

mate from Monsoon Asia: the last 2000 Years and Beyond". The workshop was sponsored by the IGBP PAGES Program, and was financially co-sponsored by the National Science Council, Republic of China and the National Science Foundation, USA. More than 150 participants from eight countries attended the workshop. A full report of the workshop conclusions and recommendations was compiled by Raymond Bradley (USA) as a PAGES Workshop Report (Series 93-1), and a summary was published in the EOS (74:601-603). A selection of papers presented in the workshop was published in 1994 by the Terrestrial, Atmosphere and Oceanic Sciences in a special PAGES issue (TAO, vol. 5, No. 3, p.349-442).

While the team members rejoice over a number of significant accomplishments, they acknowledge that there will be a continuing

struggle to ensure that Taiwan geoscientists can make further significant contributions to this global project. The initial success is only seen as the beginning of yet more promising progress in PAGES research in the areas of East Asia monsoon as well as in the crucial linkage of the subtropical area in the PEP II transect.

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record of paleoceanographic changes in the southern South China Sea was reported by Chen et al (submitted).

## Century to Decade Records from Lake Sediments

The interlaminated dark and light-colored lake sediments obtained from several mountain lakes appear to reflect large-scale wet and dry cycles over the past 2,400 years (Chen et al., 1993; Lou et al, 1996). The detected 450-years periodicity is similar to that of the solar oscillation (Chen et al., 1993). The Medieval Warm Period (1000-1300 AD) and the Little Ice Age (1300-1850 AD) were recognized (Lou et al., 1996). These two epochs were also identified from palynological records of the Central Range (Liew et al., 1995). Pollen data in Taiwan imply the occurrence of a mid-Holocene climatic optimum during 7 - 3.7 ka and a cooling period during 3.7 - 2 ka (Liew et al., 1995). A drastic floral change took place at about 4.8 ka (Liew and Huang, 1994).

Palynological data indicated that the vegetation distribution displaced vertically by about 800 m between the last glacial and the Holocene, implying a 4.8°C change in temperature in the western foothill region of central Taiwan (Huang et al, in press a). It is inferred that in east Asia, during the LGM (21 - 15.8 ka), the forest in the uplands became half open, while most of the lowlands were occupied by grassland. Less humid conditions than today prevailed in Taiwan during the LGM (Liew et al., submitted).

## Documenting Past: Environmental Changes in Taiwan and Adjacent Areas Results of PAGES Taiwan 1992-1996

Compiling and analyzing high-resolution records of past environmental changes from both historical and natural archives has been a major task of PAGES (Sheu et al., 1994). Although the Taiwan PAGES Program only started in 1992, significant results have already appeared in various international and local periodicals. Some such results are summarized in this document.

### Millennium Records from Deep-sea Sediments

Paleoceanographic studies (Wei et al., 1996, Huang et al., in press b, Wei et al., in press) indicate that the last glacial maximum (LGM) in the marginal seas around Taiwan was at about 14 -15 thousand years ago (ka) (in carbon-14 age), corresponding to a calibrated calendar age of 17-18 ka. During the LGM, the axis of the Kuroshio shifted slightly to the east (Chen et al., 1992). The summer sea-surface temperatures (SSTs) off the east coast of Taiwan were similar to today's at about 29°C through the late Quaternary, whereas the winter SSTs (~22.5°C) were ~4°C lower than today during the last glacial period (Chen et al., 1992).

The South China Sea witnessed a colder winter during the LGM: the SSTs were about 18°C, which is ~6°C lower than today's winter SST (Wei et al., 1996). The winter monsoon was considered to have been stronger during the LGM than today (Fig. 1); consequently, ocean surface was better mixed and yielded higher biological productivity (Wei et al., 1996, Huang et al., in press b, Wei et al., in

press). A higher terrigenous flux during the LGM, together with higher sea-surface productivity, resulted in higher sedimentation rates and a larger accumulation of organic carbon and carbonates during the LGM. A carbonate preservation spike occurred at ~12 ka, synchronous with the global preservation event of the Termination I (Wei et al., 1996, Chen et al., in press). A 1.05 million-year

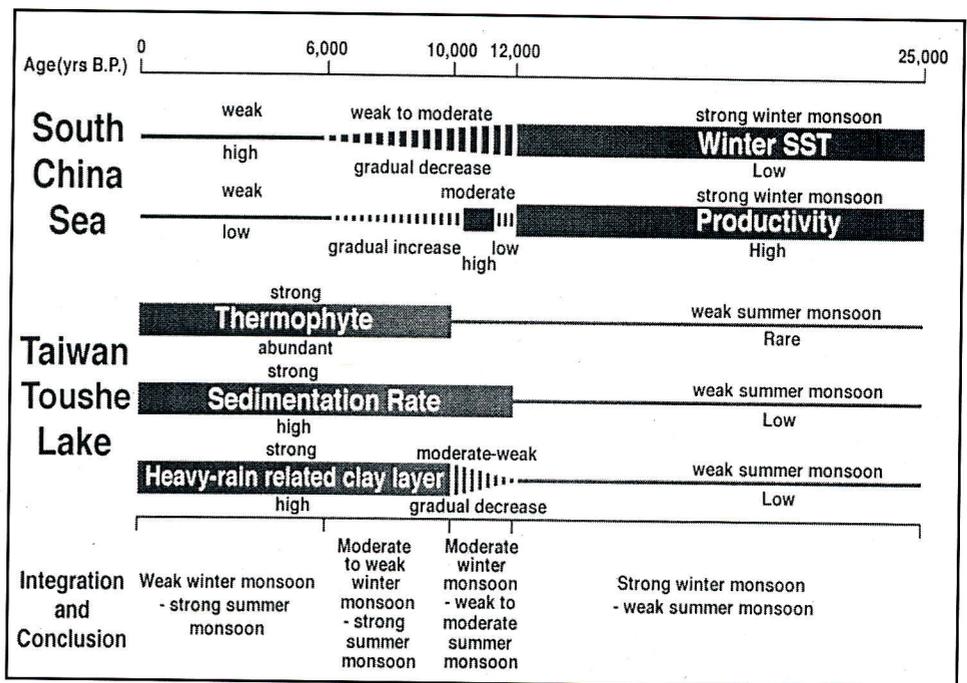


Fig. 1: An integrated monsoon history inferred from the proxy records in South China Sea and central Taiwan lake cores for the last 25,000 years. The marine and lake records are complementary and consistent, suggesting that the East Asian monsoon system has evolved from an strengthened winter monsoon during the last glaciation through a moderate to weak winter and summer monsoons during the deglaciation to an enhanced summer monsoon in the Holocene. (from Huang et al., in press a).

## Annual to Seasonal Records from Tree-Rings

Studies of tree rings of Taiwan fir allowed for the reconstruction of the summer and winter temperatures of the alpine mountain area over the past 300 years (Fig. 1). It was thereby demonstrated that cold climate prevailed during the Little Ice Age (Tsou and Liu, in press). Further more, carbon isotopic variations in a 120-year-old Taiwan fir responded negatively to the mean May-October temperatures after stable growth with a coefficient of  $-0.46 \text{‰ } ^\circ\text{C}^{-1}$  (Sheu et al, 1996).

## Monthly Records from Corals

An empirical relationship between the [Sr/Ca] concentration ratio in corals vs. sea-surface-temperature (SST) has been established in southern Taiwan. The temporal resolution is better than a month, while the SST can be reconstructed with an error less than  $0.1^\circ\text{C}$  (Lee et al., 1995; Shen et al., in press). Applying this paleo-thermometry, Lee et al (1995) detected a  $1\text{-}2^\circ\text{C}$  warming for the winter 1982-1983, corresponding to the strong ENSO of 1982. The calibration effort will soon be ex-

tended to a time span of greater than 100 years, covering the entire period since the first introduction of modern meteorological instruments to Taiwan.

## Synopsis

Deep-sea sedimentary records of the South China Sea suggest that the winter monsoons were strengthened during the last glacial (25-12 ka) while the summer monsoons were weaker than today's (Fig. 1). Ever since 12 ka, the winter monsoons have weakened, while the strength of the summer monsoons have gradually increased. An abrupt Younger Dryas-like cooling event occurred from 11.3 to 10.3 ka radiocarbon years BP (Huang et al, in press a). Palynological data obtained from central Taiwan show consistent and complementary evidence of this although the Younger Dryas is not recognizable. The vertical shifting of vegetation in the deglaciation period suggests a warming of about  $5^\circ\text{C}$  in the subalpine area of central Taiwan. Pollen data in Taiwan imply the occurrence of a mid-Holocene climatic optimum during 7-3.7 ka and a cooling period during 3.7-2 ka. Over the past 2000 years, the climate has become warmer and

wetter, intervened with the conspicuous Medieval Warm Period (1000-1300 AD) and the Little Ice Age (1300-1850 AD). Tree-ring data have also confirmed the effect of the Little Ice Age in the Taiwan alpine mountain region. The fluctuation of humidity over the past 2400 years as derived from lake sediments suggests that the recognized dry/cold periods have coincided with major historical disturbance events in Chinese history. The precise calibration of coral thermometry based upon the [Sr/Ca] ratio has been successful, it now appears promising that an accurate reconstruction of sea-surface temperature for the past several thousand years can be made.

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## PAGES CALENDAR

(\* Open meetings. All interested scientists are invited to attend)

■ **\*April 4 - 8, 1997, Lammi, Finland** - 'Circum Arctic Paleoenvironments'(CAPE) Synthesis Workshop: "Holocene Spatial and Temporal patterns of environmental change in the Arctic"

Contact: S. Hicks, Fax: (358) 8 553 1484; e-mail: sheila.hicks@oulu.fi

■ **\*April 14 - 18, 1997, IAEA Vienna, Austria** - International Symposium on 'Isotope Techniques in the Study of Past and Current Environmental Changes in the Hydrosphere and the Atmosphere'

Contact: Ms. T. Niedermayr, Conference Service Section - e-mail: niederma@adpol.iaea.or.at

■ **\*April 21 - 25, 1997, Vienna, Austria** - European Geophysical Society - See especially Session OA13, "Climate variability observation and modelling", sub-session "Reconstruction of past climates through Modelling and Observations"

Contact: G. Ramstein, e-mail: ramstin@asterix.saclay.cea.fr

■ **\*May 10 - 15, 1997, Castelvechio Pascoli, Italy** - Paleoclimate modelling and analysis, Quaternary paleoclimate analysis

Contact: Josip Hendekovic, ESF, Phone: +33 3 88 76 7135; Fax: +33 88 36 6987; e-mail: euresco@esf.org

■ **July 6 - 11, 1997, Hobart, Australia** - SCAR/GLOCHANT AND IGBP/PAGES Workshop on the

"late quaternary sedimentary record of the antarctic ice margin evolution" (ANTIME)

Contact: Ian Goodwin, Phone: +61 3 6226 7544, Fax: +61 3 6227 7650; e-mail: ian.goodwin@antarc.utas.edu.au

■ **\*August 24 - 30, 1997, Krasnoyarsk, Russia** - Siberian Transect Workshop on "Spatial-temporal dimensions of High-Latitude Ecosystem Changes"

Contact: V.A. Kopyug, Fax: (7) 3832 35 4846; e-mail: evag@ifor.krasnoyarsk.su

■ **\*August 28 - September 2, 1997, Heiligkreutz/Riedlingen, Germany** - "Seventh International Symposium on Palaeolimnology"

Contact: J. Merkt, Fax (49) 511 643 3667; e-mail: merkt@gatel.bgr.d400.de.

This Symposium is followed by a scientific celebration of the 80th birthday of Herbert E. Wright, Jr. at Wengen, Switzerland (Sept. 8 - 11)

Contact: B. Ammann, Fax: (41) 31 332 2059

■ **September 7 - 13, 1997, Johannesburg, South Africa** - Third Symposium of African Palynology.

Contact: Ann Cadman, University of Witwatersrand, e-mail: 106caa@cosmos.ac.za

■ **\*April 19 - 23, 1998, UK** - "PAGES Open Science Meeting", Royal Holloway University of London, UK.

Contact: Frank Oldfield, PAGES CPO Switzerland, Fax: +41 31 312 3168; e-mail: oldfield@pageigbp.unibe.ch

■ **\*May 16 - 23, 1998, Torshavn, Faroe Islands** - "Environmental Change in Atlantic Islands"

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e-mail: c.j.caseldine@exeter.ac.uk

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

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