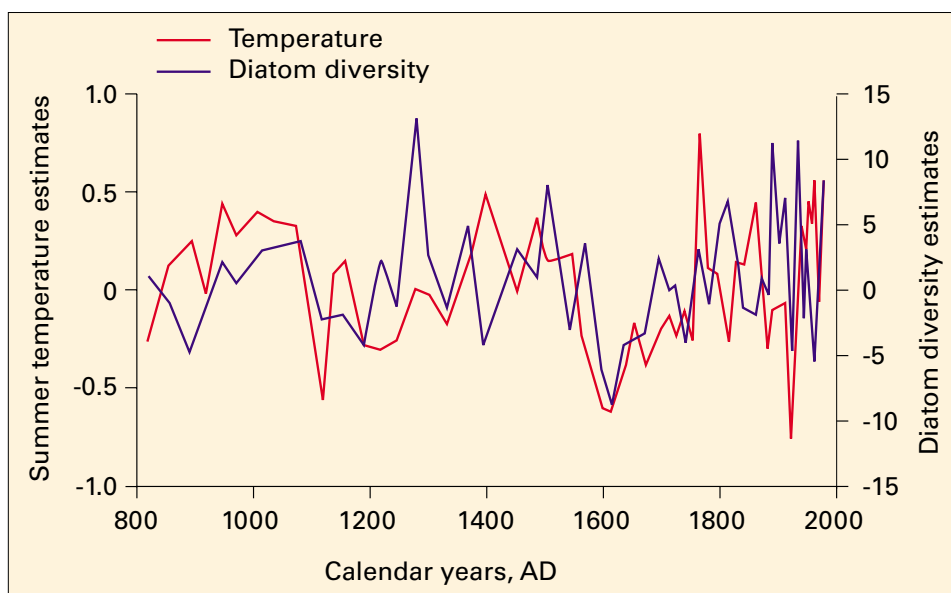


Figure 1: Northern Scandinavian tree-ring inferred summer temperature variations plotted together with diatom species richness estimates at Kassjön (northern Sweden) since AD 861 determined using rarefaction. The diatom species richness is shown with a lag of 20 years relative to the temperature data. Diatom richness is probably controlled by temperature changes driving biogeochemical processes in the catchment with a time lag of 20–25 years. Anderson et al. 1996.

sensitive to large external perturbations but, paradoxically, variations recorded in the lake sediments may have also been completely independent of climatic or any other external forcing events. In many lake sediment records, trends in proxy records of processes may be interpreted as trajectories in system behavior driven by internal organizational mechanisms that lead to greater or lesser system complexity and new steady states (Figure 3). Identifying a system's dynamic state allows the transfer of information from systems theory, which provides a strong basis to develop new hypotheses about the controls on change and to gauge the extent to which predictive models may be successfully applied in similar modern systems.

**An Integrating Initiative**

The Focus 3 Steering Group have proposed that there should be a cross-cutting and integrating initiative with the general aim of promoting the importance of system dynamics and non-linearity in forcing-response mechanisms within past environments. An

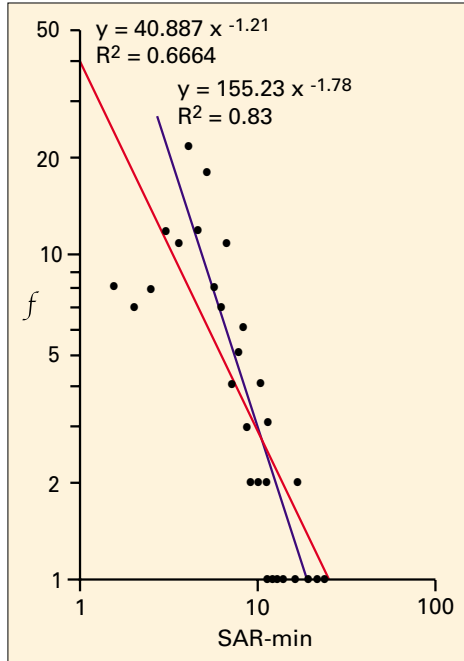


Figure 2: Frequency (*f*) distribution of minerogenic sediment accumulation rate (SAR-min) for the period 3000–10,000 cal. yr. BP at Holzmaar, Germany, showing inverse power functions for the complete (red) and linear (blue) parts of the dataset with exponents lying between 0 and -2, indicative of nonlinear self-organized criticality. Dearing and Zolitschka (in press).

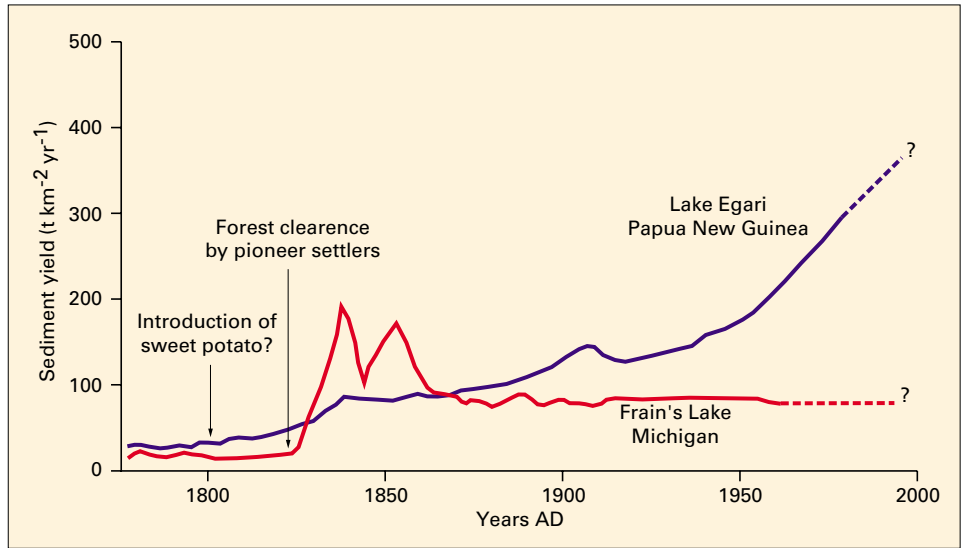


Figure 3: Reconstructed sediment yields since ~1750 AD at Frain's Lake, Michigan, USA, (Davis 1976) and Lake Egari, Papua New Guinea Highlands (Oldfield et al., 1980), based on multiple core correlations and dating by pollen influx, historical records and <sup>210</sup>Pb. The curves show very different nonlinear responses to deforestation and land management, including a relatively rapid sequence of process response time—recovery—new steady state (Frain's Lake), and a long-term trajectory of increasing erosion possibly driven by progressive weakening of intrinsic erosion thresholds caused by a combination of local forest clearing and subsistence gardening (Lake Egari).

initial list of issues for consideration includes the following:

- developing and maintaining strong linkages between the three Focus 3 Activities in order to maximize our understanding of process operation in whole environments at a range of temporal and spatial scales
- designing methodologies that maximize the opportunities to identify system states and thresholds, perhaps by focusing on 'generic' environmental impacts (e.g. deforestation on biogeochemical processes) and gradients of spatial scale (e.g. nested lake-catchment sites)
- giving equal attention to records of responses and forcings, through site selection (e.g. sites with long and continuous historical or monitored records) and the development of stronger links between paleoecologists and environmental historians
- further application of high resolution and multi-proxy studies across periods of significant environmental change through the use of laminated sediments, ultra-fine scale sampling and the development of sensitive analytical techniques

- application of mathematical and statistical tools which identify system dynamics to existing and new time-series, with stronger collaborative links between mathematicians and paleoecologists

In the coming months, it is planned to produce a document for wide distribution that expands upon this summary. The PAGES and, particularly, Focus 3 communities are now invited to offer views on this proposal. Any individuals within Focus 3 who would like to become actively involved in this cross-cutting initiative, either as experts in specific methodological or mathematical fields, as discussants of strategy or as promoters of the aims within their Activity, should contact the author or the PAGES Project Office.

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*This article is based on a presentation given at the IGBP Congress, Japan, May 1999.*

References for this article can be found at <http://www.pages.unibe.ch/publications/newsletters/ref992.html>

## Dust Indicators and Records of Terrestrial and Marine Paleoenvironments

Mineral dust aerosols play an important role in the global climate system, by mediating physical and biogeochemical exchanges among the atmosphere, land and ocean. Atmospheric dust can have a profound effect on the earth system by affecting the radiative forcing of the atmosphere, through chemical reactions with other atmospheric constituents, and through its impact as a source of micronutrients to marine and terrestrial ecosystems. As the net effect of these processes is still unknown, climate modeling studies are underway to assess the overall magnitude and direction of the forcing effect of dust on the current climate.

Records of dust from ice cores, marine sediments and loess deposits clearly demonstrate that throughout the Quaternary, glacial periods were considerably dustier than interglacial periods. The high concentrations of atmospheric dust during the last glacial period make it an excellent test of our ability to model the fluxes, concentrations, and interactive effects of dust in the atmosphere. Observational datasets are crucial for verifying that the simulated magnitudes and distribution of dust resemble reality. Validation datasets help to quantify changes in potential dust source areas (e.g. using maps of vegetation and loess accumulation), as well as identifying the magnitude and extent of dust during past climate periods.

A preliminary attempt to compile dust fluxes from ice cores and marine sediments for the Last Glacial Maximum was initiated as part of the Mineral Aerosols on Glacial-Interglacial Cycles (MAGIC) project (Figure 1 in 'Loessfest' workshop report, facing page), for comparison with model simulations of the dust cycle for the last glacial and current climates. There is a need to improve this dataset and extend it to also include terrestrial data from the last 30,000 years, in order to document the complete glacial, deglacial, interglacial sequence. In addition to eolian fluxes, this database should contain the background data necessary to interpret the flux information, as well as additional metadata. In addition to its utility for model validation, this database could provide a useful repository of dust data, serving a variety of purposes for earth scientists.

The Dust Indicators and Records from Terrestrial and Marine Paleoenvironments (DIRTMAP) database has been established to serve both the earth science and modeling communities. This initiative was recently named a highest priority item for the IGBP/GAIM Paleo Trace Gas and Mineral Aerosol Challenge (TRACES), endorsed by IGBP/PAGES Paleo Mapping Project (PMAP), and by International Geological Correlation Programme (IGCP) #413. It has been recognized as an important formal activity of the INQUA Loess Commission, over the next two inter-Congress periods (1999–2007). We are enlisting the help of the international community to produce this new database. As "Phase 1" of the data collection activities, we have established an interactive web form, through which members of the loess community can contribute information about their field sites to a global inventory of analyzed loess deposits (see the "Fink Link" at [http://www.bgc-jena.mpg.de/bgc\\_prentice/start1.html](http://www.bgc-jena.mpg.de/bgc_prentice/start1.html)).

As "Phase 2," the DIRTMAP database will target data from 0 to 30,000 years BP, containing sediment age models and accumulation rates, bulk densities, mineralogical and provenance tracer data, grain size information, and chronological data (e.g. radiocarbon dates, luminescence dates, stratigraphic correlations, etc.). Any data included in the database will have the additional documentation that is required for interpretation. DIRTMAP is intended to be a public access database. Participants will have access to the data during the developmental phase. Scientists interested in contributing to this effort or in obtaining more information can contact Karen Kohfeld, the DIRTMAP Database coordinator, at the address below.

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## WORKSHOP REPORTS

### Loessfest'99

BONN, GERMANY 26 MARCH – 1 APRIL 1999

"Loessfest'99", the INQUA/IGCP Spring Dust Festival was an international conference sub-titled "loess: characterization, stratigraphy, climate and societal significance". The initiative for this meeting came jointly from IGCP Project #413 on 'Understanding Future Dryland Changes from Past Dynamics' and the Loess Commission of INQUA. Its aims were to review the current state and future directions of loess research. "Loessfest'99" marked both the 175<sup>th</sup> anniversary of the first description of the Rhineland loess at the *locus classicus et typicus* at Haarlass, near Heidelberg by Karl Caesar von Leonhard, and the 30<sup>th</sup> anniversary of the INQUA Loess Commission. It came just five years after the 'stock-taking' meeting on *Wind-blown Sediments in the Quaternary Record* held in Royal Holloway (University of London, UK) under the aegis of both IGCP and INQUA, and the NATO sponsored gathering in Loughborough UK on *Genesis and Properties of Collapsible Soils*.

Valued support was provided by the Deutsche Forschungsgemeinschaft (DFG), the Gesellschaft für Technische Zusammenarbeit (GTZ), SAS, the Fachbuchhandlung Sven von Loga, Eijkelpark Agriresearch Equipment, the Centre for Quaternary Research, University of London, and Elsevier Science Limited, Oxford, UK, as well as from IGCP and INQUA.

In Bonn, a total of 88 papers by just under 100 participants were presented as keynote reviews, oral presentations and poster papers, and included a special evening lecture by W. von Koenigswald on *Climatic changes recorded by the Quaternary fauna in the Rhine area*. Scientists came from 16 countries on five continents.

Appropriately enough, Loessfest'99 began with keynote reviews on, first,

the question of the origins of loess particles and, second, on 175 years of loess research in Germany. The broad spectrum of geotechnical problems associated with loess as a collapsing soil were considered in a series of papers, following a keynote address on *Loess as a Geohazard*. Subsequent sessions went further into the origins of loessic dust, including data from a number of contrasting laboratory experiments. Further sessions, each led by at least one keynote review, included the latest work on paleosols in loess, the use of loess to infer the dynamics of the paleomonsoons and related atmospheric systems, and the dating of loess-paleosol sequences. More than a quarter of the papers focused on the stratigraphical record in loess-paleosol sequences, including problems associated with their dating, as well as the increasing potential of loess biostratigraphy, notably in the higher resolution use of molluscan faunas.

New data were presented from most continents, i.e. Europe, South and North America, Africa and Asia (including Siberia). Some serious inadequacies in the dating of these deposits were highlighted. Until recently, variation in climate proxy parameters such as magnetic properties, grain size and soil typology has been used for climate reconstruction. Chronometric attribution of these has been based on correlation with isotopic records. Some of these results led to a call for caution in such exercises in the absence of a sound geological framework. There was very useful debate concerning the fact that the Brunhes-Matuyama boundary invariably occurs in oxygen isotopic stage L9 in deep ocean sediments (representing a warmer epoch) but is found in loess layer L8 (associated with a cold period) in the Chinese loess. An explanation of this in terms of delayed remanence acquisition in loess with time lags (between particle sedimentation and the 'locking in' of the magnetic signal) ranging from a few thousand to perhaps as much as 35,000 years was discussed, and gave rise to considerable debate. Such time lags, although perfectly plausible, add further difficulties to high-resolution paleoclimatic reconstruction. The likelihood of site dependence to varying degrees should lead to further initiatives in the understanding and quantification of these lags.

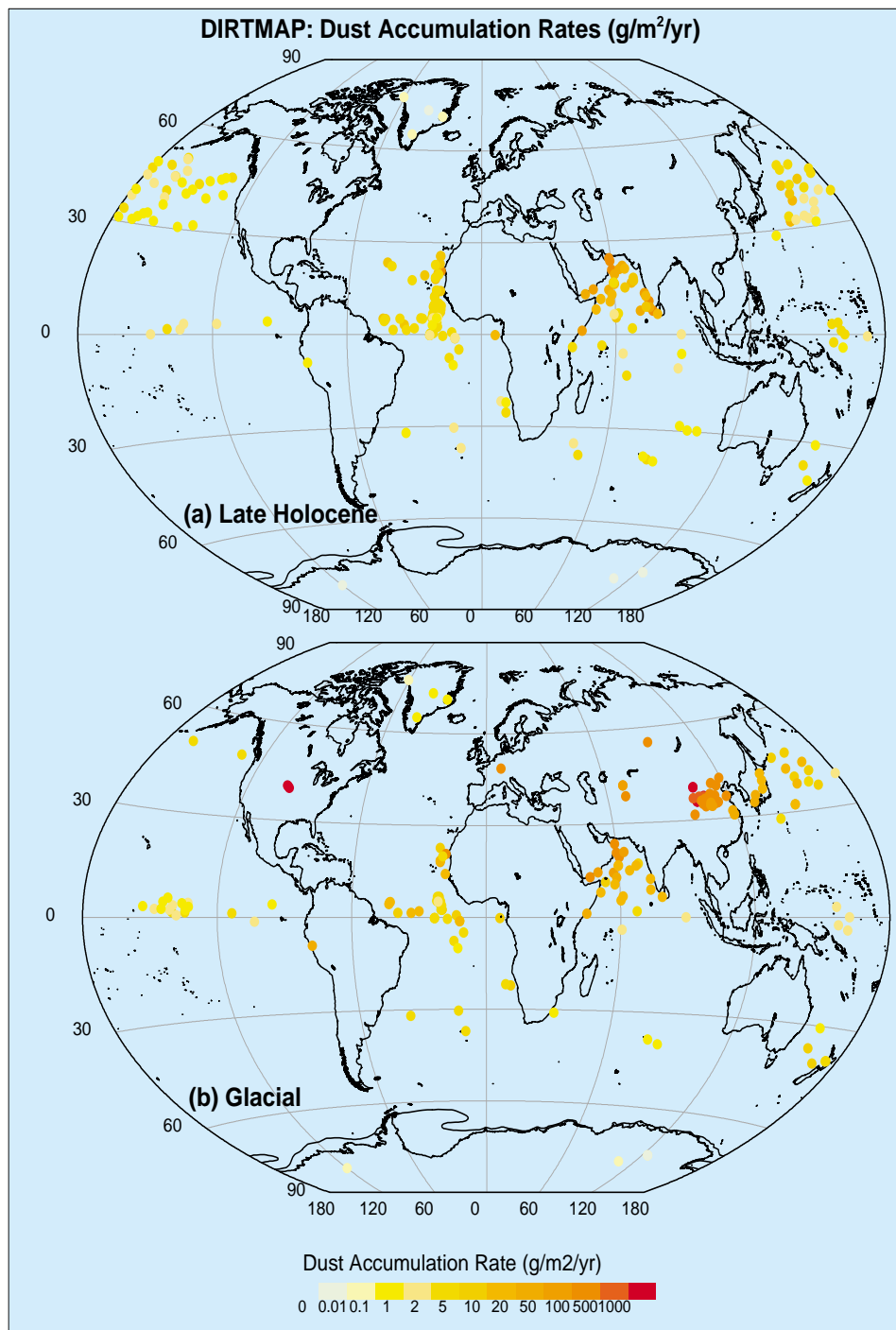


Figure 1: First approximation global map of dust accumulation rates for the modern era and the Last Glacial Maximum, presented at the "Loessfest'99" meeting by Karen E. Kohfeld.

A considerable amount of new data on absolute dating using luminescence was also presented for several new sites. Excellent concordance between loess and AMS radiocarbon ages on organic matter was noted, but it is also evident that it poses problems in explaining a consistent underestimation of radiocarbon ages from similar loess-paleosol sequences. Even so, and despite the problem of age underestimation in luminescence dating, the large volume of luminescence ages clearly suggests to

some workers that the *windows of opportunity* for loess accumulation occur postglacially and for relatively short periods of time. Thus there is now a need to reconcile the somewhat divergent inferences provided by luminescence ages and those provided by magnetic/sedimentological studies. This also points to the need for great care in the identification of high-resolution phenomena, such as Heinrich events, in loess sequences. It was proposed that

*continued on next page*

*Loessfest, continued from previous page*

we should recognize a minimum number of prerequisites when using such records. Several authors cautioned against 'wobble matching' without sufficient background data on and from the site, the selected proxy itself, and on the time series. In this context, a convincing case was made for the use of paleopedology and soil micromorphology in both climatic reconstruction and as a means of ensuring the reliability of any chronology. Several papers showed how these techniques make it possible to delineate a stage by stage record of loess sedimentation and its frequently complex patterns of diagenesis, information that is crucial for reliable dating. Yet other work in this section showed how good quality optical dating has successfully delineated the impact human occupation has had upon the loess over the past 1000 years.

There were several studies on the characterization of modern dust fall events and their climatological implications. The subtleties involved in establishing a link between present-day atmospheric dust events and climate, on the one hand, and the interpretation of the Pleistocene record of dust accretion and paleoclimate, on the other, were also explored. This discussion was a precursor to several keynote talks, several papers and a plenary discussion designed to involve the loess community in an initiative to establish a terrestrial eolian sediment data-base for the Last Glacial Maximum. The meeting strongly endorsed this DIRTMAP project (see page 6), which will involve the formal participation of both the INQUA Loess Commission and IGCP 413, as a means of gathering, synthesizing and collating data on dust, including loess, in a form capable of testing and improving global models of aeolian dust accumulation (Figure 1). Dr. Karen E. Kohfeld (Database Coordinator) has already set up a DIRTMAP website at <http://www.bgc-jena.mpg.de/>.

Taken over all, the meeting re-emphasized the value that the extended and semi-continuous nature of loess-paleosol sequences offers as the basis for terrestrial stratigraphical studies of longer-term Quaternary paleoclimates. At the same time, it brought out a number of caveats on the use (or abuse) of climatic proxies and the land-sea corre-

lations based on them. A strong message that emerged is that considerably improved understanding of the underlying physics underpinning every climatic proxy's phase relationship with climatic parameters is needed.

Selected peer-reviewed papers presented at "Loessfest'99" will be published as special issues of two international scientific serials: *Earth Science Reviews* (keynote reviews) and *Quaternary International*. The aim is to publish both by the summer of 2000.

"Loessfest'99" was a rich cocktail of scientific data and ideas on almost the whole spectrum of global loess research. The initiatives noted above, including the major international effort required to maximize the value of the DIRTMAP project, are some measure of the progress recorded by "Loessfest'99" and its potential as a springboard for further advances in loess research.

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## **LUCC-PAGES-DIS**

**BARCELONA, SPAIN, 17-20 NOVEMBER, 1998**

### **Data strategies for Research on Historical Dynamics of Land Use**

The outcomes from a joint LUCC-PAGES-DIS working meeting on Historical Land Use/Land Cover Change and two Working Group 'break-out' sessions held during the LUCC-DIS Data meeting are summarised on the PAGES Website at <http://www.pages.unibe.ch/activities/focus3/forum3.html>. The proposals outlined there are also consistent with the outcome of planning sessions devoted to developing the "terrestrial" aspects of PAGES Focus 3 (Human Interactions in Past Environmental Changes), and strengthening the contribution of PAGES-LUCC interactions. One of the most concrete outcomes has been the establishment of an initiative to reconstruct land cover for 300 years ago - "BIOME 300". Although, in many

parts of the world, major land cover changes predated this, the period since AD 1700 has seen the greatest human-induced transformations on a global scale. This will involve establishing, from all the sources available ranging from cartographic and documentary to palynological, the best possible empirical basis for reconstructing land cover around that time. It is seen as a first step towards a longer term program on land use/cover change designed to trace the major transformations in each region right up to the stage where documentary, statistical and satellite-derived data provide an increasingly secure basis for land cover mapping. Colleagues interested in contributing to BIOME 300 should, in the first instance, contact Frank Oldfield.

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## **IGBP Congress**

**SHONAN VILLAGE, JAPAN, 6-13 MAY, 1999**

A report covering "PAGES at the IGBP Congress" will appear in the next IGBP Newsletter.

At the occasion of a PAGES social gathering during the Congress, Claude Lorius presented a poem about PAGES and human dimensions:

*Il faut me pardonner  
Mais pour mieux m'exprimer  
Je dois français parler*

*Ce que je voudrais dire  
Ne prête pas à sourire  
La terre pourrait mourir*

*Les leçons du passé  
Que PAGES veut étudier  
Disent qu'il faut espérer*

*L'homme a su s'adapter  
Et il saura trouver  
Comment s'organiser*

*Notre communauté  
(C'est de PAGES qu'il s'agit)  
Eil a bien su trouver  
Les thèmes qu'il faut traiter*

*Il y a l'homme aussi  
Il se sent bien ici  
Dans ce cercle d'amis*

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# Oversnow Traverses Aimed at Understanding Recent Change in the Climate and Atmospheric Chemistry Over Antarctica

DURHAM, NEW HAMPSHIRE, USA, 19-23 APRIL, 1999

Glaciologists, geophysicists, remote sensing specialists and meteorologists from fifteen countries met to discuss the International Trans Antarctic Scientific Expedition (ITASE). ITASE is investigating the last ~200 years of change in climate and atmospheric chemistry over the Antarctic ice sheet (Mayewski and Goodwin, PAGES Workshop Report 97-1). It is jointly sponsored by the Group of Specialists on Global Change and the Antarctic (GLOCHANT) of the Scientific Committee on Antarctic Research (SCAR) and PAGES.

The available Antarctic meteorological data (re-analysis fields, in-situ observations, operational model fields) provide approximate descriptions of spatial and temporal variability of Antarctic accumulation and associated atmospheric circulation from approximately 1980 to date. Progress has been made in describing the impact of the seasonal cycle, semi-annual oscillation and ENSO cycle on Antarctic accumulation over this time period. Difficulties still remain in explaining fully the history and forcing of Antarctic climate and the links between tropical forcing and high latitude response. These difficulties arise largely because of the relatively short duration and sparse spatial coverage of Antarctic meteorological data.

By combining available meteorological data from the Antarctic and Southern Ocean with ice core proxies for a variety of climate parameters (e.g., moisture balance, atmospheric circulation and temperature) ITASE plans to extend the Antarctic climate record back ~200 years. This coverage offers the temporal perspective needed to assess the multi-decadal state of natural climate variability in Antarctic climate. In the process ITASE will be able to contribute to understanding the impact of global change on the Antarctic continent and the influence of Antarctica on global change. Examples of some of the issues treated at the meeting follow:

## Annual layer dating of ice cores and absolute dating through unique stratigraphic markers

Development of annually resolved ice core series is recognized as an essential component of the ITASE program because of the fidelity needed for comparison and calibration with instrumental series. Several dating tools are used in dating ITASE cores. These include annual layer counting of stable isotope, chemistry and particle series. These annual layer counting tools are calibrated to volcanic and nuclear fall-out markers. As an example, sulfate from a variety of well documented volcanic emissions, covering the last ~200 years, is potentially documented in Antarctic ice cores. These events include: Lascar, Chile (1993), Pinatubo, Philippines and Cerro Hudson, Chile (1991), El Chichón, Mexico (1982), Deception Island, South Shetlands (1972, 1969, 1967), Agung, Indonesia (1963), Cerro Azul, Argentina (1932), Santa Maria, Guatemala (1902), Tarawera, New Zealand (1886), Krakatau, Indonesia (1883), Coseguina, Nicaragua (1835), Babuyan, Philippines (1831), Galunggung, Indonesia (1822), Tambora, Indonesia (1815) and Unknown (1809).

## Ice core proxies for Antarctic moisture flux

A selection of twenty three ice-core-derived accumulation rate time series, distributed around the continent, were compared during the workshop. Empirical orthogonal function analysis (EOF) of the series demonstrates that within regions the series share significant common variance. Investigation into associations between regions may provide evidence of the history of moisture bearing atmospheric circulation systems potentially associated with features in the ENSO system and the Antarctic Circumpolar Wave.

## Ice core proxies for major Antarctic atmospheric circulation patterns

Recent instrumental linkages between the tropical ENSO system and the high southern latitudes demonstrate the ex-

istence of an ENSO-Antarctic climatic teleconnection. These investigations reveal that annual temperatures at South Pole are positively correlated to annual values of the Southern Oscillation Index (SOI) of the previous year (Savage et al., 1988). The ENSO signal has been interpreted at South Pole in an ice core covering the time period 1922-1984 AD, and also in a core from Dronning Maud Land. They clearly show increases in Marine Sulfate Aerosol (MSA) concentration during El Niño events identified in the Quinn *et al.* (1987) historical El Niño chronology. MSA is produced from the oxidation of atmospheric dimethylsulfide (DMS), a major emission of marine phytoplankton. A new record from South Pole was presented at the meeting. This core extends the South Pole ice core proxy for ENSO back to AD 1500 and also identifies a sea ice MSA association previously observed at a site to the north on the Newall Glacier, southern Victoria Land. Background values of MSA in the South Pole core are associated with sea ice extent anomalies (185°-245°E) and outliers in MSA are associated with warm events (El Niño events) allowing investigation of ENSO-sea ice associations. A seasalt proxy for the strength of the Amundsen Sea Low developed from the Siple Dome ice core was also presented at the meeting.

## Ice core proxies for temperature and borehole temperature measurements

Stable isotope measurements of ice ( $\delta D$ ,  $\delta^{18}O$  and deuterium excess) have classically been employed as a proxy for temperature in Antarctica and more recently borehole measurements have been undertaken to provide direct measures of snow surface temperature time series. An overview of results from these studies was presented at the meeting. Combined with instrumental observations, these results reveal an ~1°C warming in the Antarctic Peninsula and Dronning Maud Land over the past few decades. High resolution ice cores on Law Dome, Wilkes Land have enabled the discrimination of seasonal

stable isotope signals which are being calibrated to the instrumental meteorological record. This calibration is being used to resolve major precipitation events and temperature fluctuations.

### Examination of the ice sheet record between ice core sites

Ice cores can provide annually resolved records of environmental change but they are based on centimeter scale diameter samples. Snow and ice radar systems on the other hand provide detailed information that can be tuned to investigate snow layering in the upper several tens of meters of the Antarctic ice sheet and down to thousands of meters in depth to detect ice thickness and bedrock configuration. Radar measurements between and around ice core sites add information that is extremely valuable in assessing the representativeness of ice core sites and in the determination of decadal averaged snow layer thicknesses between core sites. Detailed examination of changes in topography and ice dynamics that exert controls on accumulation rate are being conducted through GPS surveys along ITASE traverse routes in order to remove the influence of these factors and more clearly assess the influence of climate change on accumulation.

### Ground truth for satellite remote sensing of the Antarctic ice sheet

Recent advances in remote sensing technology and availability of images has vastly improved traverse route selections, core site selection and spatial interpolation of ice core time series. As an example, temporal changes in snow surface elevation and velocity can be mapped using laser altimetry and interferometric methods. ITASE traverses provide unique opportunities for developing ground truthing for remote sensing experiments that are geared toward characterizing and interpreting changes in surface topography, surface temperature, surface velocity and various other surface characteristics of ice sheets (roughness, grain size, albedo).

### Future of ITASE

The workshop also provided a venue for discussing the coordination of sample collection, sample handling, data exchange, data interpretation and future ITASE oversnow traverse plans

for the next decade. ITASE efforts over the next decade are widely dispersed over the continent. Themes to be investigated by current and future ITASE investigations include:

- (1) Relationship between Antarctic precipitation variability and ENSO associated climate, particularly, precipitation variability in Southern Australia and perhaps South America.
- (2) Variations in cyclogenesis, storm tracks, moisture flux and the strength of the low pressure cells that surround Antarctica.
- (3) Interannual and decadal variability in sea ice extent and concentration,

persistence and maintenance of coastal 'latent heat' polynyas.

- (4) Changes in the chemistry of the atmosphere over Antarctica and differentiation of natural versus anthropogenic controls on such change.

Working group reports from the meeting, related references, descriptions of the research presented and the ITASE Science and Implementation Plan (Mayewski and Goodwin, 1997) are available at [www.antarc.utas.edu.au/scar/itase.html](http://www.antarc.utas.edu.au/scar/itase.html).

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## Conference on Marine Environment: the Past, Present and Future

KAOHSIUNG, TAIWAN, 26-28 JANUARY, 1999

The Conference on Marine Environment: the Past, Present and Future was the result of a series of consultations with a number of international scientific organizations (JGOFS, LOICZ, PAGES and START) as well as individual scientists. It was hoped that such a conference would provide a forum that would result in lucid, candid descriptions of the status of the marine environment. Further, experiences learned from past environmental changes were deemed useful in order to ameliorate the fast growing environmental ills that face the oceans today.

The conference was organized into several themes each with two or more sessions related to JGOFS, LOICZ and PAGES. Four sessions were devoted to the "Marine Environment, the Past" with 16 oral presentations and 4 posters. These were mostly related to the Western Pacific Warm Pool. For example, the warm pool in the eastern Indian Ocean during the last 30,000 years was discussed by P. de Deckker, during the last glacial maximum by R.J.I. Martinez, and in the Sulu Sea over the past 140 kyr by B.K. Linsley. H. Kawahata reported on the fluctuations in material transport during the late Pleistocene, and E. Matsumoto reconstructed the climate patterns of recent centuries in the Kuroshio region on the basis of corals.

M. Yoshino reported on paleomonsoon circulation in East Asia in the period of 18,000-20,000 B.P. M.Y. Oba described surface temperature off the eastern coast of Japan during the last glacial maximum.

The second major topic centered on the South China Sea. K.Y. Wei, M.T. Chen, T.Q. Lee, C.Y. Huang, E.F. Yu and L.W. Wang discussed such areas as paleotemperature, paleomonsoon and paleoproductivity, mostly based on IMAGES cores. G.J. Wei spoke about Mg/Ca and Sr/Ca coral thermometry. H.C. Lan compared the paleomonsoon records of Inner Mongolia and the South China Sea. On a larger scale Y. Ono presented the synchronicity of rapid climatic changes in Monsoon Asia. J.D. Ortiz presented the application of non-invasive methods to sediments collected from Western Pacific marginal seas. S.R. Troelstra introduced a global perspective of the conveyor belt. Finally, Z.X. Liu reported on Quaternary seismic stratigraphy in the East China Sea shelf, and Y.C. Chen discussed coccolith in the ocean environment.

After these presentations a special Workshop on the Western Pacific Margins was organized by M.T. Chen and P. de Deckker. The working group was initiated and approved in the IMAGES

SciCom meeting held in San Francisco in December 1996. The motivation of forming this working group was to better coordinate and promote all scientific activities on high-resolution late Quaternary paleoceanography of the western Pacific marginal seas (from the Bering to the Tasman Seas), and to better exchange information on paleoenvironmental and paleoclimatic records from the western Pacific covering the last 300,000 years.

The goal of this particular workshop was to establish a partnership that would significantly enhance data sharing and access, essential to the understanding of key issues of the western Pacific and Asian environmental variability. More specifically, the WEPAMA working group meeting was aimed at providing an important incentive to the development of future giant piston coring programs using the French vessel *Marion Dufresne* in the western Pacific marginal seas. Workshop participants included representatives of major members in the IMAGES program from the US, France, the Netherlands, Japan, Australia, Colombia, China, and Taiwan.

The meeting began with an introduction to the background of the IMAGES program, followed by discussions on scientific questions of the western Pacific paleoceanography: I. East Asia Paleomonsoons; II. Western Pacific Warm Pool Variability; III. SST and Circulation Patterns Since the Last Glaciation; IV. Land-Sea Paleoclimatic Linkage; and V. New Techniques and Proxies. The working group identified approximately 30 potentially good sites for giant piston coring in future IMAGES cruises in the year of 2001, and proposed the schedule for the next meeting.

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## Paleohydrology and Paleoclimate as Reflected in Lake-level Changes in China

NANJING, CHINA, 26–29 APRIL, 1999

About 40 geologists, geomorphologists, chronologists, palynologists, paleoclimatologists, and paleo-GCM experts from China, Germany, Australia, the USA, and the UK attended this international workshop with support and sponsorship from the National Natural Science Foundation of China, the Chinese Academy of Science and the Max-Planck-Institute for Biogeochemistry, Germany. The workshop was convened with the twin aims of building up the existing Chinese Lake Status Data Base (CLSDB), as a contribution to the International Global Lake Status Data Base records (GLSDB) program, and taking the first steps towards investigating the comparison of climate reconstruction based on Chinese lake records with climate model simulations. The effort is a contribution to the PMIP program, in which coupled-ocean simulations are being conducted by several groups, including scientists associated with the Testing Earth System Models with Paleoenvironmental Observations project (TEMPO).

The presentations and discussion began with reviews of recent advances in paleo-monsoon reconstructions mainly based on lake records, with "Recent research on the Asian paleomonsoon" (An Zhisheng), "High lake level records and enhanced Asian monsoon during 30–40 ka in Tibet" (Shi Yafeng), "Paleoclimate and Africa-Asian monsoon" (Sandy Harrison), "Paleomonsoon records from Australia" (Liz Pickett). There were also several database demonstrations including "A range of paleo-data bases, in the PAGES PEP II region and the paleomonsoon" (John Dodson), "Potential Global Lake Status Data Base" (Philipp Hoelzmann), and "The state-of-the art of Chinese Lake Status Data Base" (Ge Yu). Modeling presentations included "Climate simulations, including Paleoclimate modelling for 6 ka and 21 ka" (Paul Valdes), "Paleohydrology modelling in Western China since 126 ka" (Mike Coe) and "PMIP-paleoclimate data and modeling comparisons" (Sandy Harrison).

There was a series of reports on regional lake sedimentology, paleohydrology and paleoclimate and demonstrations of ongoing lake research from the Tibetan Plateau and inland Xinjiang (Li Shijie, Li Binyuan, Wang Fubao, Zheng Mianping, Tang Lingyu, Li Shengfeng), Inner Mongolian Plateau (Xiao Jule, Shen Ji), the Yunnan Plateau (Xue Bin, Zhang Zhenke) and eastern parts of China (Xu Qin Hai, Yang Dayuan, Guo Shengqiao, Wang Jian, Xiao Jiayu). The lake sedimentary records presented were mostly from the Holocene but many lakes from western China have records extending beyond the last glacial maximum, to 30–40 ka BP (Figure 1). Numerous geomorphologic investigations of these lakes show evidence of high stands and absolute lake levels in the past. Changes in lake status have been reconstructed on the basis of changes in lithology, geochemistry, geobiology and archaeology. The chronology for changes in lake status is based on radiocarbon dates, thermo-luminescence dates, and paleomagnetic and stratigraphical correlations. All have produced compelling evidence for major climatic variability across eastern Asia's monsoonal regions. There were very high lake-levels in Tibet at the start of the period 30–40 ka BP, and we know that conditions on the eastern plains of China during the LGM were very dry. Many lake level changes are nearly synchronous over China during the mid-Holocene. A few of the talks dealt with changes in fluvial systems in China, such as the extremely large flood events recorded in the channel forms of the Huanghe River (Yellow River) in the Holocene. Bin Xue and Ge Yu also reported on their recent work on the CLSDB lake status coding and documentation procedures during the workshop.

The workshop culminated in a provisional agreement to continue work towards the establishment of CLSDB. One of the first goals for the CLSDB is to create a database of lake status records spanning the last 30,000 yr BP. Addi-

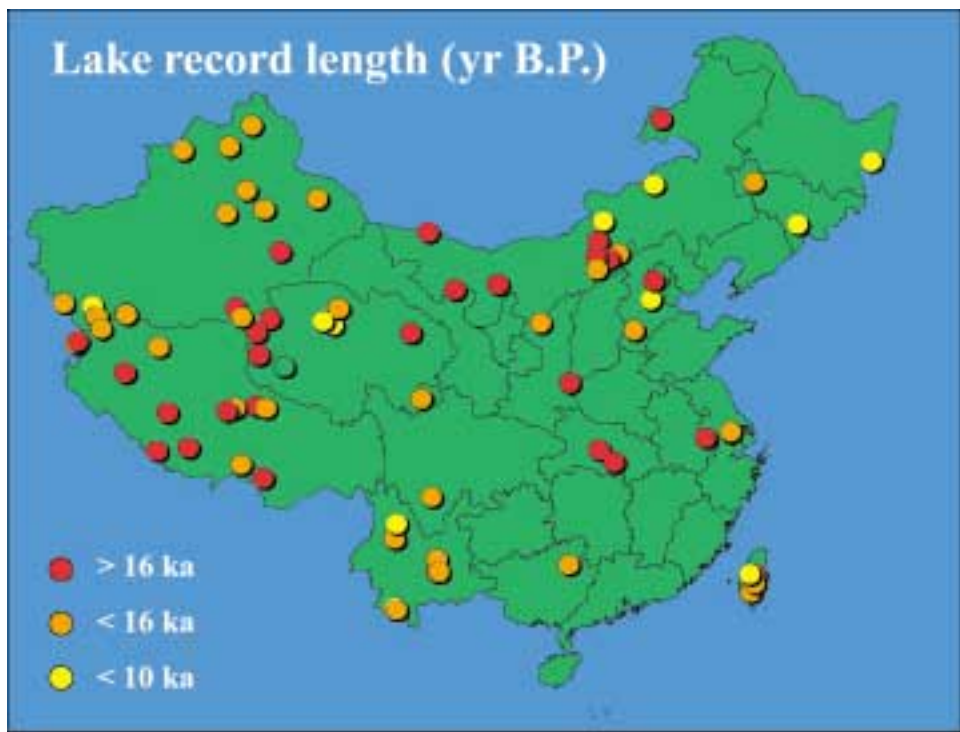


Figure 1: Record length (ka) of lake status from China Lake Status Data Base. Ca 35% lakes have records spanning beyond the last glacial maximum, and ca 10% lakes back to 30–40 ka BP.

## VARVE 99

LAMMI, FINLAND, 13–17 APRIL, 1999

Interest in annually laminated sediments (i.e. varves) has expanded considerably as studies on short-term and rapid past environmental changes have intensified within global change study programs. The impetus to hold the VARVE 99 workshop originated at the PAGES SSC meeting at Pallanza, Italy in June 1998. The aims of the VARVE 99 workshop, held at Lammi, Jyväskylä and Espoo, and organized by the Geological Survey of Finland (GSF), were to introduce the assembly of field and laboratory methods currently in use in Finland, to give progress reports on ongoing projects, to exchange ideas, and learn of recent advances elsewhere. The participants came from Europe and North America. Several members of the European Lake Drilling Program (ELDP, sponsored by the European Science Foundation) attended the workshop and a meeting of the Northern Europe Regional Group of ELDP was also held. The workshop also stimulated interest within the tree ring community and plans for future co-operation (i.e. in EU funded research programs) were initiated. It is clear that studies of annually laminated sediments will play an increasing role in the PAGES activities.

The workshop was divided into practical field and laboratory sessions, and paper and poster sessions. Lake Korttajärvi in Jyväskylä, Central Finland was visited for a coring demonstration. A coring team from GSF took several long cores using a Kullenberg corer and a piston equipped gravity corer developed at GSF (Figure 1). Working on ice, a three person coring team was able to recover, in less than half an hour, a 10 m long core from beneath 17 m of water with the help of 2 m high tripod and a small engine-operated winch. 300 kg of lead weights were added to ensure continuous but slow penetration. In principle, water depth is not a limiting factor and up to 15 m long cores, perhaps longer, can be recovered. Slow penetration seems to produce unbroken sediment sequences, whereas cores taken by a Kullenberg-type gravity corer often contain discontinuities, which are obviously the result of sudden penetration.

tional information will also be included for model validation to make the database serve the Earth science community in general. A set of protocols on the CLSDB archiving and accession policy was agreed to during the workshop.

The presentations and discussion raised some key environmental questions:

- What have been the patterns of climate change (precipitation and evaporation) on millennial to century time-scales in Asian monsoon regions?
- What is the relative importance of external forcing (e.g. precessional orbital forcing) vs. internal mechanisms during the period 30–40 ka BP?
- What is the explanation for high lake-level during the LGM in the Tibetan Plateau region?
- What has been the interplay between the westerlies and monsoon systems in eastern and southern Asia?
- What have been the impacts of climate variations during the last millennia on fluvial dynamics in the large river systems of China?

These questions will motivate future data-modeling comparison studies to enhance the understanding of the dynamic mechanisms which underlie cli-

mate change, paleo-monsoon variation and on paleohydrology.

The need to identify specific regions in eastern and southern Asia in order to test paleomonsoon model simulations using the Chinese lake data base was emphasized. Suggested key regions with advantages for future studies include the transitional climate zones, e.g. regions between the arid interior and monsoon influenced areas (Inner Mongolia), the northern limit of Pacific monsoon and the southern permafrost limit (NE China); the Tarim Basin in Xinjiang where there is little change in geography, in stark contrast to the Tibetan Plateau which encompasses the greatest changes in elevation in the world. The workshop finished with a discussion of the availability of research resources in the near future.

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One of the 10 m long cores from Korttajärvi was opened in the field for demonstration. It was continuously laminated, and probably represents the time since the regional deglaciation at c. 10,000 years BP. Korttajärvi is one of the main study sites of GSF, where a complete set of varve study methods has been applied. Five Stone Age dwelling places have been discovered on the shores of the lake and detailed pollen, diatom, charcoal, and mineral magnetic analyses combined with varve counts will reveal the history of past land use. Korttajärvi is a dimictic lake, whose varves are mainly composed of abundant allochthonous minerogenic component from the catchment which is widely covered by fine grained former lake bottom sediments. The sediment accumulation rate has been relatively high and has produced 0.5 to 1.0 mm thick varves which are easy to identify, scan and digitize (Figure 2).

In Lammi, the classic site of Lovojärvi was visited where much of the early work in the 1970's was undertaken. In situ freezing of the sediment was demonstrated and new varves accumulated during the past two decades were recognized. Diatoms are impor-



Figure 1: Kullenberg piston corer in operation on lake Pohjajärvi, Finland. The system, designed by the Geological Survey of Finland, can recover a 10 m long core in a single operation with the aid of just two people.

tant components of the varves in Lovojärvi as is the case in many kettle hole lakes in esker environments. In Finland, the annual character of laminated Holocene organic sediments was first recognized in Lovojärvi and Pyhäjärvi in the late 1960's by E. Kukkonen and R. Tynni, geologists at the Geological Survey of Finland. Subsequently, several lakes in the vicinity of the Lammi Biological Station were intensively studied by a number of students. The introduction of the in-situ sediment freezing technique in 1974 was one important step in this first study phase. Emphasis was on the study of the varve characteristics and chronology, especially the land-use history. It was also suggested that variations in varve thickness might prove to be a potential tool in the study of short-term climatic fluctuations.

During the VARVE 99 workshop various techniques were tested in the laboratory in Lammi. These included the digital scanning of X-ray radiographs, magnetic susceptibility scanning, color slides and long thin sections. Digitizing of such data for computer handling was also demonstrated. The laboratory facilities of GSF at Espoo were also visited. The current active period in the study of laminated sediments at GSF and Finnish universities has greatly benefitted from improved laboratory techniques and especially from computer based documentation and analysis of laminated sediments. Interpretation of environmental changes as documented by varves is based on advanced interdisciplinary methods such as computerized varve analysis, mineral/paleomagnetism, stable isotope geochemistry, pollen and diatom analysis and microchemical analysis.

By correlating the proxy-climatic data provided by varved lake sediments with tree-ring data representing the same time interval, a more robust interpretation of climatic and environmental changes can be worked out. These topics were discussed at Lammi. Several papers from Arctic Canada emphasized the importance of the link between sedimentary data and meteorological and hydrological data, in order to produce a model linking sediment to climate. This is our ultimate goal, made especially demanding in areas where recent land use has complicated the interpretation of climatic proxies in varved sediments.

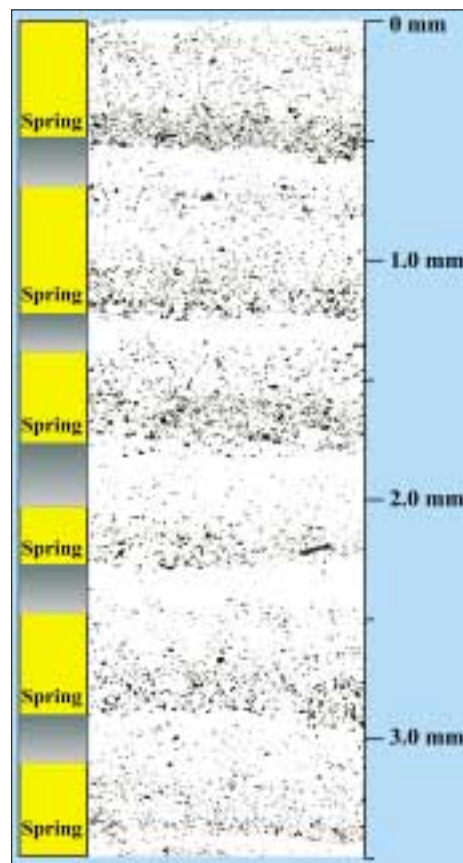


Figure 2: Distribution of mineral grains in a polished thin section (3.5 mm long) from the sediment of Korttajärvi based on a back-scattered electron image.

There is a growing tendency to concentrate on high-resolution analysis of short varve sequences or even to study intra-annual laminae. Despite recent progress, a continuous varved sequence from a site formerly covered by continental ice has yet to be discovered. Such sites probably exist in Finland and would allow time since deglaciation to be counted accurately.

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## Paleoenvironmental Significance of Varved Lake Sediments in Fennoscandia and their Contribution to PAGES Related Programs

A major theme of the previous PAGES newsletter 99-1 concerned the role of lake-sediment archives as providers of continental proxy-environmental/climate data. In this short summary we aim to highlight the contribution that ongoing and continued studies of varved lake sediments in Fennoscandia can make to PAGES related programs, such as PEP III, QUEEN and CAPE. Some of the ideas presented here originated from the "Varve 99" workshop (see previous page).

The construction of an accurate geochronology (by any means) is often a painstaking and time-consuming task. Yet, when a geological archive possesses a continuous and independent calendar year chronology, plus an array of proxy-indicators of environmental and climatic change that can be studied at an annual (possibly seasonal) resolution, the quality and quantity of paleo-environmental reconstruction that can be undertaken increases significantly (as do the economic demands). Excellent examples of research that can be

achieved include the studies of the Greenland ice-cores and the construction of regional dendro-climatological time-series from tree-ring data.

Most freshwater lake-sediments in Fennoscandia were deposited during the late Pleistocene and the Holocene. Dating of these sedimentary sequences has, therefore, relied heavily upon the radiocarbon dating method. However, the existence of annually laminated (varved) lake sediments in Finland and Sweden has been known for several decades. A considerable amount of work has been expended on methodological studies, with respect to undisturbed sediment core recovery as well as subsequent analytical techniques. The most common type of varve structure found in Fennoscandia is: (i) a light coloured mineral layer deposited during the spring snowmelt flood; (ii) a brown summer layer consisting predominantly of relatively coarse grained autochthonous organic matter, and (iii) a dark brown (often black) layer of fine grained organic matter that settles out during the winter, when the lakes are ice covered. Occasionally, thin micro-layers of mineral material can be deposited as a consequence of autumn storms (Figure 1). However, other varve types are known, such as those that contain distinct layers composed of diatom frustules or calcium carbonate. Common to all varves is the absence of post-depositional disturbance (primarily in the form of bioturbation). In many cases culturally induced eutrophication during the last few hundred years initiated anoxia and the subsequent preservation of varves. The individual layers that constitute a single varve thus provide physical, chemical and biological proxies of environmental change at a seasonal resolution. Sites located in the near vicinity of research centers and field stations have often been studied with respect to tracing increasing human influence in the form of agriculture and air pollution. Other studies have investigated the relationships between recent meteorological observations and micro-fossil records, for example pollen, spores and diatom frustules. All these studies have used the inherent calendar

year chronology to reconstruct rates of change and to detect lags between external forcing (climate) and ecosystem response. More recently, independent research groups have undertaken systematic searches for varved sequences which may contain excellent records of natural environmental and climate variability over several thousand years or longer. These searches, carried out by research groups at the Geological Survey of Finland, the University of Turku (Finland), Umeå University (Sweden), Lund University (Sweden) and the University of Tallin (Estonia) have been carried out at high latitudes and high altitudes, and in areas with vegetation still dominated by boreal forest. Varved lake sediments extend from northern Norway to south-eastern Estonia, the latter with a predicted temporal range of 14,000 years. Although most of the biological proxies generally reflect summer growth conditions, physical and chemical measurements may reveal information about the winter seasons, such as the length of ice-cover, or the intensity of the spring snow melt.

Each group working with varved lake sediments in Fennoscandia has applied different techniques to study the fine-scale variations in varve composition. The majority of the varves formed prior to human influence are thinner than 1 mm, which means that it is difficult to apply traditional paleo-ecological techniques (e.g. pollen and diatom analyses) at a scale that takes full advantage of the annually resolvable chronology. However, it is possible to calculate the influx values of certain components to produce decadal to millennial scale variations. Analytical tools that have been applied to complete sequences covering several thousands of years include the digital image analysis of photographs, X-ray densitometry and mineral magnetism. It must be stated that these techniques, which have their own advantages and disadvantages, do not effectively separate individual sediment components. On the other hand, these techniques are complementary and can identify periods of rapid change, which can form the focus of more detailed biostratigraphical investigations (Figure 2).

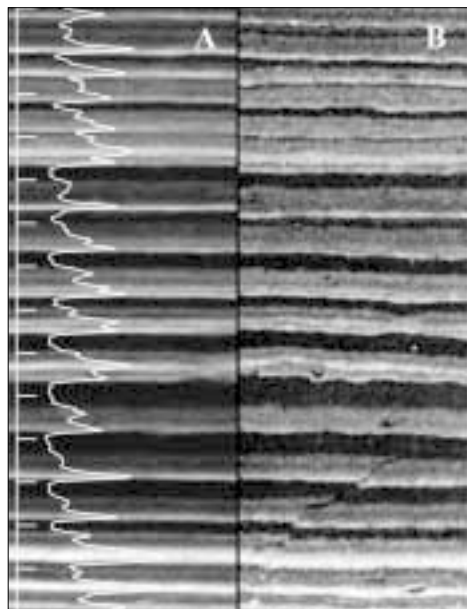


Figure 2: A) X-ray radiograph of 14 mm of fresh sediment recovered from lake Korttajärvi in Finland (depth = 200 cm from sediment surface). Relative X-ray density curve is shown in white. B) Scanned greyscale image of sediment embedded in epoxy resin (same sample as A). Light layers = mineralogenic spring season layer (deposited during the snowmelt) and dark = organic summer-winter layer (more organic).

In some respects the availability of so many varved lake sediment sequences in a relatively restricted geographical region forms a bane as well as a boon. Considering the amount of effort invested in an individual site, the question of site-selection is difficult to address and careful consideration must be given to the parameters to be analysed. The Nordic Council of Ministers has recently (1999) funded a networking project, called LAMSCAN, which has been designed to apply fairly rapid and relatively non-destructive analytical techniques to a network of varved sediment sequences in Fennoscandia. This project, co-ordinated by the Department of Quaternary Geology at Lund University, is designed to identify periods of rapid terrestrial climate change, which may have been caused by fluctuations in the North Atlantic oscillation.

There is no doubt that studies of varved lake sediments deposited during the late-Pleistocene/Holocene will produce a variety of data sets that can be compared to other independently dated environmental archives, such as those provided by ice-cores (e.g., GRIP/GISP) and tree-rings (e.g., ADVANCE-10K, see PAGES Newsletter 99-1). However, to attain this goal considerable investment must first be placed in both salaries and analytical costs. It is also essential that a holistic ecosystem framework is adopted so that the paleoenvironmental records preserved in varved sediments are correctly interpreted. Previous and ongoing studies of varved lake-sediment sequences in Sweden and Finland demonstrate (not surprisingly) that lakes and their catchments respond to external (climatic) forcing on an individual basis. The sensitivity of each lake catchment to variations in climate will vary according to the interaction between a multitude of terrestrial and limnological factors, which are site-specific. Preliminary results do indicate that the more infrequent, but major, climatic "events" are recorded in several sites and in similar variables, but that more frequent and less intense climatic variations are recorded on a site-specific basis according to the sensitivity of each ecosystem. This observation has important consequences for the interpretation of paleoenvironmental data from regions where the number of sites is very restricted. It

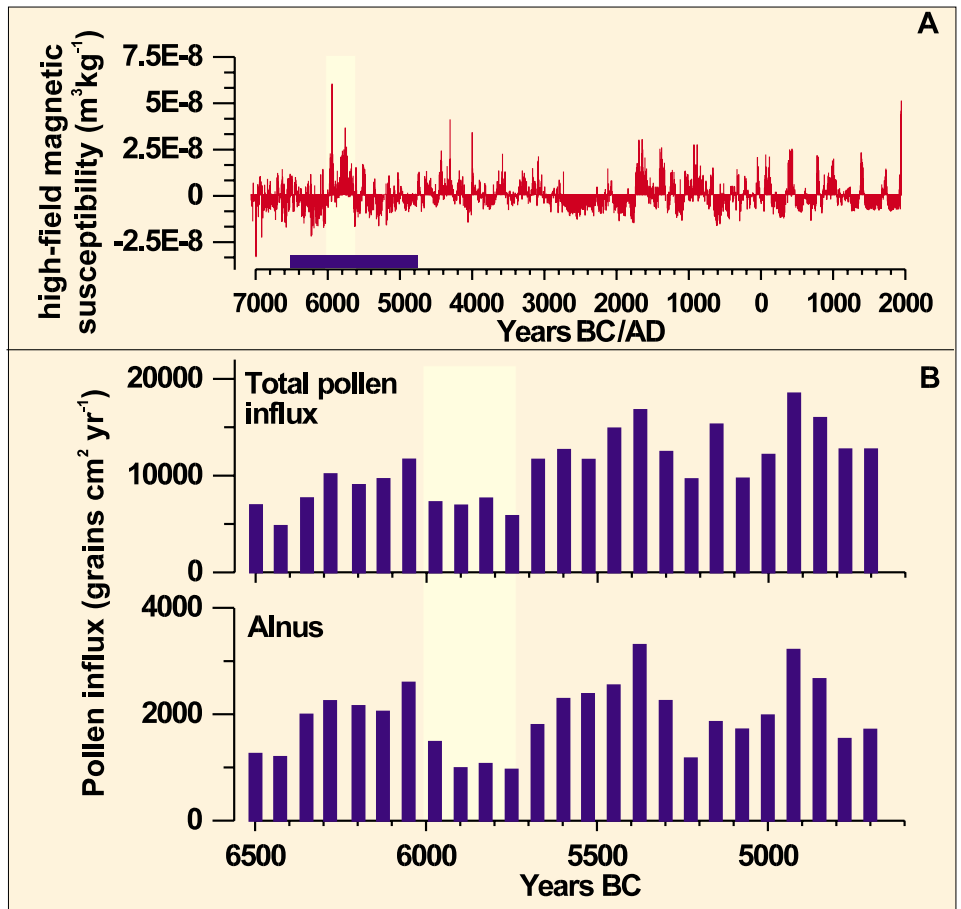


Figure 2: (A) High-field magnetic susceptibility data from a 9000 year varved sediment sequence in northern Sweden (Lake Sarsjön), plotted as the variance around a 5-degree polynomial trend. Peaks in high-field (para)magnetic susceptibility reflect periods of increased mineral deposition during the spring, and probably represent an index of winter precipitation in the form of snow. Note the major peak between c. 6100 and 5700 BC, and the increased variability since c. 3700 BC. (Data adapted from Snowball et al. 1999).

(B) Selected pollen influx values obtained at 75-year intervals over the period highlighted in (A). The total pollen influx values, which are dominated by tree species, decreased during the period of increased winter snowfall. *Alnus* (Alder) was near to its northern limit of distribution at c. 6000 BC and the decreased pollen influx values during the subsequent 300–400 years indicate a generally cooler climate (Zillén, L. in prep.). Given dating errors associated with different geochronologies this anomaly most likely correlates to a well-known period of increased glacial activity in the Scandes mountains, and the so-called "8.2 ka" cold event registered by oxygen isotope data in the Greenland ice-cores.

is, therefore, important to remember that: "Lakes are individuals, just like you and me." (Gunilla Petterson, pers. comm. 1999).

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References for this article can be found at  
<http://www.pages.unibe.ch/publications/newsletters/ref992.html>



# Monsoon Impact on El Niño in the Early Holocene

El Niño/Southern Oscillation is the most dramatic example of interannual climate variability in our world today (Philander, 1990). Recent paleoclimate evidence, however, seems to suggest that strong El Niño/Southern Oscillation events developed only after about 6000–7000 yrs BP (years before present). Time series of clastic deposits in an Andean lake in Ecuador (Rodbell *et al.*, 1999) and archaeological deposits in northern Peru (Sandweiss *et al.*, 1996) indicate less severe flooding events along the west coast of tropical South America before the mid-Holocene; records of fires in Australia (McGlone *et al.*, 1992) and isotopic records from fossil coral in the western tropical Pacific (Gagan *et al.*, 1998) also indicate less variable monsoon rainfall in the mid- and early Holocene. Here, a coupled ocean-atmosphere model is used to investigate El Niño variability in the early Holocene. Our preliminary study suggests that El Niño intensity in the early Holocene is reduced at least in part by the remote influence of the intensified Asian monsoon on the Pacific trades.

The model is a fully coupled ocean-atmosphere model – the Fast Ocean-Atmosphere Model (FOAM) (Jacob, 1997), in which an R15 AGCM is coupled with a 2.8° longitude / 1.4° latitude resolution OGCM. The model physics are similar to those of the NCAR CSM. A modern control run is performed under present climate forcing for 650 years without flux correction, and reproduces the present climatology and climate variability in the tropics adequately, as does the NCAR CSM (Meehl and Arblaster, 1998; Otto-Bliesner, 1999). In particular, tropical climate variability is dominated by an El Niño mode, which has the maximum SST variability in the eastern equatorial Pacific (Figure 1a), and which has the power spectrum peaking in the period band of 2.5–7 years (Figure 1b). Similar to the CSM, however, the strength of El Niño is about 60% of that in observations.

Climate variability in the early Holocene is simulated in a sensitivity experiment that is forced by the insolation of 11,000 yrs BP (Berger, 1978). This Holocene experiment starts from the 300<sup>th</sup> year of the modern simulation. The model is then integrated for 100 years with the last 50 years used for comparison with the modern simulation of the

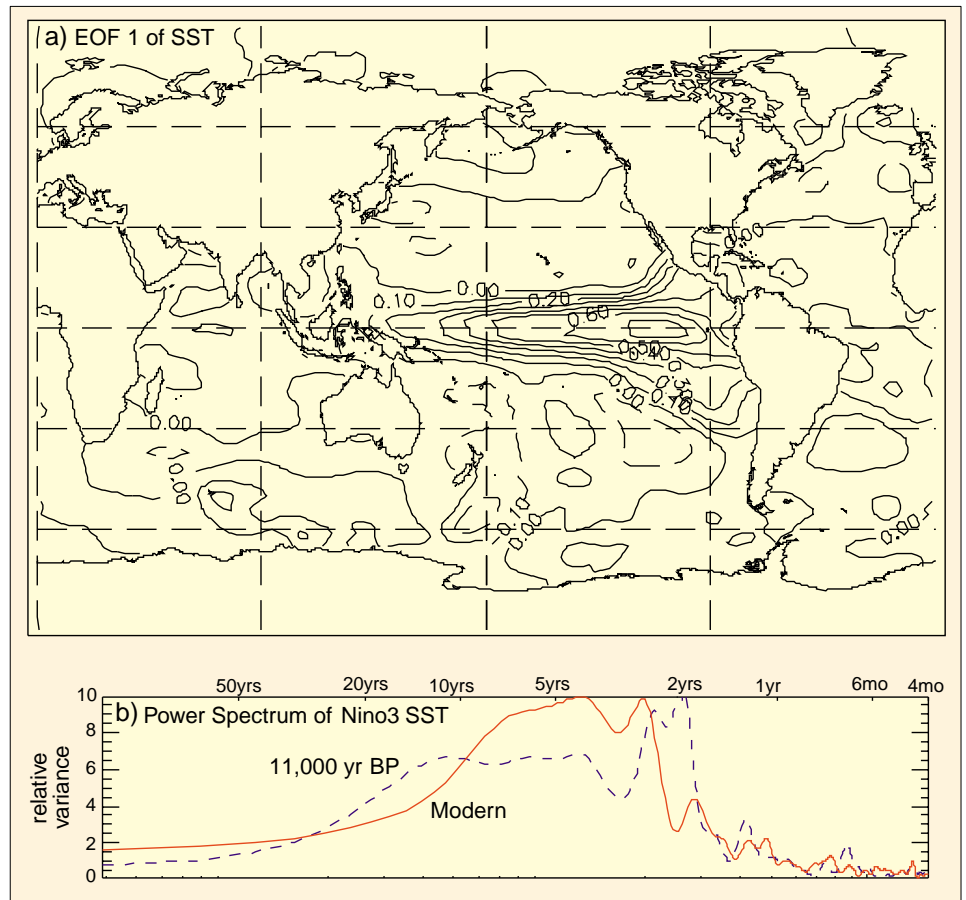


Figure 1: (a) The pattern of the first empirical orthogonal function (EOF) of SST for the modern simulation, which shows the spatial pattern of the El Niño mode (contour interval arbitrary). The time series of the EOF coefficient (not shown) resembles closely that of the SST in the Niño 3 region (140°W to 90°W, 5°S to 5°N). (b) The power spectrum (units arbitrary) of the Niño 3 SST for the modern (red) and 11,000 yr BP (blue) simulations.

same years. One striking feature in the Holocene simulation is a substantial reduction in the magnitude of El Niño, by about 20% compared with the modern control as seen in the SST power spectrum (Figure 1b). The reduction of variability associated with El Niño seems to agree with the paleoclimate evidence discussed above (Rodbell *et al.*, 1999; Sandweiss *et al.*, 1996; McGlone *et al.*, 1992; Gagan *et al.*, 1998).

The Holocene El Niño appears to be, at least in part, suppressed by the intensified Asian monsoon. In the early Holocene, the earth is closest to the sun in June, and therefore the seasonal cycle of the solar radiation is enhanced by about 10% in the northern hemisphere relative to the present. One of the most important tropical climate responses to this increase of the insolation cycle is a significantly intensified Asian summer monsoon (Kutzbach and Otto-Bliesner, 1982). This enhanced Asian monsoon can further

induce wind changes in the remote equatorial Pacific through the atmospheric Walker circulation. During boreal summer, the enhanced Indian monsoon strengthens the deep convection in the eastern Indian Ocean-western Pacific warm pool, which increases the easterly trades, and in turn the upwelling and cooling in the central to eastern Pacific (Shukla, 1987; Barnett *et al.*, 1989). The colder eastern Pacific SST further strengthens the trades through the Bjerknes feedback mechanism (Bjerknes, 1969). The combination of Asian monsoon forcing and positive ocean-atmosphere feedback leads to an increase in the equatorial trades of 1 m/s (Figure 2a), and an associated SST cooling of 0.5°C (Figure 2b) over the central to eastern Pacific (160°E to 90°W), which amount to about 10 to 20% of the total wind and SST seasonal anomalies, respectively. Since most El Niño warm events start in northern hemisphere



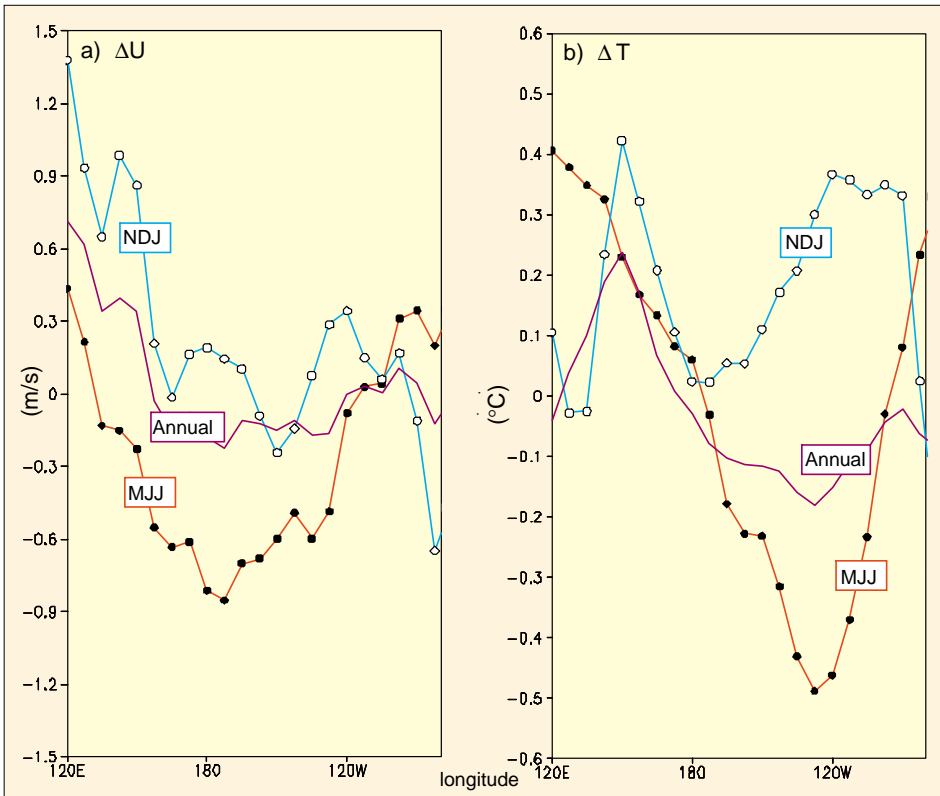


Figure 2: The change (11,000 yr BP minus modern) of (a) surface zonal (*u*-component) wind (m/s) and (b) surface air temperature (°C) averaged within 5° of the equator in the Pacific sector. The summer (May, June and July average), winter (November, December and January), and annual mean are plotted in red, blue and purple, respectively. The negative values of wind anomaly in the central Pacific implies stronger wind blowing from east to west, i.e. an enhancement of the climatological easterlies. The surface air temperature resembles closely the SST over the tropical ocean.

References for this article can be found at <http://www.pages.unibe.ch/publications/newsletters/ref992.html>

**WORKSHOP ANNOUNCEMENT**



**Russian IMAGES Workshop**

**MOSCOW, RUSSIA, 2-6 NOVEMBER, 1999**

This meeting is aimed at developing high-resolution paleoceanography in Russia and coordination of the work between different institutions nationally and internationally.

Our goals are:

1. Review of existing materials applicable to the high-resolution post-glacial paleoceanography from Eurasian Arctic and Far-Eastern seas.
2. Inter-regional correlation of sedimentary records to reveal paleoceanographic and paleoclimatic changes during deglaciation and Holocene.
3. Coordination of research methods and theoretical approaches developed in different institutions.
4. Planning of future cooperation including joint expeditions, exchange of data and samples, development of a collective database, and encouragement of cooperative analytical work.

A more detailed workshop announcement can be found on the PAGES website calendar page.

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spring and peak in the following winter, this increase of the trades and upwelling induced cooling in the early Holocene tends to suppress the growth of warm El Niño events in summer and therefore reduces their final amplitude later in the year (Barnett *et al.*, 1989; Webster and Yang, 1992).

The reduction of El Niño variability could also be related to the enhanced annual mean trades and enhanced annual upwelling cooling of the central to eastern Pacific (Barnett *et al.*, 1989; Masumoto and Yamagata, 1991). In the Holocene run, the annual mean trades are stronger by 0.2 m/s (Figure 2a) and the SST is cooled by 0.2°C (Figure 2b) in the central to eastern Pacific. A colder annual mean in the eastern Pacific has also been produced in two other coupled model experiments in the early to mid-Holocene (Bush, 1999; Clement *et al.*, 1999) and, as pointed out by Clement *et al.* (1999), may not be inconsistent with the presence of certain mollusk fauna along the coast of South America in the mid-Holocene (Sandweiss *et al.*, 1996). This lower annual mean SST could be related to two processes. First, the Asian summer monsoon enhancement, because of its nonlinear augmentation of latent heat release in the warm season, dominates over the winter monsoon enhancement, as indicated by the weaker and

opposite sign of trade response in winter (Figure 2a), and therefore results in stronger annual mean easterlies in the remote atmospheric response over the Pacific. Second, the anomalous upwelling in summer forces a shallower thermocline in the eastern Pacific, which enables the upwelling to affect SST more efficiently in summer than occurs in winter when the thermocline is anomalously deep. While this note emphasizes the importance of the remote monsoon forcing, it is also likely that local processes within the Pacific sector also contribute to changes in the behavior of El Niño in the Holocene (Clement *et al.*, 1999).

**ACKNOWLEDGEMENT**

We appreciate a helpful discussion with Dr. M. Cane.

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# Global Database of Borehole Temperatures and Climate Reconstructions

The thermal regime of the Earth's outer continental crust comprises the superposition of two conductive processes: the steady state outward flow of heat from the deeper interior, and transient perturbations to the deep regime by changes of temperature at the surface. The latter effects are commonly climatological in origin. The identification of the transient component of the subsurface thermal regime is central to the geothermal approach to climate reconstruction, and has drawn increasing attention over the past decade. With support from the international heat flow community and under the sponsorships of the US National Science Foundation (NSF) and National Oceanic and Atmospheric Administration (NOAA), a database of borehole temperatures has been assembled and analyzed for the special purpose of climate reconstruction (Huang & Pollack, 1998). This database currently contains 616 borehole temperature profiles from North America, Europe, Asia, Africa, Australia, and South America (Figure 1).

Climate reconstruction from geothermal data has its foundations in the theory of thermal diffusion. In homogeneous rock, if the surface temperature is steady, the subsurface temperature ( $T$ ) is a linear function of depth ( $z$ ), i.e.,  $T = T_0 + Gz$ , where  $T_0$  is the steady state temperature at the surface,  $G$  is the temperature gradient which is related to the thermal conductivity of the rock ( $k$ ) and the deep heat flow ( $q$ ) by the ratio  $q/k$ . However, if the surface temperature is not steady but changes with time, the subsurface temperature will depart from the linear distribution. A progressive cooling at the surface will increase the temperature gradient at shallow depth, while a progressive warming will result in a lesser gradient or even a negative gradient at shallow depths. If the surface temperature oscillates with time, oscillations in the subsurface temperature profile will follow. The magnitude of the departure of the subsurface temperature from its undisturbed steady state is related to the amplitude of the surface temperature variation. The depth to which disturbances to the steady state temperatures can be observed is determined by the duration and spectral composition of the temperature change at the surface. The ground surface temperature (GST) history is therefore recorded in the subsurface,

and by careful analysis of the variation of temperature with depth, one can reconstruct the past fluctuations of temperature at the ground surface.

The pace of climatic signal propagation in the subsurface is related principally to the thermal diffusivity of rocks. Following a change in temperature at the surface, it takes about 100 years for the perturbation to reach a depth of 150 m and 1000 years to reach 500 m depth. Moreover, the amplitude of a surface perturbation diminishes exponentially with depth as it propagates downward. Surface temperature variations of shorter period diminish in amplitude more quickly than do longer period disturbances. Because of period-dependent amplitude reduction, the effects of short period surface temperature changes are restricted to shallower depths than are the disturbances from longer period changes in surface temperature. The daily surface temperature oscillation penetrates only about 1 m and the seasonal oscillation about 15 m. Only longer term surface temperature changes are recorded at greater depths. Therefore, a geothermal climate reconstruction is characterized by a progressive inability to resolve the details of climatic excursions in the more remote past (Clow, 1992; Beltrami & Mareschal, 1995). But the compensation for the loss of resolution are increasingly robust determinations of the mean surface temperature prior to the interval of time for which some detail can be resolved, and the total temperature change from that prior mean.

Most of the boreholes that we selected for analysis penetrated to depths of 200 to 600 m, and have temperature measurements at 10 m intervals. Complications in climate reconstruction, however, stem from the fact that subsurface temperatures are also sensitive to various non-climatic disturbances (Shen et al., 1995). Attention must be given to other disturbances such as topography and vegetation patterns at the surface, and groundwater movement and lateral variation in thermophysical properties in the subsurface.

The combination of the predominant depth range of observations and the characteristic magnitude of noise has led us to choose five centuries as the standard interval over which to develop climate reconstructions (Huang et al., 1996). In the parameterization of the surface temperature history, we seek only century-long trends of temperature change. By estimating century-long parameters, we explicitly designate an adequate averaging interval rather than implicitly incorporate the variable averaging that characterizes the resolution of point estimates. This simple parameterization also enables one to easily estimate the total temperature change over the five-century time interval.

Shown in Figure 2 is a global perspective of the century-long trend of ground surface temperature change over the last 500 years based on analysis of the ensemble of borehole temperatures in this database. Superimposed for comparison is a global surface air temperature instru-



Figure 1: Location of the borehole sites.

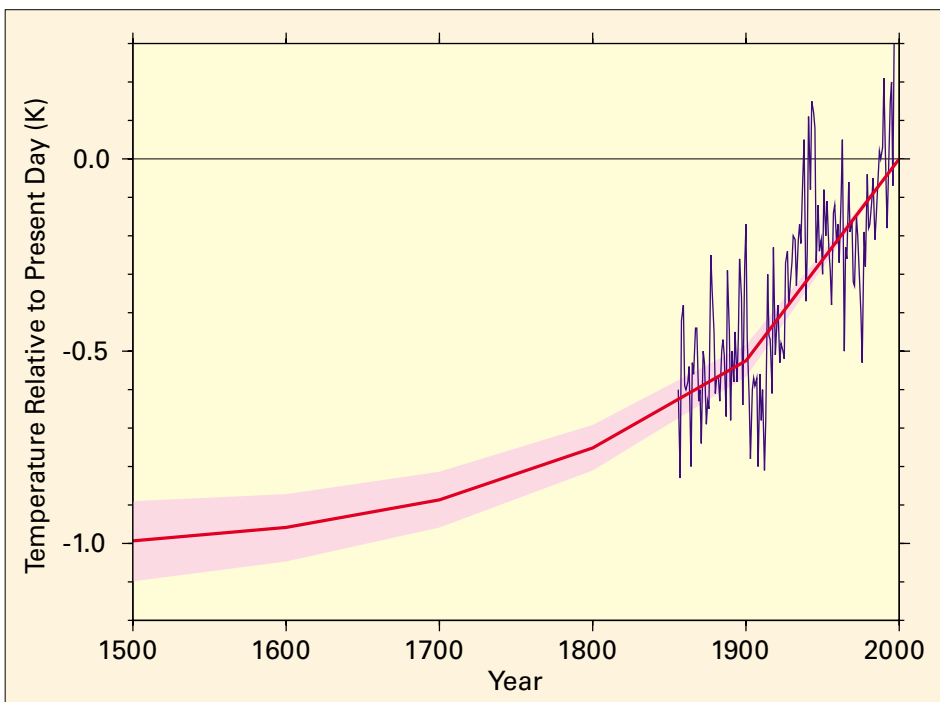


Figure 2: A global perspective of ground surface temperature change over the last five centuries. Shaded areas represent  $\pm 1$  standard error from the mean. Shown in red for comparison is the meteorological time series by Jones *et al.* (1997).

mental record, which was shifted to enable a visual comparison of the trends by a direct overlay. In the 20<sup>th</sup> century the average surface temperature of the Earth has increased by about 0.5°K, and the 20<sup>th</sup> century has been the warmest century of the past five. Almost 80% of the sites experienced a net warming over the past five centuries. The mean of the cumulative temperature change over the five century frame is a warming of about 1.0°K. The results derived from 616 borehole temperature profiles is consistent with an earlier result derived from a smaller data set from 356 boreholes (Pollack *et al.*, 1998). This geothermal analysis provides independent confirmation of the unusual character of 20<sup>th</sup> century climate.

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## FROM THE EDITORS

### Science Highlights – Request for Articles

The PAGES Newsletter is published three times a year. In addition to workshop reports and PAGES news, we publish announcements of opportunities for international collaboration from individual researchers or organizations. We also profile national research initiatives as well as ongoing or recently published high profile research. Research highlights are generally one or two pages with one or two color figures, and are included at the discretion of the editors. Authors of scientific highlights benefit from a readership of several thousand active paleoscientists world-wide and receive a reasonable number of free color reprints. Publication in the PAGES Newsletter is not meant to replace, but rather presumes, publication in peer reviewed literature. Scientists who are undertaking research which fits within the PAGES remit, and would like their work highlighted in the Newsletter, are encouraged to contact one of the editors.

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## INSIDE PAGES

### Invitation for SSC Membership

The Executive Committee of the Scientific Steering Committee (SSC) of PAGES seeks the names of colleagues who will be prepared to serve on the SSC. Colleagues who serve on the SSC normally do so for a period of 3 years, potentially renewable for one further term. Nominations are, in the first instance, recommendations from PAGES to the IGBP Officers who then select candidates for endorsement.

The PAGES SSC is responsible for overseeing the management of the project and the continuing success of PAGES depends on the leadership qualities of SSC members.

This notice is an open invitation for interested scientists either to indicate their own willingness to serve, or to propose colleagues (after consultation with them) who would be interested in serving, on the PAGES SSC. Expressions of interest and nominations should be accompanied by a covering letter and CV. In making final nominations to IGBP, the Executive Committee also reserves the right to make direct invitations. In seeking nominations, the Executive Committee is looking not only for scientific excellence and a high level of commitment to PAGES goals; it also has in mind the desirability of improving the gender balance of the SSC and the need to cover a spread of both regional and specialist areas of interest. The current membership of the SSC is available from <http://www.pages.unibe.ch/people/ssc.html>. Nominations and expressions of interest may be submitted at any time and should be sent to:

#### PAGES INTERNATIONAL PROJECT OFFICE

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**PAGES**  
PAST GLOBAL CHANGES

## Have You Seen...



This new feature in our newsletter is aimed at alerting PAGES readers to recent publications highlighting advances in paleoenvironmental science. Further details, including links to downloadable versions of the papers, data or abstracts (whenever available), and additional recent papers of interest, are maintained on the PAGES website (<http://www.pages.unibe.ch/news/whatsnew.html>). Comments or suggestions should be sent to Keith Alverson ([alverson@pages.unibe.ch](mailto:alverson@pages.unibe.ch)).

- Climate and atmospheric history of the past 420,000 years from the Vostok ice core, Antarctica, J.R. Petit et al., *Nature*, **399**, 429–36, 1999.
- Natural variability of the Earth's environments: the last two climatic extremes (18000 ± 2000 and 8000 ± 1000 yrs BP Nicole Petit-Maire, *C.R. Acad. Sci. Paris, Earth and Planetary Sciences*, **328**, 273–279, 1999.
- Northern Hemisphere Temperatures During the Past Millennium: Inferences, Uncertainties, and Limitations Mann et al., *Geophysical Research Letters*, **26**, 6, 759, 1999.
- Holocene Carbon-cycle Dynamics Based on CO<sub>2</sub> Trapped in Ice at Taylor Dome, Antarctica A. Indermühle et al. *Nature*, **398**, 1999.
- The ARTS (Annual Records of Tropical Systems) Report, PAGES Workshop report 99–1 R. Dunbar and J. Cole, 72pp. 1999. Available on request from the PAGES IPO.
- A set of overheads showing some key recent results of paleoenvironmental science is now available and can be downloaded from the PAGES website at <http://www.pages.unibe.ch/publications/overheads.html>.

## PAGES CALENDAR

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

- **\*13–17 September, 1999 "Fourth International Conference on Modelling of Global Climate Change and Variability". Hamburg, Germany**  
Lydia Dümenil, Max-Planck-Institut für Meteorologie, Bundesstrasse 55, 20146 Hamburg, Germany. Phone: +49 40 41173-310, Fax: +49 40 41173-366 [mpi-conference@dkrz.de](mailto:mpi-conference@dkrz.de), <http://www.mpimet.mpg.de/~mpi-conference/>
- **\*13–17 September, 1999 \*International Conference on Climate Change and Variability - Past, Present and Future". Tokyo, Japan**  
Takehiko Mikami, Department of Geography, Tokyo Metropolitan University, Minami-Osawa 1-1, Hachioji-shi, Tokyo 192-0397, Japan  
Phone: +81 426 77 2596, Fax: +81 426 77 2589  
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- **17–22 September, 1999, "Polar Regions and Quaternary Climate: Towards High-Resolution Records of the Last Glacial Period in Antarctica". Giens, France**  
Josip Hendekovic, European Science Foundation, 1 quai Lezay-Marnésia, 67080 Strasbourg, France. Phone: +33 3 88 76 71 35, Fax: +33 3 88 36 69 87  
<http://www.esf.org/euresco/lc99115a.htm>
- **22–26 September, 1999 "Correlations of Late Weichselian and Holocene paleoenvironmental proxy data – a comparison of independent timescales based on high-resolution lacustrine data". Lund, Sweden**  
Bernd Zolitschka, GeoForschungsZentrum Potsdam, Telegrafenberg, D-14473 Potsdam, Germany; [zoli@gfz-potsdam.de](mailto:zoli@gfz-potsdam.de)  
<http://www.gfz-potsdam.de/pb3/pb33/eldphone/4th-ws.htm>
- **30 September – 3 October, 1999 "Swedish National IGBP-PAGES Meeting". Lund/Höör, Sweden**  
Barbara Wohlfarth, Department of Quaternary Geology, Tornavägen 13, 223 63 Lund, Sweden.  
Fax: +46 46-2224830, [barbara.wohlfarth@geol.lu.se](mailto:barbara.wohlfarth@geol.lu.se)
- **3–6 October, 1999 "Alkenone-Based Paleoceanographic Indicators". Woods Hole, USA**  
Virginia (Gini) McKinnon, Department of Marine Chemistry and Geochemistry, Woods Hole Oceanographic Institution, MS #4, Woods Hole, MA 02543-1543, USA.  
Phone: +1 508-289-2394, Fax: +1 508-457-2164, [vmckinnon@whoi.edu](mailto:vmckinnon@whoi.edu)  
<http://www.pages.unibe.ch/calendar/alkenone.html>
- **4–8 October, 1999 "3<sup>rd</sup> PMIP Workshop" Montréal, Canada**  
Martine Lapointe, GEOTOP, Université du Québec à Montréal, C.P. 8888, Succursale Centre-Ville, Montréal, Québec, H3C 3P8 Canada  
Fax: 1-514-987-3635, [pmip@er.uqam.ca](mailto:pmip@er.uqam.ca)  
<http://www.pages.unibe.ch/workshops/1999/pmip.html>
- **7–8 October, 1999 "COL Symposium: Looking into the Sediment Subsurface of Lakes" Zürich, Switzerland**  
Flavio Anselmetti, Laboratory of Limnology, Geological Institute, Swiss Federal Institute of Technology (ETH), Sonneggstr. 5, ETH-Zentrum, 8092 Zürich, Switzerland. Phone: +41 1 632 3673, Fax: +41 1 632 1030  
[flavio@erdw.ethz.ch](mailto:flavio@erdw.ethz.ch), <http://www.erdw.ethz.ch/~flavio/COL99>
- **\*14–18 October, 1999 "Fourth International Conference on Asian Marine Geology". Qingdao, China**  
Ji-chun Zhu, Institute of Oceanology, CAS, 7 Nanhai Road, Qingdao 266071, China. Phone: +86 532 287 0627, Fax: +86 532 287 0882  
[zhujc@ms.qdio.ac.cn](mailto:zhujc@ms.qdio.ac.cn), <http://ms.qdio.ac.cn/newsgroup/firstannouncement.htm>
- **\*15–19 November, 1999 "International Symposium on Multifaceted Aspects of Tree Ring Analysis". Lucknow, India**  
Amalava Bhattacharyya, Birbal Sahni Institute of Palaeobotany, 53 University Road, Lucknow 226 007, India. Phone/Fax: +91 522 381 948  
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