

## LAKES



One of the major themes in the present newsletter is lakes – both as part of the full range of continental aquatic systems (pp 2–3) and as sources of sedimentary records (pp 12–16). These pictures illustrate different forms of lake coring on Swiss lakes (from left to right): on Soppensee with a piston corer from a drilling platform; on Bachalpsee with a gravity corer; a freeze core with annually laminated sediments from Baldeggersee. For more information check the University of Bern's Paleolimnology group homepage: <http://www.cx.unibe.ch/sgi/paleolimnology.html> (Photos: A.F. Lotter).

## EDITORIAL

## PAGES Synthesis

Over the next two to three years, a major responsibility of the IGBP will be to produce a synthesis of the program achievements to date. PAGES plans both to develop its own project synthesis and to contribute to the IGBP-wide task.

The intention, within PAGES, is to produce a book in the IGBP series, as well as an executive summary in the form of a glossy brochure, both to be published early in 2001. The first steps have already been taken. A draft outline of the themes around which the summary brochure will be organized has been the subject of an ongoing electronic discussion forum on the PAGES website and the format of the book itself is beginning to take shape. The goal must be to create a thematically oriented synthesis rather than a compilation of PAGES-related research. This means that in its organization, the synthesis will transgress the Foci and Activities listed in the PAGES Implementation Plan, rather

than summarize in succession the research completed within each of them. It will thus be complementary to the more 'bottom-up' syntheses of individual components of the PAGES project and will not conflict with current and future initiatives like the PEP I synthesis currently being coordinated by Vera Markgraf in the wake of the landmark meeting in Merida last March. Nor will it replicate the approach taken in compiling the special issue of *Quaternary Science Reviews* that will stand as a record of the oral presentations at the PAGES Open Science Meeting. The latest outline of the synthesis themes is designed to set the process in motion with a small group of co-ordinators, rather than to prescribe the eventual structure of the book to be produced. The first meeting of a synthesis planning group was held in San Francisco in December 1998. The themes identified by the group as the basis for the next stage in PAGES

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*Editorial, continued from front page*

synthesis, and the co-ordinators associated with each theme are as follows:

1. The human rationale for the study of past environmental change (Oldfield).
2. The course of past climate change (Bradley).
3. Forcings and feedbacks operating on the physical climate system (Stocker/Alverson).
4. Biogeochemical/biospheric aspects and impacts of past global change (Boyle/Overpeck).
5. Future directions - this section will require input from all the others, as well as from senior colleagues external to the process. Jean-Claude Duplessy and Claude Lorius have agreed to share this responsibility.

The timetable proposed follows on from the brief workshop at the Fall AGU attended by several of the initial co-ordinators and other members of the PAGES community who were on the spot. Sub-group meetings are planned for the first 4 months of 1999 to shape and refine the contents of each section. The IGBP Congress in May 1999 will provide an opportunity to collate, present and evaluate the outlines of the book. At that stage, the shape and content will be endorsed by the PAGES Scientific Steering Committee (SSC). The next stage will be the main phase of writing, culminating in a final workshop to tie the whole text together during 2000. Ideally, both the book and certainly the glossy Executive Summary booklet should be available for the IGBP Open Science Meeting planned for Spring 2001. Towards the end of this period, we anticipate that the PAGES SSC will begin to review the status and future of the PAGES project as part of a broader review of IGBP as a whole.

The task of synthesis presents the PAGES community with a major challenge; perhaps the most daunting one yet. We shall try to keep the wider PAGES community abreast of the process through the newsletter and the website and we welcome your views on the scope, purpose and optimal outcome of the synthesis process.

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## The Potential Role of PAGES in the IGBP Water Initiative

### A Proposed Integrative Inter-Project Initiative on Continental Aquatic Systems

The primary goal of this initiative, as defined in the document approved by the IGBP SC, is to understand the role of continental aquatic systems in global biogeochemical cycles. The overarching question posed at the outset is: How have continental aquatic systems and the nutrient fluxes associated with them been and will be influenced by and responsive to global change, over past, present, and future time frames? Continental aquatic systems are defined as all surface and subsurface water involved in the hydrologic cycle on the continents. This includes lakes, rivers, wetlands, soil moisture, and ground water from the point where precipitation reaches the earth's surface until it reaches the sea in full marine conditions, or until it reaches some other final base level. The "downstream" boundary is a broad zone variable in space and time wherein river water interacts with the ocean before reaching fully marine characteristics with respect to chemistry and ecology. The emphasis of the project will be on water, sediment, carbon, nitrogen, phosphorus, silicon and micro nutrients.

### Past Biogeochemistry and Paleocology

Continental aquatic systems are rich in natural archives of past biogeochemical states and fluxes. These take the form of lake, reservoir and near-shore marine sediments, ground waters and accumulated wetland sediments and peats. Analyses of such archives can provide insight into both the past biogeochemistry of the systems studied and of the changing conditions of climate, vegetation, soils and human land use to which changes in aquatic biogeochemistry are linked. They can document the impact of biogeochemical changes on the nature and functioning of aquatic ecosystems in the past. In addition, paleo-records can provide information on the pristine state of drainage basins which are now severely altered by human activity, and thus out of biogeochemical and ecological equilibrium.

Currently available evidence suggests that even in long-settled and highly developed areas of the world, (e.g. Western Europe), the main changes in aquatic biogeochemistry have taken place within the

last 150 to 200 years, despite the fact that agriculture, deforestation and local settlement began centuries and, in many cases, millennia before this. The main initial forcing factors seem to have been population growth, urbanization, industrial development and the construction of integrated sewer systems. Current forcing increasingly reflects the impact of non-point agricultural sources for N and P. It may be that further evidence from long-settled areas, in Eurasia and the Mediterranean region for example, will build a case for a more flexible time frame, but we believe that the main focus should be on the last 200 years. This has the added advantage of being compatible with the time frame prioritized by LUCC and GCTE for reconstructing past land cover and terrestrial ecosystems. Moreover, chronologies of sedimentation can often be provided for most of this period, using radiometric techniques such as <sup>210</sup>Pb. There are also opportunities for quantitative calibration over this time interval, through comparison with direct observations during the most recent period.

Recent research confirms that paleolimnological studies can track past atmospheric contamination using the record of metal and fly ash deposition. The fossil record in the sediments can be used as a basis for reconstructing past water quality, including changes in pH, with a high degree of precision. It can also be used to reconstruct past P loadings to a reasonable level of approximation. More research is required to establish the degree of confidence with which it may become possible to reconstruct past changes in N and Si concentrations and fluxes from sedimentary evidence. Records of past particulate inputs are often extremely well preserved in and quantifiable from the sedimentary record and these are of special importance where nutrient delivery and sequestration are particle-associated. At the same time, sediment studies allow calculation of bulk catchment yields and sediment source ascription in ways that can be directly related to soil and terrestrial ecosystem processes, such as accelerated erosion and deforestation.

### Lake Sediments and Past Climate

There is growing evidence to show that paleolimnological research can provide robust reconstructions of climate varia-



bility and of the sensitivity of aquatic ecosystems to such variability. Since both natural variability, including extreme events, and anthropogenic forcing will contribute interactively and in as yet unknown proportions to future climate changes, it is important to understand the links between natural climate variability and aquatic ecosystem response. For this, a longer time scale than the last 200 years will be needed. Case studies spanning the last 1000 to 6000 years are therefore envisaged and these will also have the advantage of including the time frame of direct interest to the PAGES Focus 3 initiative on the Human Impact on Fluvial Systems since the beginning of Agriculture (LU-CIFS – see PAGES Newsletter 98–1). The information generated by these studies will provide a more realistic view of pre-industrial base-line conditions and of the sensitivity of aquatic systems to the temporal pattern of natural variability.

High resolution, near-shore marine sediments with a major terrigenous component can provide paleorecords broadly comparable to those available through lake sediment studies. In addition, they can be used to document the impact of changing sediment and biogeochemical fluxes on marine and coastal ecosystems.

## Ground Water, Mountains and Wetlands

Ground water forms a major human resource. Under favorable conditions, ground waters (unsaturated zone as well as saturated zone environments) may also act as an archive of climatic and environmental change. This information is obtained from conservative chemical species, noble gas ratios and isotopic signatures. This archive is the only other indicator, apart from ice cores, which may store water directly from former times. The ground water archive not only helps to quantify source contributions, ground water age, recharge rates and the future consequences of abstractions, but also human impacts from diffuse and point source contamination. Currently available research methods include the tools for understanding the fluxes of nutrients and contaminants between surface and ground waters, the role of ground waters as both sources and sinks and the future consequences of present and projected levels of exploitation.

In many upland areas and in regions dependent on the capacity of the world's mountains to store and deliver water for

human use, glaciers and snow fields form an important part of the aquatic system. The response of these to recent climate change and their vulnerability under conditions of predicted global warming is a further area of concern into which paleodata can shed light.

Wetlands also contain paleo-records from which their role as biogeochemical sinks and sources, both of nutrients and trace gases can be reconstructed. Growing acknowledgment of the importance of wetlands in geochemical cycling and environmental management points to the need to exploit these systems as archives of recent changes in nutrient flux and sequestration rates.

## Summary

In summary, sedimentary and other paleorecords can help to quantify the role of natural variability and human impacts on biogeochemical cycling in the continental aquatic component of the earth system, on a catchment, regional and, potentially, a global scale. They can provide information on base-line conditions and realistic management targets in amelioration programs. In addition, they can put present day observations, data sets and experiments in a realistic, dynamic context that acknowledges the role of changing forcing mechanisms in the fluxes, stocks and concentrations of at least some nutrients. In so doing, paleo-research also provides an essential tool in model development and validation.

The PAGES SSC has approved in principle the establishment of a new Activity within 'Focus 3' (Human Interactions in Past Environmental Changes). This Activity, to be led by Rick Battarbee, University College London, has been entitled "human impact on lake ecosystems and the role of palaeolimnology" (LIMPACS). One of the tasks for LIMPACS will be to link with and contribute to the IGBP-wide 'Water' initiative and thereby ensure that it serves the needs of both PAGES and the IGBP community as a whole.

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The above report is a modified extract from the IGBP briefing document on "Continental Aquatic Systems".

## PEP I

### New Leader

Geoff Seltzer, professor of Quaternary Geology and Geomorphology, Dept. of Earth Sciences, Syracuse University, has taken over the leadership of the PEP I transect from Vera Markgraf. Geoff's research focuses on the glacial and climatic history of the Andes of Ecuador, Peru, and Bolivia. Specifically, he is developing high resolution (centennial to millennial scale) records of climate change for the late Quaternary (last 20,000 years). The development of such proxy records provides the primary means by which hypotheses are generated and tested regarding the patterns and mechanisms for global climate change during the Quaternary. Recent research projects that Geoff has been involved with include: the history and climatic interpretation of glaciation in the Bolivian Andes, the pollen stratigraphy of lake cores and its relevance to changes in vegetation and climate, the physical sedimentology of glacial lakes in the central Andes, relict ice deposits in saline lakes of southwestern Bolivia and their relevance to issues of regional climate change and the Holocene record of lake level change in the Bolivian cordillera from cores of lacustrine sediments. His future research projects in the Andes include: high resolution glacial geologic and palynologic studies of the Ecuadorian and Peruvian Andes, the sedimentology of Lake Titicaca as a potential high-resolution and long-term climate record from the tropics, the use of cosmogenic isotopes in surface dating of moraines in the Bolivian Andes and stable isotope stratigraphy of marl-rich lakes in the Peruvian Andes. Geoff has an exciting set of plans building on the success of the recent PEP1 meeting on interhemispheric patterns of climate change in the Americas (Merida, March 1998) and complementing the ongoing PEP I synthesis project. His goals for PEP I will be the subject of a future PAGES newsletter report.

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## Russian IMAGES activities during 1997 and 1998

Russian paleoceanographic research linked to IMAGES is coordinated at the Shirshov Institute of Oceanology (SIO), Russian Academy of Sciences in Moscow. The team includes Drs. M. Levitan (the official Russian representative to IMAGES), E. Ivanova, and I. Murdmaa. About 10 scientists are investigating IMAGES related questions both at the SIO as well as its Atlantic (Kaliningrad) department. In addition, the following institutes are also involved: Pacific Institute of Oceanology Far East Branch in Vladivostok, (Dr. S. Gorbarenko); Moscow State University (Drs. Y. Polyakova and S. Nikolaev); Institute of the Lithosphere in Moscow (Dr. O. Naidina); and Murmansk Institute of Marine Biology (Dr. G. Matishov).

Russian paleoceanographic activities during 1997/1998 were mainly concentrated in two regions: the Arctic and Far-East seas. Four cruises of the *R.V. Akademik Sergei Vavilov* (SIO) were carried out in the Barents (Cruises 11, 13, and 14) and Norwegian (Cruise 12) Seas. The programs of these cruises included studies of present and past thermohaline circulation in the region, as well as faunal and sedimentological responses to Late Quaternary climatic changes. Altogether 37 gravity cores, up to 6 m long, were collected and sampled for paleoceanographic studies (including lithology, geochemistry, micropaleontology, mineralogy and isotopy). Paleomagnetic study of selected cores from the Barents Sea was carried out during Cruise 14 by specialists from the All-Russian Research Institute of Ocean Geology (VNII Okeangeologiya, St.-Petersburg) and the All-Russian Institute of Geology (VSEGEI, St.-Petersburg). Most of the cores from the Barents Sea recovered sedimentary records of the Holocene and last deglaciation. The materials collected are now the subject of geochemical, micropaleontological, and sedimentological studies being undertaken at the Shirshov Institute of Oceanology. The results will be used to reconstruct paleoenvironments, in particular Atlantic water inflow into the region during postglacial time.

Detailed investigations of the history of the Laptev Sea and eastern Siberian river discharges since the Last Glacial Maximum were performed by research-



*R.V. Akademik Sergei Vavilov*

ers from the Institute of the Lithosphere and Moscow State University as part of a joint Russian-German project on the exploration of the climatic system of the Laptev Sea. High-resolution paleoceanographic data from the Sea of Okhotsk were recently obtained by scientists from the Pacific Institute of Oceanology in cooperation with colleagues from the Shirshov Institute of Oceanology and the USA.

Preliminary results of this Arctic research were published in the abstract volumes of two meetings "Quaternary problems and perspectives for the next century" (St.-Petersburg, September, 1998) and "Marine Periglacial and Glaciation of the Barents-Kara Sea shelf in the Pleistocene" (Murmansk, November, 1998). In addition, during the last year Russian paleoceanographers discussed their work at the International School on Marine Geology (Moscow, October, 1997), at two sections of the 6<sup>th</sup> Zonenshain Memorial Conference (Moscow, February, 1998) and at the 6<sup>th</sup> International Conference on Paleoceanography (Lisbon, August 1998).

Several Russian scientists involved in IMAGES participate in international co-operative projects with German (project KOMEX), French ("The Arctic seas influence on thermohaline circulation in the North Atlantic"), Norwegian (Arctic paleoceanography) and American (sea-surface temperature reconstructions in the Western Equatorial Pacific and Sea of Okhotsk studies) colleagues.

Since 1993, Siberian scientists from the Limnological Institute, Siberian Branch in Irkutsk, led by Dr. M. Grachev have played a very active role in the International Baikal Drilling Project. The results obtained to date include a detailed climatic record of the last 250,000 years, based on micropaleontological, mineralogical, geochemical and paleomagnetic studies in the upper 50 m of the sediment sequence. The climatic oscillations revealed are comparable with those in marine records.

Looking to the future, in 1999, Russian paleoceanographers will host an international workshop (co-funded by IMAGES) to discuss the problems and perspectives involved in correlating high-resolution records from the Arctic and Far East seas.

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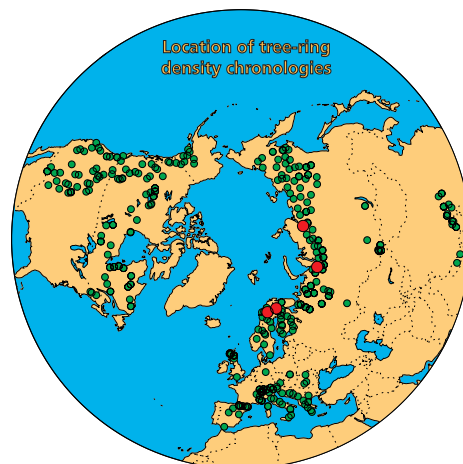
## Analysis of Dendrochronological Variability and Associated Natural Climates in Eurasia – the last 10,000 years (ADVANCE-10K)

Over recent years, with support from the European Union's Climate and Environment Programme and the Swiss National Science Foundation, ADVANCE-10K has brought together some 30 collaborators from 17 institutions, located in 10 European countries. All of these workers share the common goals of gathering, screening, and archiving a mass of primarily Eurasian tree-ring measurements. The ultimate aim is to interpret these data in terms of annually-resolved climate variability; on spatial scales that range from local to near hemispheric and on temporal scales extending over a few hundred to many thousands of years.

One major focus of the project is the continuing development of an extensive network of 'modern' tree-core samples, all taken from relatively cool and moist sites, spread around the northern hemisphere, generally at latitudes above 60°N, or at higher elevations in more southerly areas. The sites are selected because of the likely sensitivity of local tree growth to climate, specifically temperature, variability. To date, multiple tree-core collections have been made from some 400 sites and the samples processed under the guidance of Fritz

Schweingruber at the Swiss Federal Institute for Forest, Snow and Landscape Research in Birmensdorf, Switzerland, to produce not only ring-width data, but also measurements of intra-annual ring-density. These have enabled firmly dated width and density chronologies to be built with annual resolution for each location, typically spanning 300–400 years.

These chronologies are capable of representing detailed patterns of year-by-year temperature anomalies across large areas of the northern continents. Linear transfer functions that relate patterns of recent instrumentally observed summer temperatures to those recorded in the contemporary tree-ring data, provide quantitative temperature estimates, the accuracy of which is demonstrated by comparison with early independent temperature records. The tree-ring network is currently being used to reconstruct a multi-century history of summer temperature changes across northern North America, Europe and, most recently, northern Russia. Though the present sample network extends over the whole of northern Siberia, the greatest concentration of sites and the best temperature reconstruc-

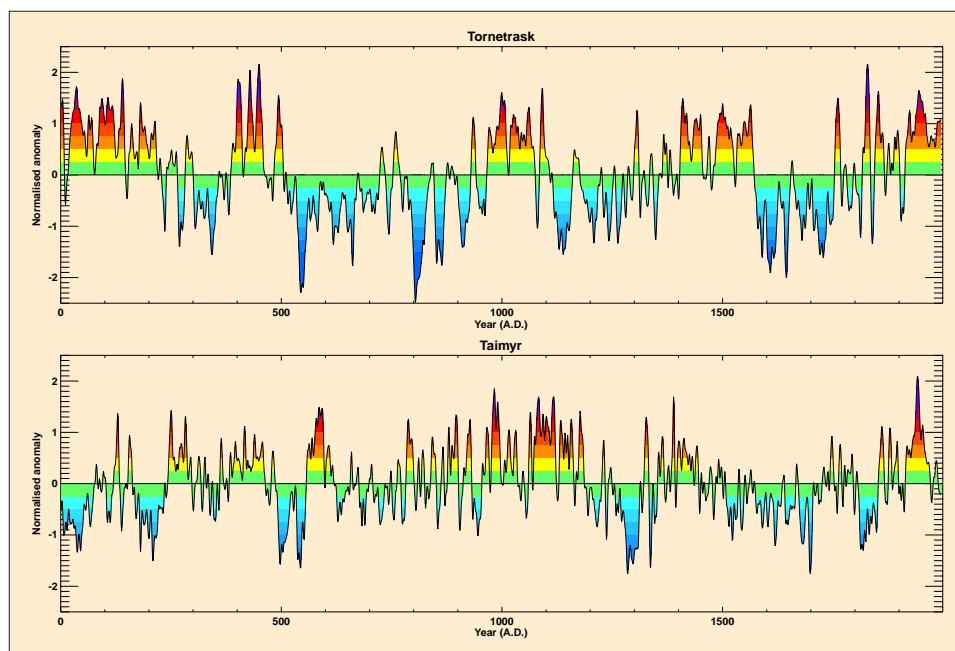


The present ADVANCE-10K tree-ring density network. The red circles show the locations of the long sub-fossil chronologies.

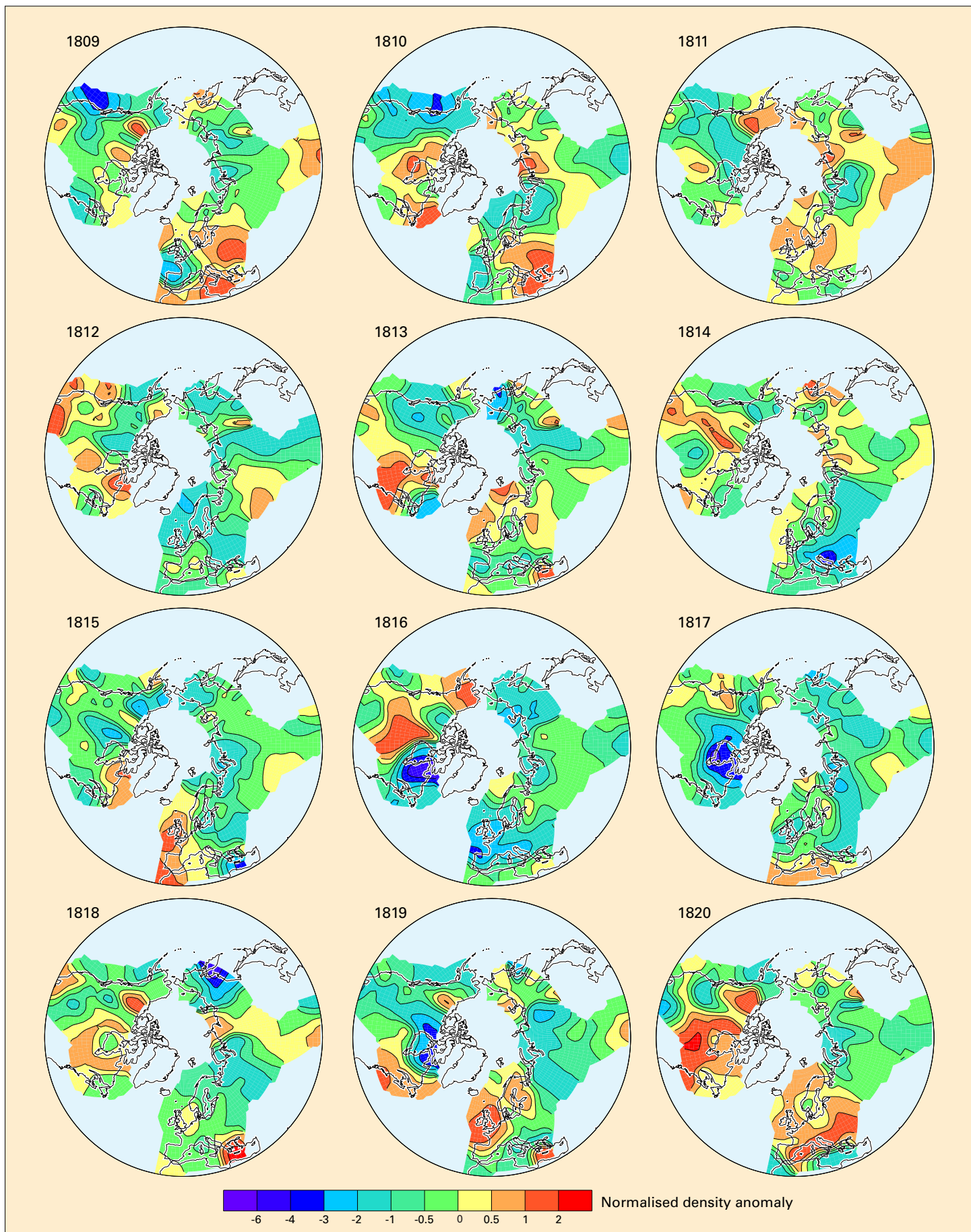
tions come from the region between the Finnish border and the Ural Mountains. There presently remains vast scope for expanding and improving the Russian densitometric database and the prospects for a rapid acceleration of this work have been boosted recently by the establishment of a new tree-ring densitometry facility, the first in Russia, at the Institute of Forest, Krasnoyarsk, made possible through the support of the European INTAS scheme.

Besides reconstructing maps of temperature variability, it has also been possible to provide a useful indication of very large scale mean temperature changes over the last 600 years by averaging the tree-ring density chronologies across the entire network. The resulting series provides strong evidence of the effect of different known volcanic eruptions, such as in 1453 (Kuwaie, 1452); 1601 (Huaynaputina, 1600); 1642 (Mt. Parker, 1641) and 1816 and 1817 (Tambora, 1815) on Northern Hemisphere mean temperature. The data also suggest dates for probable, but as yet unattributed, large eruptions, such as that in 1695.

At a handful of high-latitude locations in northwest Sweden, northern Finland and on the Yamal and Taimyr peninsulas, Russia, ADVANCE-10K is working toward the construction of continuous ring-width chronologies that will provide unique regional evidence of annual, decadal and century timescale temperature changes, all



Examples of long sub-fossil ring-width chronologies presently under construction: these are from northern Sweden (Tornetrask) and Russia (Taimyr). The temperature-indicative data are expressed here as standardised anomalies from the 2000-year mean, smoothed to emphasise decadal and longer timescale variability.



Tree-ring density anomaly maps indicating areas of relatively warm and cool summers during the early 19<sup>th</sup> century. Over the hemisphere as a whole, 1810–1820 was one of the coolest decades of the millennium, in part due to the effects of large explosive volcanic eruptions in 1809 (known through ice acidity) and 1815.



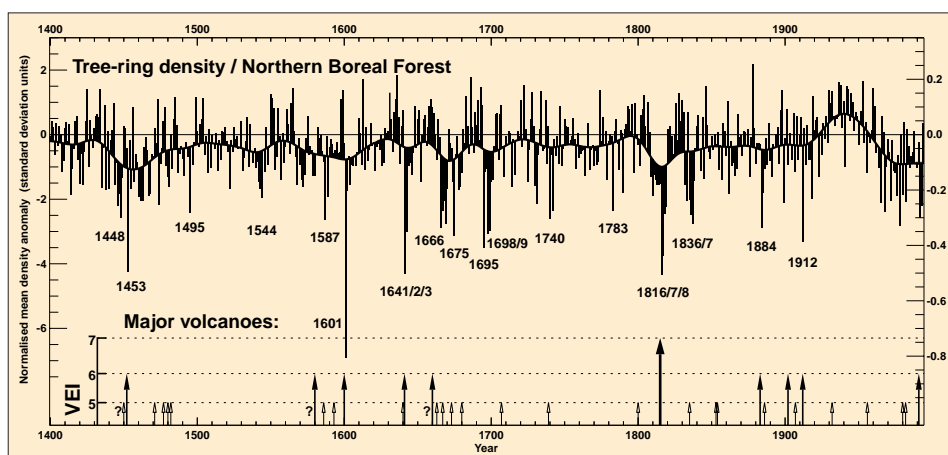
# DENDROCHRONOLOGY

firmly dated to the exact year over many thousands of years. These are long-term projects, which ultimately depend on locating sufficient suitable sub-fossil wood samples whose ages span all periods of the full record. Continuous chronologies have been constructed for the last 2000 years at all locations. In Sweden and Finland, almost all of the preceding 5000 years is also complete, although a firm chronological link across the 3<sup>rd</sup> and 4<sup>th</sup> centuries B.C. is still to be established. In Yamal, the 'modern' continuous chronology extends over 4 millennia and much earlier material, as in Taimyr, is either already measured or awaits processing. The potential to produce 7000 to 8000-year long series at all of these locations will be realized in the near future.

Further south, in central Europe, the project has brought together many thousands of oak ring-width series from historical, archaeological or sub-fossil origins that were previously dispersed in different dendrochronology laboratories in Sweden, Holland, Denmark, the United Kingdom, Germany and Poland. Several new regional 8000-year long chronologies have been constructed using objective clustering techniques. Temporal variability in the strength of interregional associations shown in these series, as well as detailed analysis of the extent of climate control of the chronology variability are underway.

Important work comparing tree-ring data collections located in Hohenheim and Göttingen has recently produced a corrected and extended absolutely-dated oak series reaching back more than 10,000 years – the longest in the world – allowing an extension and revision of previous radiocarbon calibration curves.

Different phases of active oak germination and deposition throughout the Holocene have been identified in land-grown and bog contexts. There is also other evidence for the existence of notable environmental events such as a pronounced decrease in oak growth in the middle 6<sup>th</sup> century A.D. that may be linked to very cool conditions seen in the high-northern trees in A.D. 536. Another low oak growth period lasted for about 100 years between 6270 and 6040 B.C., corresponding with the oxygen isotope evidence for contemporaneous cold in Greenland and Antarctic ice cores.



*Averaging temperature-sensitive chronologies from around the hemisphere provides a precise record of interannual temperature variability demonstrating a clear link between cool summers and large explosive volcanic eruptions.*

In the immediate future, work will continue on important statistical issues related to the processing and interpretation of all of the various tree-ring collections. Potential anthropogenic influences on recent tree growth will become an increasingly important focus of the work. Increased tree productivity during the 19<sup>th</sup> and early 20<sup>th</sup> centuries and post-1950 declines in tree density trends have recently been identified in our data. The extent, detail and implications of these phenomena have yet to be further explored. Chronology confidence and the expression of climate forcing are most strongly expressed on short (annual to century) timescales. New data processing techniques are exploring the reconstruction of longer period variability. This will require the extraction of common long-term growth trends from much larger regional data collections than are currently available. The precise reconstruction of tree line movements will become increasingly feasible and the potential for comparison and reconciliation with other long-term, though less well resolved, climate proxies extracted from ice, lake sediments, speleothems, or peat will become increasingly practical and important. This multiproxy work should contribute usefully to the aims of PAGES PEP III research as well as CAPE and PEP II.

Increased collaboration with, and support for, our Russian colleagues would enable a vital extension of the work in central and eastern Siberia. Furthermore, the development of North/South transects of tree-ring data in central Siberia and Scandinavia would enhance the work of the IGBP terrestrial

transects. Future work could also usefully incorporate active participation of workers engaged in ongoing work in the Himalayas as well as establish a firm tree-ring chronology in central Europe extending back into the Younger Dryas, some 12,000 years ago. Finally, better collaboration with other, including non-European, dendroclimatologists and those synthesizing paleodata across the whole of the high-latitude and high-elevation regions will continue to be sought.

A special issue of *The Holocene*, detailing the results of ADVANCE-10K, is scheduled for publication in late 1999. All of the primary data collected under this project, along with the regional chronologies and associated derived reconstructions will be made available through the World Data Center-A for Paleoclimatology.

For details of the aims, participants, publications or other information relating to ADVANCE-10K contact the author or visit our web site. ADVANCE-10K is funded by the European Union under ENV4-CT95-0127: Scientific Officer Ib Troen.

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## PANGAEA - Network for Geological and Environmental Data

In 1993, scientists from various German research institutes working in the field of paleoclimatology initiated a project to implement a common information system which guarantees longtime storage of data in consistent formats and provides access for the scientific community. Based on the discussion and recommendations of this group, the information system PANGAEA was developed which is now operated by the Alfred Wegener Institute for Polar and Marine Research (AWI) and the Center for Marine Environmental Sciences (MARUM).

The system is able to store any type of data with related descriptions. Due to its importance for marine geological work, it is also able to give information about the availability of sampling material. The system has standardized import/export routines, access with uniform retrieval functions and tools for the visualization of data. The system is designed as a network using client/server technology with access and data exchange through the Internet.

The emergence of an integrated earth systems science also calls for a full knowledge of past conditions, and for data sets that are drawn as composites from different methods, techniques and archives of paleoclimate. The major challenge of PANGAEA in this effort is not only to have the data archived and accessible but to allow retrieval and extraction of individual parts from a comprehensive data collection.

Keeping the complexity of paleoclimate data in mind, the resulting system still needs flexible access tools with high functionality. Thus users of PANGAEA need to go through a short tutorial to learn the principles of the data model and the retrieval process. Due to the simplified data model and the uniform tools on all tables, the system is easy to use once the principles are understood.

In the PANGAEA standard retrieval (<http://www.pangaea.de/retrieval>) the full functionality of the system is realized. To fulfill the requirements of a more specific data access, individual retrieval tools can easily be designed due to the generic structure of the software. As an example the user may try the interface PanCore which was created to obtain

information about available sediment samples/cores in international repositories. A similar interface for a search to published data sets using an author's name or a keyword is in preparation.

The further possibility for retrieving data from PANGAEA is the direct download interface. Using the standard retrieval a data curator can save retrieval information on his local web server. A click on a link to this information included in a web page starts the retrieval and provides the requested data set as a tab-delimited text file (e.g. <http://www.pangaea.de/projects/SFB261/>, click on 'data' in the reference of Müller P. et al, 1994).

### The data model

The simplified data structure of PANGAEA is shown as a graphic on the opening screen of the client software (Fig. 1). The graphic allows the user directly to access all tables. The structure mirrors the processing steps for scientific data in general. In projects (PROJECT) cruises are carried out for sampling or measurements (CAMPAIGN). During a cruise at a number of locations (SITE) different samples may be taken or measurements are made (EVENT). At distinct points/intervals the medium to be investigated (e.g. sediment, ice or coral) is sub sampled or measured (SAMPLE). From the investigation of each sample parameter specific values will result (DATA). Data can be retrieved and exported in any combination together with meta-data in an individually configured table.

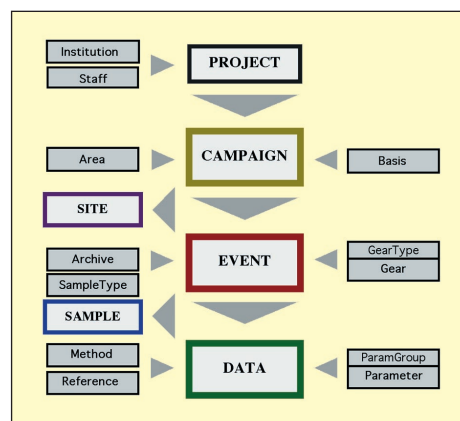


Figure 1: The hierarchy in the PANGAEA data model mirrors the path from the sampling in projects to the published data.



### Data handling

The meta-data comprises related information about cruises, sampling sites/sets and storage facilities. The most important meta-data are the location (latitude/longitude) and the elevation of an event. Scientists and institutes related to data sets are stored with their full addresses. Other related items, such as the names of ships, gear or sample types, are defined in lists which can be updated at any time. The parameter list is organized in groups and consists of about 5000 definitions used in marine and paleoclimate research. References for cruise reports or published data can be typed in or imported from professional bibliography software.

The import of meta-data is organized through predefined forms which are available for the import of references, campaigns and sites/events. Analytical data are imported via tab-delimited text with the parameter names or the PANGAEA-ID in the header of the input matrix. Meta-information related to the data (method, owner, comments) has to be defined prior to the import, the relations are made during the import process.

To improve the data consistency, data sets can be stored at different levels of processing. The primary data (e.g. counts of a microfossil assemblage or weights of granulometric investigations) are the raw data for calculations and interpretations. Archiving the raw data allows future recalibration or interpretations. The secondary data are those values calculated from the raw data, and in many cases are given as percentages or other units of concentration. Parameters evaluated from the secondary data (e.g. by statistical methods) are defined as tertiary data (e.g. paleotemperature).

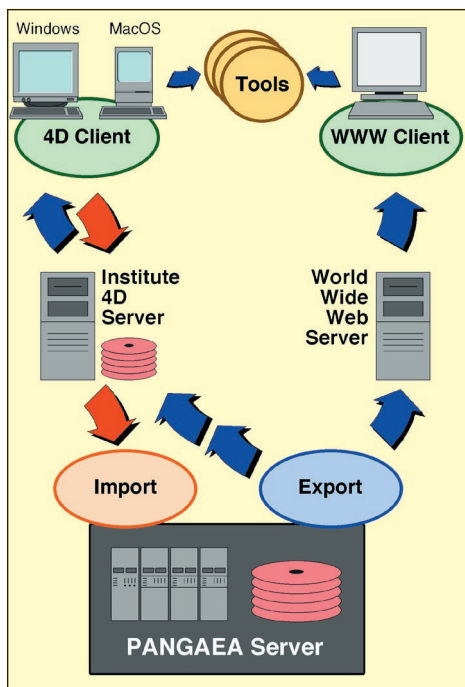


Figure 2: The PANGAEA network uses client/server technology through the Intranet/Internet to communicate and distribute data between institutes.

The retrieval tool for finding and extracting data from the system is uniformly designed for all levels and allows the use of complex combinable search criteria. Data can be exported as tables or plotted with one of the visualization tools. Tables can be sorted and configured individually. Multiple data sets can either be displayed with identical parameters and locations in one column, or the data can be split by locations and/or different versions of data sets into separate columns, thus allowing the direct comparison of data sets from different investigations or locations.

When dealing with the archiving and publication of data, copyright has to be considered. If an information system also stores unpublished data, it is crucial for the acceptance and the trust of the database that the data can be protected. In PANGAEA the owner of a specific data set is able to define access rights for individual users or groups.

### Technical setup

PANGAEA uses client/server technology through the Internet with a main server (SUN E10000, 8 processors, 8GB internal memory, 100GB hard disk capacity) running SYBASE as the database management software. The client soft-

ware for import/export, written in 4<sup>th</sup> Dimension (4D), runs on the operating systems MacOS and Windows. The 4D clients are used by the data curators for project data management (<http://www.pangaea.de/projects/>) and for the import of data from different institutions participating in the network. The client software to be used on the World Wide Web is written as a Java applet and allows read only access on published data for anyone. Registered users can also share unpublished data. The applet includes a draft map and plot functionality for quick overviews. Due to the use of Java applets, users of the web client should use recent browser software versions. Non-Java interfaces are in preparation.

### External tools

For the geographical presentation of data the PANGAEA tool PanMap was developed as a stand-alone mapping application for vector data (<http://www.pangaea.de/software/>). PanMap can be used to draw sampling sites with meta-data or analytical data in a geographical context. Maps can be configured with different projections, the styles of map elements can be changed, additional vector data or site information can be imported and managed in different layers, and graphics can be exported. The General Bathymetric Chart of the Oceans (GEBCO) is provided as a bathymetric data source.

The PANGAEA tool PanPlot enables the user to plot data versus depth/altitude or time. Scales and graphic features can be modified by the user and distinct parameters can be selected from a data matrix. PanPlot and PanMap can be directly accessed by the 4D clients. When using the Java web client, data have to be downloaded to the PC first and the visualization software then has to be started by the user. PanMap and PanPlot are freeware.

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## In Memory of Hans Oeschger

*Hans Oeschger, one of the founding fathers of PAGES died on December 25, 1998. His role in the establishment and promotion of PAGES drew on both his distinction as a scientist and his commitment as a person. His passing has evoked many tributes in both national and international media. His distinguished career, culminating in the award of both the Tyler and the Revelle prizes, is described more fully and with great insight and affection in these accounts and they reinforce the immensely high standing he had among his peers. Here, we have tried to bring a specifically PAGES dimension to our commemoration by inviting two of his close associates during the development of the project to give their personal recollections. The first of these is Jack Eddy, who worked alongside Hans in the early planning stages:*

Hans was one of several proponents for a paleostudies component in the initial architecture of ICSU's International Geosphere-Biosphere Program, and with that goal in mind he accepted membership on the first Scientific Committee for the IGBP in 1985/86. Based on his own early work, and that of his colleagues at the Physical Institute that he directed in Bern, he recognized the valuable role paleoclimate information could play in clarifying some of the main issues that then clouded conjectures regarding the enhanced greenhouse effect. He was also concerned that projects of the WCRP had put so little emphasis, or trust, in paleoclimate data. Hans helped identify candidates who might serve on the initial steering committee for what came to be known as the IGBP Past Global Changes (PAGES) project. He hosted the early meetings in Bern and served as its co-chairman.

Members of the IGBP Working Group on Global Changes of the Past, and later of the PAGES Steering Committee, favored expanding the concept beyond Hans' initial thoughts regarding greenhouse warming and isotope chemistry. With these other insights the PAGES concept was broadened to embrace many different disciplines; to include Holocene as well the somewhat longer time scales of the last glaciations; to utilize PAGES as a vehicle to coordinate the efforts of disparate (and sometimes competing) factions in paleoscience; and to open up and centralize paleo data sources around the world as a way of achieving this kind of needed organization and synthesis.



Once these and other goals were defined and agreed upon, there were months and years of writing and convincing to be done, funds to be raised, meetings to be run, and battles to be won before PAGES was accepted as a workable core project of the IGBP. In these early labors, however, as in the initial work of project concept and definition, Hans was involved only peripherally, for by nature and personal inclination his principal interests and contributions were on quite another scientific plane.

The period of the initial conception and definition of the PAGES project – the early Spring of an effort that is now mature – found Hans in the late Autumn of his own career at the University of Bern, and at a stage when the long shadow of his earlier years of work in isotope chemistry was well recognized around the world. The lustre of his early work in ice-core studies was of undeniable help in launching the PAGES project. Indeed, it was his heart and name, more than his time or the work of his hands, that Hans principally contributed, first to the IGBP and then to the PAGES project.

Hans readily accepted the suggestion of a joint Swiss/US-sponsored PAGES Core Project Office in Bern, which was a gift he gave of yet another kind, made invaluable by the eminence of Swiss studies of tree-rings and varves and ice cores, as well as the reputation of the laboratory that he had directed in Bern. His name and reputation were also a help in the efforts needed to secure the initial commitments from the US and the Swiss National Science Foundations to support the work of the new project office, and on his retirement from the faculty of the University of Bern, Hans devoted much of his time to its endeavors.

*Once the PAGES project was established, its further progress owed a great deal to the fruitful interaction between Hans and Herman Zimmerman, whose recollections of him thus form a natural sequel to the above:*

My first contact with PAGES came at the second meeting of the PAGES Scientific Steering Committee in Bern (April, 1992). Prior to this, Hans and I had some minor interaction concerning the initiation of the GRIP and GISP2 projects in Greenland, but now we had committed to working closely together in developing the framework of the PAGES Project and in establishing the project office in Bern. Hans and Jack Eddy co-chaired that meeting of the PAGES SSC

and much of the future structure of the project was outlined there. By that time, Hans and Jack had already completed the organizational spadework for the PAGES office. PAGES had been accepted as a core project of the IGBP and proposals to the Swiss and US National Science Foundations were already submitted. Discussions were well underway about the funding arrangements and other details for the establishment of the PAGES office.

When Jack Eddy found that he could not actually participate as co-director in Bern, my role crystallized as “the organizational person” to help develop the office’s operational procedures, and organize the international paleoscience community’s linkage to the global change effort. Hans and I often mused over lunch as to how our personalities meshed and were well suited to our separate roles within the PAGES world and how surprisingly well we worked together. Hans was the tireless PAGES’ safety net. When help was needed with the funding agencies, the research community, or the international planning groups, Hans was there on an airplane, or writing letters and articles. He was the great ambassador for global climate research, for the paleosciences, for the application of isotopic techniques – his special love. After retiring from his professorial positions at the University of Bern, he devoted his full energies to promoting climate studies in general, and PAGES in particular.

Hans and I were closest when there was an editing chore to be done. He wrote with a Swiss accent, but his work also had a distinctive style and flare. We spent long hours editing out the accent, but keeping the flare. The term “climate surprise” came from Hans’ not being able to find quite the correct phrase in English, but we left it, because it actually described just the right thought – the abrupt, short-lived, climate changes of the glacial stages that had been unexpectedly found in the ice core records from Greenland.

Hans delighted in a fine meal at a favorite Bernese restaurant, and there were many of these. He delighted in explaining the ‘typische’ Bernese cuisine – even when, having to translate for me, the correct word in English eluded him. One can imagine the topics of discussion: from isotopes in precipitation, to the climate record teased from tree-rings and ice cores, and to his displeasure – indeed anger, with the few “scientists” who nay-sayed the importance of the greenhouse gas problem or his exas-



peration with those who denied the evidence of the paleoclimate record. But his remembrances about his professor, the late Fritz Houtermans, who inspired Hans to undertake the study of isotopic geochemistry, were always the high point of lunch. It was Houtermans who first asked Hans to set up a radiocarbon laboratory.

In Hans’ case, it is difficult to separate the scientist from the man. He was genuinely and personally concerned about how the change in our planetary environment would impact people and his beloved Swiss Alps. Mankind’s great experiment with the Earth’s atmosphere was his personal concern. He was a strong advocate for science in the service of society, and he considered it his personal responsibility to point out the climate risk to future generations by loading the atmosphere with greenhouse gases. As Hans would say: “in the frame of PAGES, we need to learn from the experiments that nature has conducted in the past and that are recorded as trace constituent concentrations and isotopic signatures in earth system components in natural archives”.

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## Large Lake Records and New Perspectives for Continental Paleoclimate Archives

SAN FRANCISCO, USA, AGU FALL MEETING, DECEMBER 1998

Related to the need to improve our understanding of global paleoclimate patterns and their forcing, there has been a growing interest within the paleoclimate community in linking marine and terrestrial records. While the last decades have seen an immense effort by the whole paleoceanographic community in recovery and study of marine records, the terrestrial community has only recently begun to coordinate such a concerted effort (see PAGES Workshop Report 96-4: Continental Drilling for Paleoclimate Records). To take inventory of the geographical range and types of paleoclimatic information that can be obtained from long lacustrine sedimentary records, D. Ariztegui, V. Markgraf and P. Baker convened a session on "Large Lake Records and New Perspectives for Continental Paleoclimate Archives" at the AGU Fall Meeting 1998 in San Francisco.

Thirty-eight oral and poster presentations illustrated both the level of activity world-wide in the recovery and study of long lacustrine sediment records, as well as the extent of interest in that research. Presentations dealt with paleolimnological and paleoclimate results from studies of lacustrine sequences from essentially every continent, including Antarctica, from the Quaternary to the Permian. A large variety of geophysical, neo- and paleolimnological methods, many of them

comparable to paleoceanographic methods, were discussed. Results were shown from ongoing pioneering projects in South America (Patagonian lakes, Lake Titicaca), east Africa (Rift lakes), Kyrgyzstan (Lake Issyk Kul) and Siberia (Elgygytyn Crater). New insights into long-term paleoclimate change comprising several glacial-interglacial cycles were presented by multidisciplinary projects in North America (Coastal Alaska, Lake Winnipeg, Laurentide Great Lakes, Great Salt Lake, Owens Lake, Lake Estancia, Guatemalan lakes), Asia (Lake Baikal, Qinghai Lake, Lake Biwa, Dead Sea) and Europe (Lake Constance, Lake Steisslingen, lakes in southern Sweden). From all the different studies presented it became apparent that every lake system presents its own challenges in terms of chronology, presence of climate proxies (geophysical, geochemical and biological) and limnological and regional climate implications. Development of new proxies and their paleoclimate potential is therefore an important aspect in most of these studies. Some of the new advances in the analysis of lake sediments for paleoclimate reconstruction worth mentioning include: using  $\delta^{15}\text{N}$  as a tracer for variations in salmon abundance, sulphur isotopes in gypsum and redox-sensitive metals and image analysis to quantify sedimentary observations from thin-sections. In this context



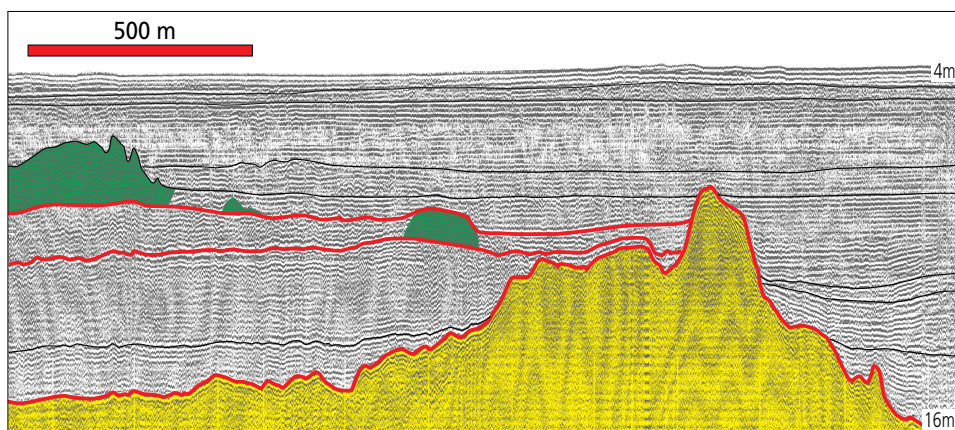
Acquisition of high-resolution seismic data on Lago Cardiel (49°S). (Figures provided by the Limnogeology Laboratory, ETH Zürich, Switzerland).

the crucial importance of modern calibration studies was also stressed, and presentation included analysis of  $\delta^{18}\text{O}$  in cellulose of aquatic algae and water plants in tropical lakes and of ostracode species in Patagonia. Another conclusion from the presentations was the importance of high resolution and multi-disciplinary studies in order to obtain more accurate and realistic paleoclimatic reconstructions.

Finally, recent advances on the Global Lake Drilling (GLAD800) initiative were presented by K. Kelts, S. Colman, T. Johnson and I. McGregor (NSF Continental Drilling Program). The proposed facility, including coring platform and coring devices, is conceived to obtain high-quality undisturbed sediment cores, and would be available for all NSF or International Continental Scientific Drilling Programme (ICDP) projects around the world and represent an important step towards the development of a global network of long continental records (for more details see next page).

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Within the framework of PEP I, two closed basin lakes in Southern Patagonia were surveyed in January 1998 by an international team of researchers. Evidence of dramatic lake level lowstands are clearly recognized in this seismic profile of Lago Cari-Laufquen (41°S). Red lines mark seismic reflections that indicate times of very shallow lake levels or even subaerial exposure.

### Erratum

The report on the SEA Dendro Workshop in PAGES newsletter 98-2 was missing two acknowledgements. The tree ring climate reconstruction figure was from Hemant Borgaonkar and Brendan Buckley was a co-author of the article.

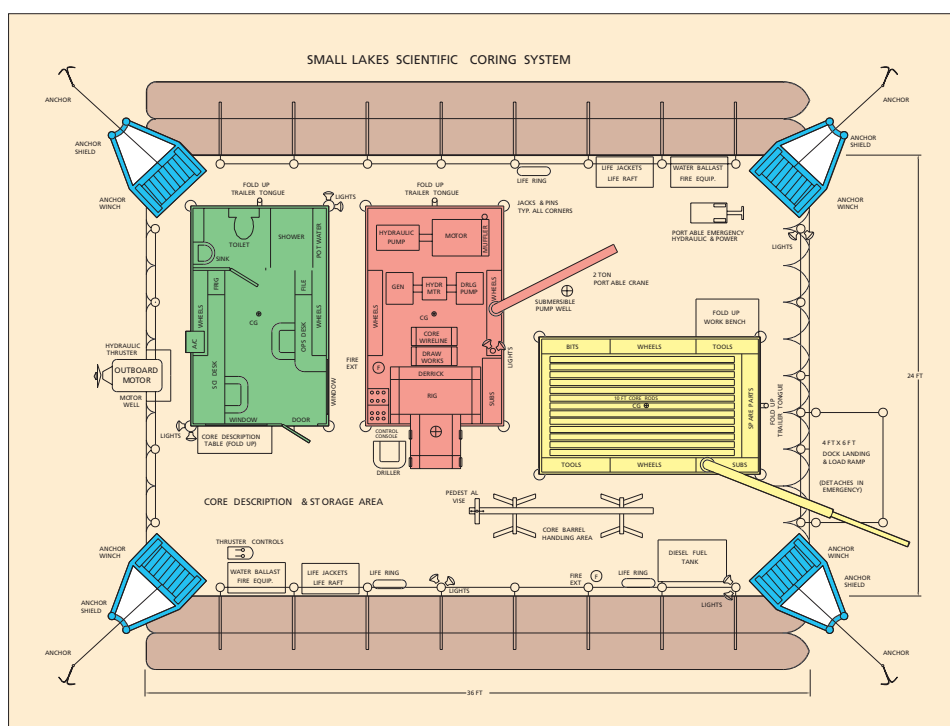


## PAGES Lake Drilling Task Force (LDTF)

The PAGES Lake Drilling Task Force (LDTF) has been active for three and a half years now, and has yet to drill a lake (except for Baikal, where the Baikal Drilling Project (BDP) was begun earlier). However, slow but steady progress has been made, and optimism is still high.

A formal feasibility study of drilling in large lakes has been completed. This study was carried out by a consortium of commercial companies, funded by the International Continental Scientific Drilling Program (ICDP), and presented to the LDTF in April, 1998. It was targeted at long (800+ m) cores from the largest, deepest lakes. The recommended equipment consists of an oil-field drill rig mounted on a large, modular barge (made up of 40x8x8-ft modified shipping containers), which would incorporate dynamic positioning and heave compensation. This system would certainly accomplish our goals, but is quite expensive: estimated costs for drilling operations on a single large lake are on the order of 3–4 million USD. It is clear, however, that obtaining ~1000 m cores in large, deep lakes will require this type of investment.

At the suggestion of some of the managers at US NSF who are focused on paleoclimate records (and less interested in sediments more than a few glacial cycles old), smaller-scale possibilities have begun to be explored. This concept was reinforced by discussions at an ICDP-funded workshop in May, 1998, to plan drilling at Lake Titicaca. Shortly afterward, a group called DOSECC (Drilling, Observation, and Sampling of the Earth's Continental Crust) stepped forward with an offer to help. DOSECC is a private, non-profit corporation funded by US NSF (similar to the Joint Oceanographic Institution (JOI) for the oceanographic community) to assist with U.S. continental drilling activities. DOSECC offered the services of its engineers to help design a smaller lake drilling system. They also offered to operate the system at cost (much lower than commercial costs), and to own, store, and maintain it, once initially acquired, for future drilling operations. These offers were viewed as significant advances of our plans and needs, so we proceeded to try to take advantage of them.



*Preliminary drawing of the raft for the smaller drilling system*

The initial design criteria were cores as much as 200 m long in as much as 200 m of water. It is likely that this is sufficient to address most (but not all) paleoclimate issues in most (but not all) lakes. The design produced by DOSECC, and discussed at a small meeting in Minneapolis in October, 1998, calls for a mining-style drill rig mounted on a 24x36 foot raft supported by marine industrial-grade inflatable pontoons. Further discussions revealed that the system could be equipped with a drill rig that would have a total drill-string length of up to 800 m and still obtain cores of standard Ocean Drilling Program (ODP) diameter. This system could also be mounted on a larger barge for drilling operations in lakes that are too large for the anchored, inflatable-pontoon-based raft.

The smaller system is viewed as complementary to the larger drilling system, providing additional options at more modest costs. In no way can it serve as a replacement for the original larger system, which still would be required for drilling deep cores in the largest lakes. An intermediate option would be to mount the smaller drill rig on a more substantial barge and drill as deep as the 800 m total-drill-string limit would allow.

It was suggested that the smaller drilling system be constructed near

DOSECC engineering headquarters in Salt Lake City and tested in nearby Great Salt Lake and Bear Lake, which have excellent scientific justifications for drilling. Despite the excellent scientific reasons for drilling in Great Salt and Bear Lakes, this operation would still be focused on design, acquisition, and testing of the system, and would not be intended as a new drilling initiative in competition with the lake drilling projects tentatively approved by ICDP (IDEAL lakes [Edward, Malawi, and Tanganyika], Lake Titicaca, and Qinghai Lake).

Representatives of groups with research experience in Great Salt Lake and Bear Lake met in mid-December, 1998, to draft a proposal that would be submitted to both ICDP and US NSF. The groups include the Universities of Arizona, Minnesota, Kansas State, and Utah, as well as the U.S. Geological Survey. A variety of scientific issues that could be addressed by drilling were discussed, including paleoclimate (over the last 150–450 ka), neotectonics, structural geology, and basin/biological evolution. The amount of drilling associated with each of these objectives varies, so the associated costs were modularized in the proposal. In all cases, cores obtained in the testing operation would be subjected to basic processing and archiving (split-



Lake Sonachi, Eastern Rift Valley, Kenya  
(Photo: Dirk Verschuren).

*LDTF, continued from previous page*

ting, description, logging, and reconnaissance dating and compositional analyses). From there, the cores would be available for future detailed analytical projects. The acquisition and construction costs of the system are about 0.7 million USD. Minimum costs for test-drilling operations and basic core processing are about 0.3 million USD for 300–400 m of core (paleoclimate or neotectonic issues only). For the 2500 m of core that would be necessary to address all of the scientific issues, the drilling-processing costs would be about 0.5 million. Total cost of the acquisition and testing project would therefore range between 1.0 and 1.2+ million USD.

We have been working for almost four years to develop a functional lake-drilling system. We believe that the proposed drilling system would provide an opportunity to address many of the priorities of ICDP and PAGES, including those of previously reviewed ICDP lake-drilling projects. Much depends on the fate of this latest proposal in the review process at ICDP and NSF over the next few months (January–April, 1999). Stay tuned.

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## PEP III African Crater Lakes Workshop

GENT, BELGIUM, OCTOBER 10–11 1998

Unraveling the climatic history of Africa and the Near East during the past 2000 years remains one of the major challenges in paleoclimate research, and sediment records from crater lakes are among the most valuable sources of information on this history. However, apart from the unique biology and distinct hydrogeological settings of the tropical and subtropical crater lakes dotting the southern half of the PEP III transect, their study also involves issues of access, organization, and scientific infrastructure that are quite different from the situation in Europe and add to the challenge of obtaining high-quality climate-proxy records from them (see PAGES Newsletter 97–2). The 1996 PEP III strategy meeting in Bierville (see PAGES Report 97–2) stressed the urgent need to redress the current geographic imbalance of paleoclimatic information within the PEP III transect, and recommended prioritization of a research initiative focusing specifically on high-resolution, PAGES Time Stream 1 paleoclimate reconstruction using sediment records from crater lakes and other small lakes in Africa and the Near East.

The African Crater Lakes workshop in Gent brought together a group of leading paleolimnologists currently active in Africa and the Near East, PAGES representatives, and specialists in data acquisition and management who could take on the function of a thematic working group to promote, guide and coordinate future lake-based, late Holocene paleoclimate research following PAGES guidelines with respect to time resolution, chronological control, climate-proxy calibration, and data management.

#### Regional data synthesis

Despite the large number of crater lakes and other small natural water bodies across Africa and the Near East, only a small subset of them are likely to have accumulated a continuous record of past environmental change resolvable at sub-annual to decadal time scales. A major objective of the meeting was to identify and rank specific study sites according to their potential for paleoclimate reconstruction. The main part of the meeting therefore comprised region-by-region

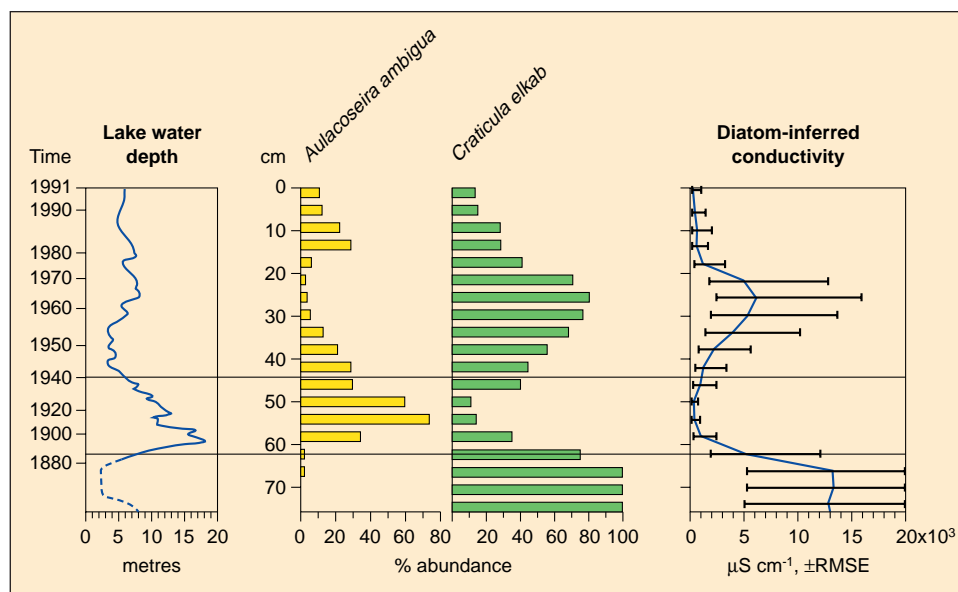
summaries of the present status of Time Stream 1 paleoclimate research in Africa and the Near East, and comparative evaluation of sites according to their potential to preserve a continuous sediment record of late-Holocene hydro-climatic variability. The geographical hub of the southern PEP III transect is the East African Rift, within which key areas include central Ethiopia (data summarised by H. Lamb and L. Carvalho), central Kenya (D. Verschuren), and southwest Tanzania (D. Williamson, P. Barker). Other important clusters of crater lakes, so far less well studied paleolimnologically, exist in western Uganda (D. Verschuren), Cameroon, and Madagascar (F. Gasse). Important complementary archives exist in the form of small high-altitude headwater lakes, in some cases pro-glacial, and recent work on Mt. Kenya was described by K. Holmgren (on behalf of W. Karlén) and P. Barker. The intense hydrological deficit in north-eastern Africa means that few lakes of any kind are available for study, making the handful of extant crater lakes in northern Sudan prime study targets (S. Kroepelin). A greater density of crater lakes exists adjacent to the Jordan Rift and in central and eastern Turkey (N. Roberts). Subtropical regions at the southern end of the PEP III transect seem to have few lake sites suitable for high-resolution paleoclimate research (L. Scott), and are likely to be better served via other climate-proxy archives such as speleothem records (K. Holmgren).

#### Research Questions

The working group identified two principal categories of research questions: (1) fundamental questions about the history and causes of climatic variability, and (2) methodological questions about the reliability of sedimentary proxy records as the source of information on that climatic variability.

(1) The primary goal of Time Stream 1 paleoclimate research on African crater and other small lakes is to document the temporal patterns and spatial coherence of past climatic change with a quality of proxy data and chronological control that permits evaluation of possible causative mechanisms over a hierarchy of time-





Validation of lake sediment records can be provided by historical data. Here, the recorded water level of Lake Oloidien, Naivasha, Kenya (left) over the last century is compared against the results of a  $^{210}\text{Pb}$ -dated short sediment core. Stratigraphic changes in the two principal diatom taxa, *A. ambigua* (fresh, planktonic) and *C. elkab* (halophytic, benthic) and inferred conductivity, match closely to the sequence of historic lake-level fluctuations at this site. (Simplified from Verschuren, D., Tibby, J., Leavitt, P.R. and Roberts, C.N. The environmental history of a climate-sensitive lake in the former 'White Highlands' of central Kenya. *Ambio*, in press).

scales. For high-frequency variations, such as those induced by ENSO or solar forcing, a prime criterion for a lake-sediment record to be of value is that it possesses the annual chronometer of varves. On the other hand the working group recognized that for documentation of the long-term climate shifts contemporary with the European Little Ice Age, and the frequency, intensity and duration of major drought and flood episodes, a more important criterion is that a lake has been adequately sensitive to hydroclimatic variations without desiccating completely during the more arid phases.

(2) Within- and between-site integration of climate-proxy data required for documentation of temporal and spatial coherence in past climate critically depends on the reliability of both the lake system and the sedimentary climate proxies to record truthfully climate history. The working group stressed the importance of developing strategies for the calibration and validation of reconstructed climate variations, in particular fluctuations in effective moisture (P-E), at individual sites. Crater lakes are not fundamentally different from other aquatic systems in having complex and sometimes lagged hydrological, hydrochemical and biological responses to climatic variations. As much as possible, climate-proxy data from recent lake sediments must be validated against historical limnological and climatic time series. Of particular value for climate-proxy validation are lake districts and systems where suitable conditions exist to elucidate processes of climate-proxy formation and preservation through compara-

tive historical paleolimnology. The prospective generation, integration, and use of multi-proxy data obtained from a network of lake-sediment and speleothem archives also raised important issues of information management (S. Juggins). It was agreed that development of a relational database system will be a primary requirement if systematic and quantitative intra- and inter-site comparison of lake sediment data within the PEP III transect is to be achieved.

### Recommendations

A multiple-track approach was proposed for future PEP III Time Stream 1 paleoclimate research:

1) Four lake districts in East Africa already tested for scientific and logistic suitability should be developed as natural laboratories for validation of climate-proxy archives: the Debre Zeit (Bishoftu) crater lakes in Ethiopia, the Lake Naivasha system in Kenya, the cluster of proglacial and high-elevation crater lakes on Mt. Kenya, and the Rungwe crater lakes in Tanzania.

2) From each of these districts, one lake should be selected for the recovery of a high-resolution climate-proxy record spanning the last 2000 years. These sites will form an initial spatial network of high-quality small-lake records that can be compared with records of possible climate-forcing mechanisms, and linked to comparable climate-proxy records obtained from the large African Rift lakes (under the auspices of IDEAL), speleothems (SPEP III), and corals.

3) Exploratory fieldwork for high-quality sediment records should be un-

dertaken in other promising regions along the southern PEP III transect, such as Cameroon, western Uganda, Sudan, Turkey, and Madagascar. Because modern sediment samples collected from these lakes will be essential for establishing a comprehensive training set for numerical calibration of biological and geochemical climate proxies throughout the PEP III transect, community-wide coordination and integration of effort is needed to ensure that a common set of protocols is applied to the collection and processing of samples and environmental data.

4) High priority should be given to the application and testing of a relational database, based on that developed for the PALICLAS Italian crater lakes project (see Juggins, Newsletter 98-2), to compare and integrate data produced in lake-specific investigations and to interface the PEP III results with global data archives (World Data Center-A).

5) Progress in this multi-faceted initiative should be reviewed and presented to the wider scientific community at the INQUA Congress in Durban (August 1999) to promote community-wide scientific coordination and stimulate involvement of African scientists.

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## European Lake Drilling Programme (ELDP)

The European Lake Drilling Programme (ELDP) was launched as an ESF (European Science Foundation) Scientific Programme by the ESF Executive Council in November 1995 for a period of five years, starting operations in January 1996. It is supported by the member organisations from Belgium, France, Germany, Norway, Poland, Sweden, Switzerland and The Netherlands.

Scientists involved plan to further the recovery and interpretation of high resolution lacustrine paleoclimatic and paleoenvironmental archives in Europe. As many sites have already been studied in detail by individual research teams, it has become an attractive challenge to pool these data from as many European regions as possible on a common calendar-year time scale to give answers to some of the key questions of PAGES.

Continental paleoclimate records are critical because they provide evidence of the impacts of past climatic changes that were relevant to human societies and their activities. Among these records, high resolution lake sediments have particular advantages for paleoclimatic reconstructions and modelling, as they are present in various different environments and geographic locations, they provide continuous and high-reso-

lution records, they are archives for a large variety of climate- and environment-related proxies, they provide data needed for modelling climate changes, they give an enhanced continental perspective on paleoclimatic information and they contribute to land-sea-ice correlations.

The main activities of ELDP are built around major annual workshops to provide effective links between ongoing research programmes. Previous ELDP workshops have been organised in Le Bischenberg (France), in Cracow (Poland) on "European dimension of high resolution lacustrine records" and in Ptolemais (Greece) on "Mediterranean Lacustrine Records" – for the latter see the report below. The next workshop is planned for Lund (Sweden) on "Correlations of Late Weichselian and Holocene paleoenvironmental proxy data – a comparison of independent timescales based on high-resolution lacustrine data" – see the calendar on the last page of this Newsletter. During ELDP workshops special efforts are devoted to the correlation of high resolution paleoenvironmental records across the European continent which are focussed along four main transects. For these transects regional working groups have been formed which are an integral part of ELDP. These working groups are related



to "Northern Europe", the "Atlantic Transect" (see also working group report in the PAGES Newsletter 98–2, p. 11), "Central Europe" and "Southern Europe". An additional topical working group is related to "Climate Variability in Annual to Milankovich Frequency Bands".

For more information on the programme's progress and on recent developments, please visit the ELDP homepage at <http://www.gfz-potsdam.de/pb3/pb33/eldphome/>.

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## Mediterranean Lacustrine Records

PTOLEMAIS, GREECE, OCTOBER 14–18, 1998

The 3<sup>rd</sup> international ELDP Workshop, entitled "Mediterranean Lacustrine Records" was held in Ptolemais, Greece, on October 14–18, 1998. The meeting attracted 34 participants from 12 European countries and two participants from Israel and Japan. It began with brief reports of the five different ELDP working groups: "Northern Europe" (I. Snowball), "Atlantic Transect" (S. Leroy), "Central Europe" (J. Merkt), "Southern Europe" (R. Julia) and "Climate Variability in Annual to Milankovich Frequency Bands" (J. Meulenkamp). These were followed by presentations concentrating on lacustrine records from the Mediterranean area covering the time span of marine oxy-

gen isotope stages 1 to 5 or, roughly, the last 130,000 years. Talks included such topics as high resolution interglacial records, climatic fluctuations detected during the last glacial and their relation to similar events recorded in Greenland summit ice cores and marine sediment records, short-term climatic events during the late glacial and early Holocene, environmental changes during the last 2000 years, the application of tephra layers as time markers and as a correlation tool, biotic and abiotic responses to orbital and solar forcing, and climatic modelling. A mid-conference one day field trip was organised to the late Neogene lacustrine sediments of the Ptolemais basin, providing an impressive ex-

ample of the effects of orbital forcing in Milankovich and sub-Milankovich frequency bands to sedimentological and environmental processes.

Extended abstracts of almost all presentations and the excursion guide have been published as volume 1998/6 of *Terra Nostra – Schriftenreihe der Alfred-Wegener-Stiftung*. This volume can be ordered online at <http://www.aw-stiftung.de/publikationen.htm>.

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## The Global Paleo-Vegetation Project (BIOME 6000)

JENA, GERMANY, OCTOBER 6–10, 1998

The Global Paleo-Vegetation Project (BIOME 6000) was initiated at a workshop in Hörby, Sweden in 1994 under the joint auspices of IGBP-GAIM, IGBP-DIS, IGBP-GCTE and IGBP-PAGES. The aim of BIOME 6000 was to assemble pollen data for 6000 and 18,000 years before present (yr B.P.), and to use these data to construct global maps of vegetation for these time periods, using a standard, objective “biomisation” technique based on the classification of plant taxa into plant functional types.

Although there have been several BIOME 6000 workshops, focussing on assembling and creating regional BIOME 6000 data sets, the workshop recently held in Jena was the first opportunity for the BIOME 6000 community to meet since its inauguration. The Jena meeting had two goals: (a) to review the progress that had been made towards producing global biome maps for 6000 and 18,000 yr B.P., and (b) to review future applications of the technology and very extensive data sets being developed by the project.

Reports on the state of the regional BIOME 6000 data sets were presented for Beringia (Mary Edwards), the Western USA (Kathy Anderson), Eastern and Boreal North America (Jack Williams), Europe (Joel Guiot), Russia and central Asia (Pavel Tarasov), South America (Rob Marchant and Henry Hooghiemstra), Africa (Dominique Jolly), Japan (Shinya Sugita), China (Ge Yu) and Southeast Asia-Australasia (Geoff Hope and Liz Pickett). These reports made it clear that the biomisation technique provides robust reconstructions of the modern vegetation, across a wide range of climates and vegetation types and even in regions significantly impacted by human activity. Biome maps for 6000 and 18,000 yr B.P. have been produced for most regions of the globe. The biomisation of the remaining regions (specifically South America and the Southeast Asia-Australasia regions) is being very actively pursued, and biome maps for these regions are expected to be ready during the winter of 1998/1999.

The BIOME 6000 project was originally envisaged as providing data sets

that could be used for model evaluation within the IGBP-GAIM “6000 yr B.P. experiment” (an initiative to quantify the importance of biophysical feedbacks in the climate system) and within the Paleoclimate Modelling Intercomparison Project (PMIP). Sandy Harrison gave an update on progress within PMIP and showed how the BIOME 6000 data set for Africa had already been used to demonstrate that model-simulated changes in the African monsoon in response to orbital forcing were too small to explain the observed vegetation changes. Presentations by Colin Prentice, John Kutzbach and Claudia Kubatzki, reporting on work carried out within the GAIM “6000 yr B.P. experiment” and within the TEMPO (Testing Earth system Models with Paleoenvironmental Observations) project, made it clear that it will be necessary to incorporate feedbacks due to ocean- and/or land-surface changes in order to simulate the observed enhancement of the African monsoon more realistically. Ocean and land-surface feedbacks are also implicated in the correct simulation of e.g. the Asian monsoon and high-latitude summer warming during the mid-Holocene, and northern hemisphere mid-latitude cooling and the expansion of deserts at the last glacial maximum. The BIOME 6000 data set will, of course, be an important resource to evaluate planned coupled atmosphere-ocean-biosphere model experiments which incorporate such feedbacks.

However, as several presentations made clear, model evaluation is not the only task to which the BIOME 6000 approach can be usefully applied. Bob Thompson showed results of the biomisation of pollen and plant-macrofossil data from western North America for multiple time periods, and how these results could be used to document the evolution of vegetation since the glacial maximum. Joel Guiot and Shinya Sugita demonstrated alternative methods that could be used to make quantitative climate reconstructions from biomised data. Joel Guiot also discussed ways in which the biome data at individual sites could be spatially generalised in order to derive gridded maps of land-surface

conditions which could be used to specify land-surface characteristics in model simulations. Although these approaches have been developed with data sets for specific regions, they could be applied globally.

The existing BIOME 6000 data sets, and the additional applications of BIOME 6000 data and methodology demonstrated at the workshop, could contribute significantly to a number of IGBP initiatives. The potential links between BIOME 6000 and some of these initiatives were explored in presentations by John Dodson (the Pole-Equator-Pole transects), Rachid Cheddadi (European Pollen Data Base), Louis Francois (the Paleo-Carbon Cycle Modelling Intercomparison Project), Sheila Hicks (CAPE: Circum-Arctic Paleo-Environments), Matt Duvall (PALE: Paleoenvironments of Arctic Lakes & Estuaries), Ralph Schneider (IMAGES), Frank Oldfield (Global Land Cover), and Colin Prentice (GAIM Paleo Trace Gas and Mineral Aerosols Challenge).

The Jena meeting amply demonstrated that the BIOME 6000 project is alive, well and on target to achieve its goal of producing global vegetation maps for 6000 and 18,000 yr B.P. in 1999. The success of the project is largely due to a very extensive collaboration, now involving more than 150 scientists worldwide. The first fruits of this international collaboration, in the form of biome maps for individual regions, are being published in three special issues of the *Journal of Biogeography* during 1998–1999. However, the demonstration of new applications of the BIOME 6000 approach and the lively discussions at the Jena meeting indicate that we can expect an even richer, long-term scientific harvest from BIOME 6000.

Our thanks go to the German IGBP Secretariat for their support of this meeting and to IGBP-GAIM, IGBP-DIS and the MPG for providing the funding that made it possible.

**SANDY P. HARRISON AND I. COLIN PRENTICE**

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# ANNOUNCEMENTS

## START Young Scientist Award Program

To recognize the achievements of outstanding young scientists from Africa, Asia and Oceania, the International START Secretariat is requesting nominations for the START Young Scientist Award Program. Award decisions will be based on a journal article published by the young scientist (preferably in English). In keeping with START's mission of conducting research on regional aspects of global change, the article should focus on some aspect of global change research that is being conducted on a regional level or has a strong regional focus.

Awards, which include an honorarium, will be made to scientists from developing countries in each of the START regions: Africa, South Asia, Southeast Asia, East Asia and Oceania. Award announcements are expected to be made in June 1999.

Applicants for the START Young Scientist Awards must be 40 years of age or younger. In the case of multi-authored

articles, the applicant should be the lead author of the article. The article should have been published within the last two years.

Recipients of START Fellowship/Visiting Scientist Awards are strongly encouraged to submit articles they may have published based on research conducted with START support.

Articles will be reviewed in consultation with the respective START Regional Centers/Secretariats and by a special review committee. Applicants or nominators should submit the journal article and a brief biography to:

### AMY FREISE

Program Associate  
International START Secretariat  
2000 Florida Avenue, NW, Suite 200  
Washington, DC 20009  
USA  
Phone: (+1-202) 462-2213  
Fax: (+1-202) 457-5859  
afreise@agu.org

## PAGES Grants for Swiss Summer School

PAGES is pleased to announce a competition for at least three young scientists from developing countries to attend the Swiss summer school "The Dynamics of the Earth System: Processes and Records of Past Climate Change" July 17–24, 1999. The summer school will be held in Hasliberg in the Bernese Oberland and will be coordinated by Thomas Stocker and Andy Lotter from the University of Bern. The week long program features a series of lectures by internationally renowned paleoscientists as well as opportunities for poster presentations. Detailed information about the summer school is available from the website <http://phkup0.unibe.ch/summer/>. For scientists without access to the internet, please contact the PAGES IPO for details.

In addition to the week long summer program, it is hoped that the PAGES fellowship winners will be able to spend a week in the PAGES office in Bern making personal connections with PAGES, while at the same time raising the profile of research in their home country at the PAGES IPO. Applicants for a fellowship should send their applications

materials to arrive at the PAGES IPO no later than Monday May 19th. Note that this is an extended deadline, and also a different place to submit materials than for the general summer school as listed on the website. This extended deadline is granted only to people applying for these PAGES fellowships, and is due to the relatively late announcement of this opportunity.

Application materials required for this PAGES fellowship are:

1. An abstract of your poster if you would like to present one.
2. Your curriculum vitae, including date of receipt (or anticipated receipt) of PhD and contact address, phone number, fax number and email if possible.
3. Your list of publications.
4. One letter of recommendation by a referee of your choice.
5. A one page statement of why and how you would like to establish closer contact with the PAGES research community during a short stay at the PAGES IPO.

## UPCOMING WORKSHOP

### Inter-PEP Linkages

APPENBERG, SWITZERLAND, SEPTEMBER 1-2, 1999

Developing from the success in promoting inter-hemispheric research programs through the three PEP (Pole-Equator-Pole) transects, the time has come to compare and contrast the results to date from these programs. Linking activities between the three PEP transects can help to further strengthen our understanding of mechanisms and causes of present and past global climate change and variability. To this end, a workshop on "Inter-PEP Linkages" is planned for September of 1999 at the Appenberg conference center near Bern, chaired by Vera Markgraf (University of Colorado) and Steve Colman (USGS, Woods Hole), in conjunction with both PIs' stay at the PAGES office in Bern. The goal of this workshop is to formulate a science agenda for research programs that will enhance inter-PEP linkages. Scientists will be invited who previously have shown interest or have been actively involved in intra-hemispheric linkages of climate, present and past. The approach will be to focus on specific climate phenomena and climate anomalies of zonal character, and their paleoenvironmental expression, such as ENSO, Indian and African monsoons and westerly winds.

### VERA MARKGRAF

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The European Geophysical Society has presented its most prestigious award, **Honorary Membership**, to W. Dansgaard, C. Lorius and H. Oeschger (†, see p. 10) for their common fundamental achievements in our present knowledge of the climate of the Earth. The official award ceremony will take place during the 24<sup>th</sup> General Assembly at The Hague, The Netherlands, Monday April 19, 1999.



## Changes in PAGES SSC

PAGES SSC welcomes two new members in 1999:

**Vera Markgraf**, having passed on the mantle of PEP1 leadership to Geoff Seltzer (see p. 3), has freed up some time for duties on the PAGES SSC. Vera is a research professor in the Institute of Arctic and Alpine Research, University of Colorado. She brings to the SSC an expertise in late Quaternary palynology with focus on reconstruction of past climate, dynamics and forcing of climate change, with special emphasis on South America and times of transition, such as the late glacial. Vera will be spending part of a sabbatical year in Bern starting in June 1999, and will work closely with the IPO on issues of inter-PEP comparisons and the PAGES synthesis effort.

**Thomas Stocker** brings a much needed dynamical and modeling perspective to the SSC. Thomas is a professor of Climate and Environmental Physics at the Physics Institute, University of Bern and has been Co-director of the Physics Institute since 1993. He has a wide range of modeling interests which include both paleo work as well as looking at the influence of magnitude and

rates of potential future CO<sub>2</sub> increases on the ocean thermohaline circulation. In addition, he is an active participant in Antarctic ice core research. Based in Bern, Thomas is in regular contact with the IPO and we look forward to working with him in 1999 on both the development of the PAGES/CLIVAR intersection program as well as the PAGES synthesis effort.

At the same time two members rotate off the SSC:

**Michael Lautenschlager** provided a modeling perspective and a wide ranging interests including multiproxy reconstructions of the Asian monsoon system. All the members of the PAGES SSC and the IPO join in thanking Michael for his valuable contributions.

**Ray Bradley**, having finished two terms on the SSC, is stepping down as chairman and at the same time rotating off the SSC. He plans to keep an active profile in PAGES however, concentrating his efforts on the PAGES synthesis and leadership of the PANASH project. Ray's past efforts for PAGES have been crucial to its success. As well as acting as Chair during a period of challenging

transition, he has also been central to the establishment of the PALE (subsequently CAPE) and PANASH Activities.

Finally, PAGES welcomes a new chairman to the SSC:

**Tom Pedersen**, professor in the department of Earth and Ocean Sciences, University of British Columbia, is already well known to PAGES through his active participation in the IMAGES program and membership on the PAGES SSC. In 1999, he takes over as chair of the SSC. His interests encompass a broad spectrum within sedimentary marine and lacustrine geochemistry, with a current research focus on chemical variability in sediments and stable carbon, oxygen and nitrogen isotopic analysis of carbonates and organic matter to determine how the ocean behaved in the past. He also has ongoing research interest in the controls of accumulation, burial, preservation, and composition of organic matter in open-ocean and continental margin sediments. ■

## PAGES Workshop Support

PAGES workshops serve to synthesize information, coordinate on-going research, define new avenues of research, and organize community participation in the implementation of relevant research. Workshops are generally open to broad community participation, though PAGES funding for each is limited. PAGES also sponsors smaller workshops devoted to defining and launching specific projects, as well as topical working groups to advance areas of PAGES-related science.

It is the responsibility of workshop organizers to generate most of the funding necessary for the workshop. PAGES funding can however be provided to demonstrate international interest, and thereby help organizers obtain national funding. In general, PAGES funding is no more than 10,000 US\$ per workshop and is wherever possible and appropriate earmarked for participants from developing and former eastern block countries. PAGES also usually requests

a written post-workshop product, for example an item for inclusion in the PAGES newsletter, production of a PAGES workshop report, or increasingly, a special issue of a peer reviewed publication.

A proposal consists of a brief (no more than one page) description of the workshop goals, planned workshop products and planned use of PAGES funds submitted to the PAGES IPO for discussion by the PAGES SSC. The SSC meets annually to determine funding for the subsequent year. The proposal deadline for the 1999 PAGES SSC meeting, at which workshops for the year 2000 will be discussed, is April 15, 1999. Almost all the funds for 1999 have already been allocated.

Further details, including a list of completed and planned PAGES workshops can be found on our website (<http://www.pages.unibe.ch/workshops/workshops.html>). ■

The PAGES IPO maintains a database of **national PAGES activities**. This includes individuals who serve as national or regional PAGES points of contact, research programs being carried out nationally as contributions or complements to PAGES, as well as workshops and conferences being held in specific countries. In 1999, we plan to make this database available on our website. At present, we would greatly appreciate it if any information relevant to this database is e-mailed, faxed or snail-mailed to the IPO. Once the database is online, we hope to have a web based submission capability. ■

## PAGES CALENDAR

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

• **\*April 28, 1999 "A forum on: Isotopes in Paleoclimate Research". Leicester University, United Kingdom**

Contact: Melanie. J. Leng, NERC Isotope Geosciences Laboratory, Keyworth, Nottingham NG12 5GG, United Kingdom.

Phone: +44 115 9363527 Fax: +44 115 936 3302

m.leng@nigl.nerc.ac.uk

<http://www.pages.unibe.ch/workshops/isotopeforum.html>

• **May 3–6, 1999 "Global Ocean and Land Surface Temperatures during the Last Ice Age". HANSE Wissenschaftskolleg, Delmenhorst, Germany**

Contact: Ralph Schneider, Fachbereich Geowissenschaften, Universität Bremen, Postfach 330 440, 28334 Bremen, Germany.

Phone: +49 421 218 3579, Fax: +49 421 218 3116

rschneid@uni-bremen.de

• **May 6–14, 1999 "IGBP Congress (with PAGES Scientific Steering Committee Meeting)". Shonan, Japan**

Contact: IGBP Secretariat, Royal Swedish Academy of Sciences, Lilla Frescativägen 4, Box 50005, S-104 05 Stockholm, Sweden.

sec@igbp.kva.se

• **May 10–14, 1999 "International Symposium on Isotope Techniques in Water Resources Development and Management". Vienna, Austria**

International Atomic Energy Agency, IAEA-SM-361, Vienna International Centre, P.O. Box 100, Wagramer Strasse 5, A-1400 Vienna, Austria.

official.mail@iaea.org

<http://www.iaea.org/worldatom/thisweek/preview/1999meet/infsm361.html>

• **May 21–27, 1999 "Paleoclimate Modelling and Analysis: Quaternary Earth System Interactions and Modelling". Albufeira, Portugal**

Contact: Dr. 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

euresco@esf.org

<http://www.esf.org/euresco/lc99108a.htm>

• **\*July 17–24, 1999 "Swiss Climate Summer School: The Dynamics of the Earth System: Processes and Records of Past Climate Change". Hasliberg, Switzerland**

Contact: Thomas Stocker, Climate and Environmental Physics, University of Bern, Sidlerstrasse 5, 3012 Bern, Switzerland.

Phone: +41-31-631 44 62, Fax: +41-31-631 44 05

<http://phkpu0.unibe.ch/~stocker/summer/>

• **\*July 18–30, 1999 "IUGG99, Special Session MC11: On the Use of Coupled Models for Paleoclimate Studies". Birmingham, UK**

<http://www.bham.ac.uk/IUGG99/>

• **\*July 28 – August 2, 1999 "IGCP Project No. 396, Continental Shelves in the Quaternary, 4<sup>th</sup> annual conference". Cape Town, South Africa**

Contact: Mike Meadows, Dept of Environmental & Geographical Science, University of Cape Town, South Africa.

Fax: +27 21 650 3791

meadows@enviro.uct.ac.za

<http://www2.env.uea.ac.uk/gmmc/igcp/capetown/igcp99.html>

• **\*August 3–11, 1999 "The Environmental Background to Hominid Evolution in Africa - INQUA XV International Congress". Durban, South Africa**

Contact: Dr D.M. Avery - Secretary General, South African Museum, P.O. Box 61, Cape Town 8000, South Africa.

Phone: +27-21-243330, Fax: +27-21-2467

mavery@samuseum.ac.za

<http://INQUA.geoscience.org.za>

• **September 1–2, 1999 "Inter-PEP Linkages". Appenberg, Switzerland**

Contact: Vera Markgraf, Institute of Arctic and Alpine Research, University of Colorado, Boulder CO 80309-0450, USA.

Phone: +1 303 492 5117, Fax: +1 303 492 6388

markgraf@spot.colorado.edu

• **\*September 13–17, 1999 "Fourth International Conference on Modelling of Global Climate Change and Variability". Hamburg, Germany**

Contact: Dr. Lydia Dümenil, Max-Planck-Institut für Meteorologie, Bundesstrasse 55, 20146 Hamburg, Germany.

Phone: +49 40 41 173-310, Fax: +49 40 41 173-366

mpi-conference@dkrz.de

<http://www.mpimet.mpg.de/~mpi-conference/>

• **September 17–22, 1999, "Polar Regions and Quaternary Climate: Towards High-Resolution Records of the Last Glacial Period in Antarctica". Giens, France**

Contact: Dr. Josip Hendekovic, European Science Foundation, 1 quai Lezay-Marnésia, 67080 Strasbourg, France.

Tel: +33 3 88 76 71 35, Fax: +33 3 88 36 69 87

<http://www.esf.org/euresco/lc99115a.htm>

• **September 22–26, 1999 "Correlations of Late Weichselian and Holocene paleoenvironmental proxy data – a comparison of independent timescales based on high-resolution lacustrine data". Lund, Sweden**

Contact: Bernd Zolitschka, GeoForschungsZentrum Potsdam, Telegrafenberg, D-14473 Potsdam, Germany.

zoli@gfz-potsdam.de

<http://www.gfz-potsdam.de/pb3/pb33/eldphome/4th-ws.htm>

• **September 30 – October 3, 1999 "Swedish National IGBP-PAGES Meeting". Lund/Höör, Sweden**

Contact: Dr. Barbara Wohlfarth, Department of Quaternary Geology, Tornavägen 13, 223 63 Lund, Sweden.

Fax: +46 46-2224830

Barbara.Wohlfarth@geol.lu.se

• **October 3–6, 1999 "Alkenone-Based Paleoceanographic Indicators". Woods Hole, USA**

Contact: 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

<http://www.pages.unibe.ch/calendar/alkenone.html>

• **\*November 15–19, 1999 "International Symposium on Multifaceted Aspects of Tree Ring Analysis". Lucknow, India**

Contact: Dr. Amalava Bhattacharyya, Birbal Sahni Institute of Palaeobotany, 53 University Road, Lucknow 226 007, India.

Phone/Fax: +91 522 381 948

bsip@bsip.sirnetd.ernet.in

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