

# Appendix A - The Past Global Changes (PAGES) Program

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## A.1 The PAGES mission

PAGES is the International Geosphere Biosphere Program (IGBP) project charged with providing a quantitative understanding of the Earth's past climate and environment. One major obstacle standing in the way of producing reliable predictions of global climate change and its environmental impacts is a lack of data on time scales longer than the short instrumental record. Natural archives of past climate variability can provide relevant information over longer timescales. One major goal of PAGES is to provide this information to scientists, policy makers and to the general public.

## A.2 Research program

The PAGES research program is structured so as to bring researchers from a variety of disciplines and countries together to work on common themes. Thus, no explicit disciplinary or national structures exist within the program. Rather, the program elements are designed so as to reduce constraints imposed by geography and artificial disciplinary boundaries like those that commonly separate physical oceanography from continental paleoecology from archaeology. Although the five foci which make up the core of the PAGES program have been created to group types of research together, they are by no means restrictive, and collaboration between foci are strongly encouraged. The activities of each Focus are guided by a chair and a small steering group.

### Focus 1 - PANASH

The goal of the Paleoclimate and Environments of the Northern and Southern Hemispheres (PANASH) focus is to reconstruct paleoenvironments and paleoclimate along three Pole-Equator-Pole (PEP) terrestrial transects (Figure A.1) using a multiproxy data and modeling approach. One of the major roles of the PEP transects is to facilitate the development of north-south research partnerships and foster a unified sense purpose within the diverse international and interdisciplinary community addressing questions of past global change. The PEP

transects have been extremely successful in achieving these goals as evidenced by the strong community interest in PEP activities (more than 300 people attended the PEP3 conference "Past Climate Variability Through Europe and Africa" in Aix-en-Provence, 27-31 August 2001), as well as the peer reviewed synthesis publications that have arisen from each transect (Markgraf 2001, Dodson and Guo in prep, Battarbee et al. in press).

In addition to supporting the PEP transects, PANASH as a whole stimulates exchange of information among marine, atmospheric, and terrestrial scientists, historical ecologists and environmental archaeologists globally. Its primary tasks are to:

- document the amplitude, phase and geographic extent of climate change in the two hemispheres,
- determine the history of potentially important forcing factors,
- identify the important feedbacks which amplify or reduce the influence the effect of these forcings,
- identify the mechanisms of climatic coupling between the two hemispheres.

The basis of all PANASH activities is understanding the modes of climatic and environmental variability by answering problem-oriented questions, through the use of global, multi-proxy based climate and environmental reconstruction. Further information about PANASH can be found here:

[www.pages-igbp.org/structure/focus1.html](http://www.pages-igbp.org/structure/focus1.html)

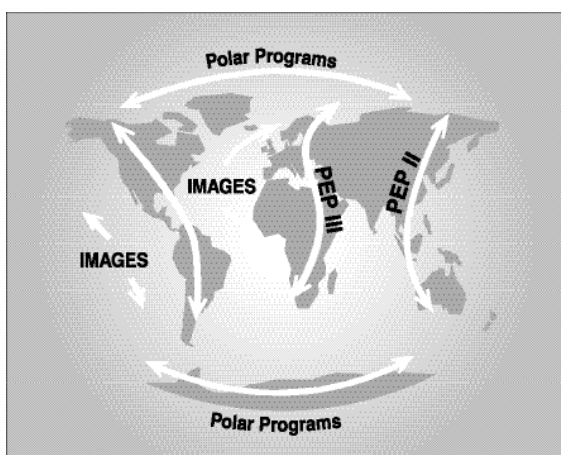
### Focus 2 - The PAGES/CLIVAR Intersection

The PAGES/CLIVAR Intersection focus aims to improve the understanding of decadal to century scale climate variability, especially as relevant to improving predictability, through the use of high resolution paleoclimatic data. The activities within this focus are overseen by a joint working group shared between PAGES and the World Climate Research Program (WCRP) Climate Variability and Predictability Program (CLIVAR). The four principal areas of concentration, as outlined at the first international CLIVAR conference (Alverson et al. 1999), are:

- extending the instrumental climate record back in time with quantitative proxy data that can be accurately calibrated against instrumental records
- documenting and understanding rapid climate change
- documenting and understanding natural climate variability during the Holocene and other interglacial periods with background climatic states similar to those of today
- Testing the ability of climate models to capture known past climate variability.

Further information about the PAGES/CLIVAR intersection can be found at

[www.clivar.org/organization/pages/index.htm](http://www.clivar.org/organization/pages/index.htm)



**Fig. A.1.** A schematic diagram showing some of the main Foci within PAGES. The Pole-Equator-Pole (PEP) transects within focus one, PANASH; focus three, IMAGES; and focus four, Polar Programs. The other two PAGES foci, the CLIVAR/PAGES intersection and Ecosystem Processes and Human Dimensions, do not have clear geographic boundaries.

### Focus 3 - IMAGES

The International Marine Past Global Changes Study (IMAGES) is the marine program shared between PAGES and the Scientific Committee for Ocean Research (SCOR). The principal aim of this program is to understand the mechanisms and consequences of past climate changes as long as ocean circulation, salinity, ventilation, carbon sequestration and flux, using oceanic sedimentary records. IMAGES supports a number of working groups, some of which are oriented around cruise planning and others around more general research questions. One major task of IMAGES is to organize international pooling of financial resources and research expertise in order to enable cruises to be carried out

throughout the world oceans. All IMAGES activities are carried out with strong input and interaction from climate modelers, continental scientists and ice core researchers. Further information on the IMAGES program is available here:

[www.images-pages.org/](http://www.images-pages.org/)

### Focus 4 - Polar Programs

The Polar Programs focus is bi-polar. Examples of research within the remit of this focus include the European and US N GRIP ice core programs, EPICA and the International Trans-Atlantic Scientific Expedition (ITASE) which seeks to map the spatial variability of Antarctic climate over the last millennium. This initiative is shared with the Scientific Committee on Antarctic Research (SCAR). In addition to ice core work, a wealth of other archives in polar regions are employed to provide a robust picture of high latitude environmental change. For example, the ESF-funded Quaternary Environment of the Eurasian North project (QUEEN) concentrates on mapping the extent of the last glaciation, the CircumArctic Paleo-Environments program (CAPE) facilitates integration of paleoenvironmental research on terrestrial and adjacent margins covering over the last few glacial cycles. Further information on the Polar Programs focus is available here:

[www.pages-igbp.org/structure/focus4.html](http://www.pages-igbp.org/structure/focus4.html)

### Focus 5 - Past Ecosystem Processes and Human Environment Interactions

The Past Ecosystems and Human-Environment Interactions focus highlights PAGES concern with ecological responses to climate change and past human activities. The research within Focus 5 integrates past human-environment interactions at sub-continental scale with research and modeling based on present day ecosystems and watersheds. The focus is divided into three main activities: Human Impacts on Terrestrial Ecosystems (HITE), Land Use and Climate Impacts on Fluvial Systems during the Period of Agriculture (LUCIFS) and Human Impact on Lake Ecosystems (LIMPACS). These activities are case-study based and focus on ecosystems made vulnerable to global change through any combination of natural and human induced stresses. They also explore the basis for the durability of long-sustained ecosystems, questions of sensitivity, thresholds and non-linear responses. Further information about Focus 5 is available here: [www.pages-igbp.org/structure/focus4.html](http://www.pages-igbp.org/structure/focus4.html)

### A.3 Initiatives

The original list of tasks and activities that once underlay PAGES Foci (Oldfield 1998) has been almost entirely transformed. PAGES now supports initiatives driven by scientific questions. The PAGES Steering committee serves to critically ascertain if proposed initiatives should qualify for PAGES endorsement and support. Successful initiatives are expected to develop a clear research and workshop agenda over a 3-5 year period leading to a tangible goal. PAGES support for these initiatives is flexible but can include enhancing the profile of the initiative, advertising it to the international community and providing partial funding for workshops. One example of a successful initiative is the Environmental Processes of the Ice Age: Land, Oceans, Glaciers (EPILOG) program, which arose in 1999 as a multi-national working group of the PAGES marine program IMAGES and recently published an extensive special issue on ice sheets and sea level of the last glacial maximum (Clark and Mix 2002). The required qualifications to be considered as a PAGES initiative are:

- A question which seems likely, within a 3-5 year timeframe, to be tractable in the sense of leading to a peer reviewed product which advances the field.
- A clear reason why PAGES should be involved, for example to facilitate new international or interdisciplinary bridges and community building.

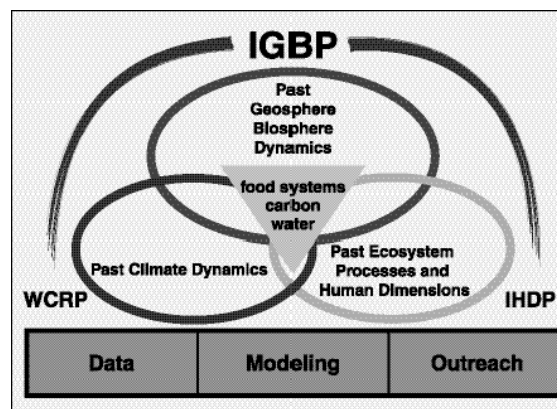
### A.4 Program Structure

PAGES activities are overseen by an international scientific steering committee (SSC) appointed by the Steering Committee of the IGBP. The sixteen members, who each serve for at most two consecutive three-year terms, are chosen to provide a balance of scientific expertise and national representation. This committee meets once a year to provide guidance for and oversight of the program as a whole. A subset of five committee members serves as an executive committee, which is in more regular contact with the International Project Office. As a general guideline the five member executive committee includes an American and a Swiss by virtue of the fact that these countries provide the bulk of PAGES core funding, and a member from a less developed country. By direction of the SSC, the staff of the small and efficient International Project Office (IPO) carries out the day to day running of the PAGES program as a whole. These activities include maintaining the PAGES website and database, organizing meetings and workshops, editing

and writing PAGES publications, and serving as a liaison with other global change programs. The staff of the IPO nominally consists of three full time positions, executive director, scientific officer and office manager. In addition, the office regularly hosts both short and long term (sabbatical) visits from paleoscientists around the world.

### A.5 Links with other international programs

PAGES continues to be primarily concerned with understanding the past operation of the Earth system. As shown schematically in figure A.2, the PAGES remit includes the physical climate system, biogeochemical cycles, ecosystem processes and human dimensions. Thus, PAGES activities are not restricted to IGBP, but overlap substantially with IGBP's sister programs within the "earth system science partnership," the WCRP, International Human Dimensions Program on Global Environmental Change (IHDP) and Diversitas. As indicated at the base of the schematic in Figure 1, facilitating publicly accessible paleodata access, engaging with the climate modeling community and strengthening the role of developing countries in PAGES research continue to be three foundation blocks upon which the wider PAGES scientific program rests.



**Fig. A.2.** The PAGES research agenda is more than paleoclimate. It explicitly identifies the need to improve understanding of geosphere-biosphere changes at the global scale and to link human-environment interactions with studies of ecosystem processes. This schematic provides a simple visualization of the overarching themes that express:

- the major research areas with which the PAGES community is concerned
- the main areas of interaction with not only IGBP, but also the other principal organizations in the earth system science partnership, WCRP and IHDP and Diversitas
- the way these overlap and link into the three cross-cutting themes within the earth system science partnership on sustainability issues of food systems, carbon and water.

the underpinning aspects of data, modeling and outreach that are essential to the success of the whole enterprise.

PAGES has built bridges with many other international scientific programs. Although only two of our Foci are officially shared, Focus 2 with WCRP-CLIVAR and Focus 3 with SCOR, all of them have substantial interactions with other programs. PAGES has launched joint initiatives with all of the other components of the IGBP, including both the core projects of IGBP phase 1 and the newly developing projects of IGBP phase 2, due to officially begin operation in 2003. A full listing of PAGES science partnerships is available on the PAGES website, some examples include the Global Network for Isotopes in Precipitation (GNIP), shared with the WCRP and the International Atomic Energy Agency (IAEA) and the International Mountain Research Initiative, co-sponsored by three other IGBP core projects, IHDP, GTOS and UNESCO. Through its intersection activities with other global change programs, PAGES provides the historical context for global change programs.

## A.6 Outreach and communications

One major task for PAGES is to provide easy access to paleoenvironmental information, to active researchers in paleosciences, researchers in other aspects of global change research, and the public. One of the most important communication platform is the website [www.pages-igbp.org](http://www.pages-igbp.org). This site is modified regularly and includes lists of new products, links to paleoenvironmental databases, science highlights, a calendar of upcoming events and information on how to become involved in PAGES activities. A set of overhead view graphs, based in part on figures from various PAGES publications, is available to download from the website. These overheads are regularly used by scientists for educational and public outreach lectures. The overheads are sent, on request, free of charge to scientists in developing countries who are unable to download and print them from the website. The PAGES website also supports an online database of paleoscientists, searchable by name and expertise.

Another important element in the PAGES communication strategy is the newsletter. PAGES NEWS is produced three times a year and sent free of charge to 3000 subscribing scientists in more than 70 countries. All are made available as pdf files on the PAGES website. Such wide distribution, coupled with a high degree of proactive submission by the research community has made the newsletter an important vehicle for the dissemination of research results, workshop reports and program news,

especially in countries with limited access to western journals. Each issue is developed around a specific theme, which might be a PAGES program or a particular paleoarchive. Ideas for themes for newsletter issues are always welcome.

In addition to its newsletter and website, PAGES strongly encourages publications in the peer reviewed literature as one outcome of all of its scientific activities. An exhaustive list of publications which have come about through research linked to PAGES is difficult to construct because of the very inclusive nature of PAGES organization. However, some examples of recent books and special journal issues which have arisen directly out of PAGES programs include (Dodson and Guo 1998, Alverson et al. 2000, Kroepelin and Petit-Maire 2000, Markgraf 2001, Mix et al. 2002, Dodson and Guo in prep, Battarbee et al. in press, Mix et al. in press).

## A.7 Data archives

Internationally accessible data archives are one of the primary foundations for paleoclimatic research that seeks to go beyond reporting results on a site by site basis. PAGES is committed to the IGBP principles of ensuring the preservation of all data needed for long-term, global change research and making them openly available as soon as they become widely useful. PAGES recognized the value of such data libraries at its outset and was an important early supporter of the World Data Center for paleoclimatology, Boulder ([www.ngdc.noaa.gov/](http://www.ngdc.noaa.gov/), appendix B). The WDC-Paleoclimatology is now a key source of paleoclimatic information that is made freely available to scientists across the globe. In addition to data repositories, PAGES, through the decisions of its data board, encourages the development of thematic and national relational paleoclimate databases such as PANGAEA initiative ([www.pangaea.de](http://www.pangaea.de)). Future progress in understanding climate history will depend increasingly on the provision of well-documented data by such data centers. PAGES supports a data board with a primary responsibility for assuring compatibility and accessibility of available existing paleo-database. The PAGES data board is open to all interested participants and includes members from most major database centers and focus leaders.

## A.8 Capacity building - encouraging north-south research partnerships

PAGES has a strong interest in capacity building. The majority of paleo-environmental data are extracted in less developed countries. Recent high profile examples include ice cores from Kiliman-

jaro, tree rings and lake sediments from Siberia, loess records in China, tropical tree rings in SE Asia, and speleothems in Oman. Flying western scientists around the world to take these records home and analyze them, the current practice for the most part, is no more justifiable than bringing cultural artifacts back to the British Museum was in 1800. A better way to bring these records together into a synthesis view of past environmental change is to facilitate the careers of independent working scientists within the many countries in which these archives exist and to ensure that they are well tied into global efforts.

PAGES allocates approximately 20% of its budget directly to activities geared towards building the capacity of scientists residing in developing countries to carry out active participation in paleoenvironmental research. In addition, most PAGES workshop and summer school support is earmarked for participants from developing countries. In addition to finances, PAGES seeks to follow up one time support wherever possible by enhancing the number of young scientists from developing countries in our database, nominating outstanding individuals for various awards and entraining them directly in our major scientific initiatives. We occasionally host visits at the PAGES office usually when tied to academic visits at a department at the nearby University of Bern or the Swiss Climate summer school.

The PAGES Regional, Educational and Infrastructure Efforts (REDIE) project seeks to:

- Enlist scientists and technicians in developing countries in international paleoenvironmental research activities
- Promote the development of paleoscience research within developing countries.

Within the REDIE program, a number of approaches are used. Financial support is made available for the attendance of active young scientists at key conferences and summer schools. PAGES publications are made available free of charge to libraries and university laboratories in less-developed countries. Scientists from Asia, Africa and South America sit on the PAGES Science Committee and act as liaisons with their regional communities. PAGES scientific meetings are regularly organized in developing countries, with ample support and presentation time provided for the attendance of scientists from the region.

### A.9 How to get involved with PAGES activities

There are many ways to get involved with PAGES activities:

- **Join existing programs** by contacting the relevant focus leader directly or sending a description of your research project to the IPO, which can help link your project to complementary efforts around the world.
- **Propose a new initiative** as outlined above under 'initiatives' to the scientific steering committee by sending a brief written proposal to the IPO.
- **Propose a workshop** by sending a one-page description of the goals of the workshop, the expected products, likely speakers, the planned use of PAGES funds and likely additional sources of support.
- **Nominate someone for the SSC** by sending a brief cover letter and c.v. to the PAGES office (pages@pages.unibe.ch)

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