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Palaeogeography, Palaeoclimatology, Palaeoecology 171 (2001) 91–95

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**PALAEO**

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## Introduction

# Quaternary environmental change in the Indonesian region

Biogeographically, there has been an interest in the Indonesian region for a long time, on the one hand as one of the major centres of high plant diversity including the highest number of primitive angiosperms in the world and, on the other hand, as the major global divide between faunas of the Australasian and Asian regions. Originally seen as ancient patterns, related to first static and then moving continents, it is becoming increasingly clear that both tectonism and climate change have extended into and, in terms of climate, accelerated during, the Quaternary period. It has also been discovered that a component of the fauna, the genus *Homo*, has had a long Quaternary history in the Indonesian region and that this is important to debates over the evolution and migration patterns of people and their cultural development, as well as to considerations about the impact people might have had on other components of the ecosystems of this region. Consequently, patterns of variation and diversity must be seen in the light of Quaternary environmental change.

The need for high quality Quaternary environmental data from the region is also being recognised for the understanding of global climate change as it has been realised that patterns of change cannot be totally accommodated by climatic forcing initiated in the North Atlantic region. The South-East Asian equatorial region, the so-called ‘Maritime Continent’ with the highest sea surface temperatures in the form of the West Pacific Warm Pool and high convective activity, is regarded as the ‘Boiler Box’ of the globe, influencing the distribution of moisture over a large proportion of the earth’s surface, and it is critically located in relation to the monsoon activity and El Niño variability. The constantly changing configuration of land and sea, due to continuing tectonic and

volcanic processes and alterations in sea level associated with glacial cyclicity, are likely to have had marked effects on both oceanic and atmospheric circulation patterns with repercussions for both regional and global climates.

Despite the accepted importance of a knowledge of the Quaternary environmental change to the understanding of the region and its potential role in climate forcing, research into most aspects of the Quaternary of the area, as in other humid tropical parts of the world, has been limited and opportunistic. Perhaps, an important exception is the study of mid- to high-altitude palaeoenvironments that have provided valuable data on past temperatures from altitudinal changes in vegetation (e.g. Flenley 1985; Stuijts 1993; Van der Kaars and Dam 1995). It is only recently that more systematic programmes have been initiated involving international collaborations and major inputs from researchers within the region. Some impetus for these programmes has been provided, for example, by a need to understand more about long-term climate–fire relationships in light of well publicised environmental, social, political and economic impacts of droughts and biomass burning associated with extreme ENSO events in recent years (e.g. Goldammer, 1999) and with the erection of the Pole–Equator–Pole structure to the International Geological Biological Programme’s Past Global Changes (PAGES) project (see Oldfield, 1998) that has clearly indicated the lack of data for this part of the East Asian/Australasian transect.

This special issue has been designed to bring together the results of a number of recent research initiatives and to provide a basis, and hopefully enthusiasm, for continuation and extension of research in this region. It focuses mainly on the late Quaternary

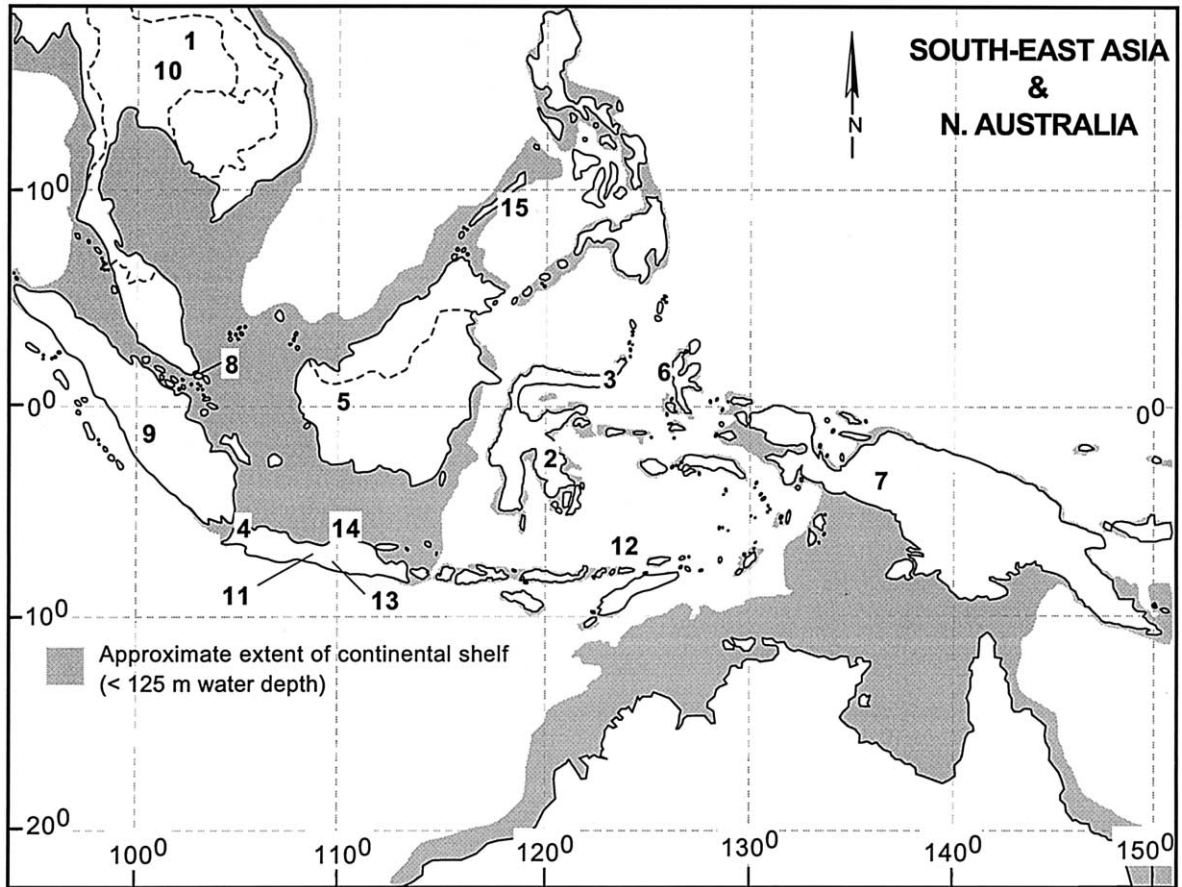


Fig. 1. Location of the studies. The numbers refer to the respective papers in this issue.

history of lowland Indonesia from sediment-based studies, as this has been perceived as the largest and the most relevant gap in knowledge to the understanding of recent patterns of climate change. However, it also includes the recent research and reviews on vertebrate palaeontology, human evolution, historical patterns of biomass burning and archaeologically related sediment studies that extend the temporal and spatial scope of the issue and provide a broader context for understanding the significance and applications of the Indonesian research. Locations of research sites covered by this issue are shown in Fig. 1. The research presented here is complemented by studies on marine cores in the South China Sea to the north of Indonesia, collected by the joint German–Chinese cruise 95 with the vessel *RV Sonne* (Sarnthein and Wang, 1999) and from an IMAGES-IV

cruise in eastern Indonesia (with the vessel *Marion Dufresne* in 1998), results of which are forthcoming. In addition, a very useful overview on coastal dynamics and sea-level changes in the region has been provided by Woodroffe and Berryman (2000). More general background information on Southeast Asian environments and additional recent research findings on Quaternary environments within the Indonesian region is incorporated into the forthcoming edited books of Kershaw et al. (2001) and Metcalfe et al. (2001).

The study of marine cores has provided some chronostratigraphic pictures of late Quaternary changes within the region. The incorporation of palynological research into the study of several marine cores has also provided a good connection between marine and terrestrial environments. However, concern has

been expressed (see Hope, this volume, for example) of the degree to which marine pollen records, divorced from source vegetation, can provide an accurate picture of changing environments on land. This question is addressed in the paper by Van der Kaars, who provides a valuable overview of the modern patterns of pollen representation in core-top samples from a range of marine sites in southeastern Indonesian waters. These data, in addition to helping to refine interpretation of marine records, also introduce information on dispersal characteristics and source plant ecology of many pollen taxa recorded in subsequent papers that are derived from the study of terrestrial environments.

The next six papers will provide new insights into late Quaternary, low altitude environments within the Indonesian region from a number of different islands and settings. A landscape approach is adopted for Halmahera (Suparan et al.) and this illustrates the complexity of processes that has operated throughout much of tectonically and volcanically active eastern Indonesia during the late Pleistocene and Holocene. Palynology plays a minor role here, but it is prominent in the other contributions which, from different types of sedimentary basins (a tectonic lake in North Sulawesi (Dam et al.), a volcanic crater in West Java (Van der Kaars et al.), a solution hollow in ultramafic rocks in South Sulawesi (Hope), an inland peat forest in West Kalimantan (Anshari et al.) and a coastal peat forest in Singapore (Taylor et al.) provide a remarkably consistent picture of climate change. It is clear that precipitation was reduced substantially during the Last Glacial Maximum, extending to the beginning of the Holocene, to the extent that rainforest cover was reduced, probably in all except currently the most humid parts of the region, and grasslands were greatly expanded. At two sites (Lake Tondano, North Sulawesi and Rawa Danau, West Java) diatom records generally reinforce and refine moisture variability estimates derived from sedimentary and pollen evidence. Although there is some equivocation expressed about temperature changes in one or two individual records, the fact that all five records indicate greater representation of higher altitude taxa during the late last glacial period provides strong evidence for temperature lowering during this

period. It is likely also that montane elements formed a component of lowland forests as proposed by Colinvaux et al. (1996) for the Amazon region of tropical South America. The Singapore site of Taylor et al. also indicates that, in contrast to the widely accepted model of coastal peat forest development in the Indo-Malaysian region, climate, rather than hydrosere succession, can be the dominant influence.

The impact of people on the landscape is very evident in lowland records within the last few thousand years, although the record from South Sulawesi indicates that this was not universal. The presence of charcoal through all records, indicates that fire has been a feature of the dynamics of rainforest but, considering that *Homo sapiens sapiens* are likely to have been present for at least 60,000 years, the oldest inferred age for any of the sequences, it cannot be established that fires would have occurred naturally in the rainforest.

Disturbance provides some focus for palynological contributions from highland Indonesian sites. It is the major theme of the paper by Flenley and Butler who examine a range of potential causes of rainforest disturbance, in relation to biodiversity, in a submontane environment within Sumatra. They conclude that people have been a major 'disturbance agent' over the recorded last 7000 years but have had little influence on forest diversity. The 1400 year record of Pudjoarinto and Cushing from the Dieng Highlands of Central Java provides valuable information on landscape change that complements historical records, and incorporates an intriguing story of the impact of environmental change on human activity.

Penny provides the first substantial Quaternary pollen record for the Indochina region and, although there are problems with continuity of sediment accumulation and dating, the alternation of tropical and temperate vegetation components allows realistic estimates to be made of temperature changes. The last glacial period, extending back to at least 40,000 years B.P. was clearly cooler than the Holocene, and probably drier. Unlike possible geomorphic evidence from the region, there is no evidence of significant drying during the Last Glacial Maximum and it is possible that conditions were too dry for the period to be represented, a situation common to many

parts of the world. There is good evidence, both from pollen and charcoal, of the impact of people from the mid Holocene, and this impact is detailed for the late Holocene in the study of Boyd and McGrath.

Interpretation of charcoal records has been problematic for many of the contributors to this volume and others. In a novel analysis, Haberle et al. produce a regional pattern of charcoal representation from an amalgamation of charcoal frequency curves from 10 sites in the New Guinea–Indonesia region. They conclude that although people are an important cause of fire, rapid climate change during the last glacial-Holocene transition and increased climatic variability within the last 5000 years were important influences on fire activity over the last 20,000 years.

Longer term perspectives on Quaternary environmental change are provided by the fossil vertebrate studies of van den Bergh et al. and Storm that have a more sustained history of research in lowland Indonesia than palynological studies. Van den Bergh et al. provide a fascinating and authoritative overview of changing biogeographic patterns and evolutionary changes in Quaternary fauna of the region related to tectonic history as well as changing climate and sea levels. In the absence of continuous records through much of this period, environmental interpretation is inevitably based on the ecology and biogeography of the vertebrate taxa in the, relatively few, recorded vertebrate assemblages. There is consistency between environmental reconstructions in the late Quaternary where both vertebrate and pollen evidence is available, but there is a clear need for a more substantial chronostratigraphic and palaeoecological record to provide a full understanding of vertebrate patterns. The focus (by Reis and Garong) on late Quaternary vertebrates from Palawan Island, formally part of the Philippines but most likely attached to Borneo during lowest sea level phases, is an encouraging development, in terms of application of existing information on late Quaternary environments to explanation of vertebrate assemblages and distributions. Storm makes very good use of available palaeoenvironmental and evolutionary data from the Indonesian region, and elsewhere, to provide a new perspective on the topical question of the evolutionary history of humans in Australasia.

The contributions to this issue clarify late Quatern-

ary patterns of climate change. They demonstrate that lowland Indonesia experienced substantial climate change and that these changes were compatible with those suggested from the highlands, and from the higher latitudes of the South-East Asian mainland. Pollen analysis is shown to be central to palaeoenvironmental elucidation, alleviating any remaining concerns that it cannot be applied usefully to resolution of regional change in lowland equatorial rainforests. However, there is some concern that there are still many unidentified pollen taxa and taxa that do not contribute ecological information. Consequently there is need for a great deal more research into species structure and composition of lowland forests and into pollen morphology before palynology is able to achieve its full potential in these environments. The importance of associated geomorphic, sediment facies, pollen and diatom studies are also demonstrated. In contrast to pollen, diatom identification is not a major problem, although there needs to be a major effort to construct a modern diatom/water quality/ecology data base for the region to allow refinement of diatom interpretation.

A variety of different site types have contributed to the production of the regional picture. This is encouraging for the task of finding suitable sites to fill in the great deal of local variation that will be present in this vast, and still largely unexplored, area. Many of the records produced could also be extended, as few actually reach to the base of the sedimentary deposits. Priority should be given to the extension of records from those sites that are accessible to heavy coring gear, in order to establish a firmer framework for assessment of the timing and degree of human impact on forest systems, and for refinement of interpretation of vertebrate and early human assemblages, in relation to environmental change, within the early- and mid-Quaternary.

The potential for determination of major human impact in more recent times, in relation to historical and archaeological data, has been demonstrated here. This needs to be complemented by high resolution palaeoecological studies of the last few thousand years, to provide a basis for determination of the rates, nature and causes of landscape changes that have clear relevance to future management and climatic prediction issues. Again, there are very suitable sites for such studies.

## Acknowledgements

We thank the following, most of whom have active research interests in the southeast Asian region, for the benefit of their expertise in reviewing the manuscripts: Anne-Marie Aucour, Rick Battarbee, Nick Branch, Raymonde Bonnefille, Yves Coppens, Ed Cushing, John de Vos, John Dodson, Liddie Dupont, John Flenley, Françoise Gasse, Simon Haberle, Kamaludin Hassan, Lesley Head, Henry Hooghiemstra, Fred Janssen, Stephen Jackson, Roy Larick, Bob Morley, Sarah Metcalfe, Jane Newsome, Storrs Olson, Dan Penny, Sue Page, Anne Marie Semah, Pat Shipman, Chris Stringer, Elise Van Campo, Bob Wasson, Sun Xiangjun and Azmi-Mohd Yakzan. Thanks are also due to the Faculty of Earth Sciences, Utrecht University, IPPU- Department of Palaeobotany and Palynology, Netherlands Institute of Applied Geoscience TNO and the Department of Geography and Environmental Sciences, Monash University for facilities and support.

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26 September 2000

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