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THE ORIGIN, DEVELOPMENT, PRESENT STATUS AND IMPORTANCE OF THE LOWLAND PEAT SWAMP FORESTS OF BORNEO

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The peatlands of Borneo have been classified into coastal, basin/valley and high peats. Their formation is related to past and present climatic conditions, land erosion, sediment transport and deposition, pedogenesis, fluctuations in sea level and coastal building/uplift processes. The age of tropical peat varies from around 800 years to in excess of 10 000 years. The natural vegetation of tropical peatlands is forest within which most of the tree families of lowland dipterocarp rain forest have been recorded although the canopy is lower and more open. Tropical peatlands perform important ecological, economic and environmental functions.

Keywords: Deferrification, peatland, tropical podzols

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INTRODUCTION

Tropical peat makes up approximately 10 per cent of the global peatland area of which some 15 million hectares occurs on the island of Borneo (Brunei 10 000 ha, Kalimantan 13 000 000 ha, Sabah 90 000 ha and Sarawak 1 500 000 ha), although present estimates are inaccurate and confusing (Andriesse 1974, Driessen & Soepraptohardjo 1974). Most occurs in lowland coastal and sub-coastal locations inland of mangrove swamps.

Tropical peat, unlike that of temperate and cold parts of the world which is formed mainly from the remains of low-growing plants (*Sphagnum* spp., *Poaceae, Cyperaceae* and *Ericaceae*), is derived from forest trees. In contrast to temperate peatlands, few detailed investigations have been carried out on the genesis, evolution and ecology of tropical peat swamps; in spite of this lack of knowledge they are being drained and developed, often with disastrous consequences.

World attention is now focused upon peatlands globally because they are major stores of carbon with implications for climate change. Although the proportion of carbon dioxide entering the atmosphere from peatland degradation and destruction is small compared to other fossil sources it is increasing, especially in the tropics (Armentano & Verhoeven 1988, Matthews & Fung 1987).

THE PRINCIPAL PEAT TYPES OF BORNEO

There are three major types of lowland peatland on Borneo (Figs. 1, 2) (Sieffermann et al. 1988) which are distinguished by their location, mode of formation and radiocarbon dating. Two of these (basin or valley and coastal peats) have formed in shallow depressions 1–10 m above mean sea level. The third type, high peat, occurs in slightly more elevated, watershed situations, 15–50 m above mean sea level, overlying sandy, often deeply podzolised soil mineral material. The origin and development of these peats is related to past and present climatic conditions, land erosion, pedogenesis, fluctuations in sea levels and

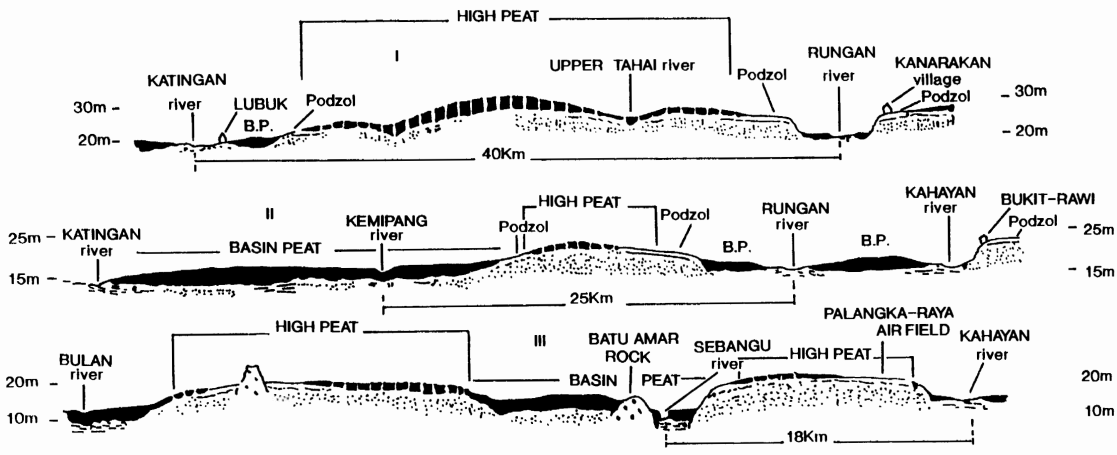

Fig. 1. Cross-section through peatlands in Central Kalimantan, Indonesia (after Sieffermann et al. 1988).

coastal building and uplift processes. The maximum depth of tropical peat deposits has been reported to be 20 m (Whitten et al. 1987).

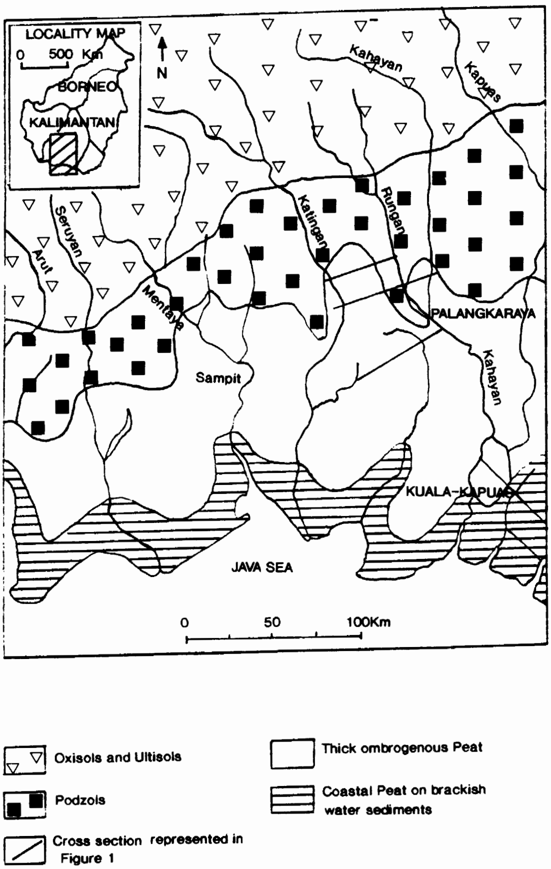

Fig. 2. General soil type succession in Central Kalimantan Province, Indonesia (after Sieffermann et al. 1988).

VEGETATION OF BORNEO PEATLANDS

The vegetation is low altitude, low canopy forest (Anderson 1964, 1976) within which most of the tree families of lowland evergreen dipterocarp rain forest are represented (Whitmore 1984). Anderson (1983) describes a catena of six forest types from the edge to the centre of Sarawak peat swamps which forms a concentric vegetation zonation related to different ecological conditions (Table 1). There is a general reduction in the number of tree species per unit area and their height from the edge to the centre. In contrast, there is an increase in the number of tree stems per unit area except in the centre where the forest is often highly degraded.

CHRONOLOGICAL RELATIONSHIPS AND ORIGIN OF BORNEO LOWLAND PEATLANDS

Radiocarbon dating of peat samples from Sarawak (Wilford 1960, Anderson 1964), Central Kalimantan (Sieffermann et al. 1988) and West Kalimantan (Diemont & Supardi 1987) show variations in the dates of origin from 800 to 4575 y BP for basin and coastal peats. High peat is much older (over 9 000 yBP) (Rieley et al. 1992). Close to the surface, however, high peat has been dated between 4 790 and 6 000 B.P. indicating that the surface layers have disappeared through progressive degeneration and oxidation of the top deposits at some time during the last 6 000 years. It is possible that high peat continued to form during the period of initiation and rapid

Table 1. Summary of the phasic communities in the catenary sequence of forest types on peat swamps in Sarawak (after Anderson 1983).

Catenary type	Vegetation community	Structure/physiognomy
1	*Gonystylus–Dactylocladus–Neoscortechinia* association (mixed swamp forest)	Similar to lowland dipterocarp evergreen forest on mineral soils
2	*Shorea albida–Gonystylus–Stemonurus* association	Similar to Type 1 but dominated by scattered, large trees of *Shorea albida*
3	*Shorea albida* consociation	The even, upper canopy (45–60 m) is dominated by *Shorea albida*
4	*Shorea albida–Litsea–Parastemon* association	Dense, mainly even-canopied forest composed of relatively small trees (medium pole forest)
5	*Tristania–Palaquium–Parastemon* association	Transitional between Types 4 and 6
6	*Combretocarpus–Dactylocladus* association	Resembles savannah woodland or heathy forest (low pole forest)

accumulation of coastal and basin peat and only ceased when the climate became drier some 2 500 yBP (Fig. 3).

The fastest rate of accumulation of coastal and valley peats was 20 cm per 100 years some 3 000 years ago (Diemont & Supardi 1987). High peat accumulated most rapidly between 8 000 and 7 000 yBP at a rate of 24 cm per 100 years (Sieffermann et al. 1988).

ROLE OF TROPICAL PEAT IN CARBON CYCLING AND CLIMATE CHANGE PROCESSES

Globally, there are between 388 and 408 million hectares of peat with an estimated carbon store of 70×10^3 million tonnes and a carbon accumulation rate of 0.02–0.06 Gt per year (Immirzi et al. 1992).

Tropical peatlands (approximately 10% of the world resource) are under threat owing to both natural oxidation (cf. high peats) and human interference through land drainage prior to utilisation for agriculture, energy or horticulture. Any major disturbance to peatlands leads to loss of carbon to the atmosphere and tropical peatlands may be contributing up to 30 tonnes per hectare per year (Armentano & Menges 1986).

DISCUSSION

There are uncertainties concerning the role of tropical peatlands and important aspects have not been investigated, especially (1) the total area of tropical peat deposits; (2) their precise roles as sources and sinks of carbon dioxide and methane under different climatic conditions and forest types; (3) the interrelationships between carbon dioxide and methane production, evolution and fixation; (4) the influence of climatic, hydrological and hydrochemical variations on the rate of carbon flux between peat and the atmosphere; and (5) the magnitudes of carbon losses in solution

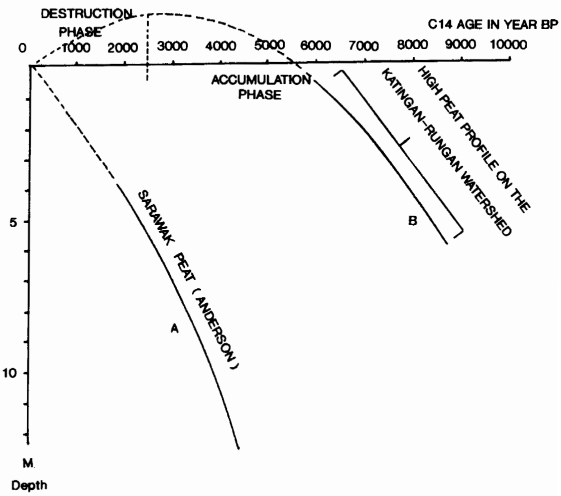

Fig. 3. Comparison of ^{14}C ages of basin peat (Sarawak, Anderson 1983) and high watershed peat of Central Kalimantan in relation to depth (after Sieffermann et al. 1988).

at present and in the past in the blackwaters draining out of peatland areas.

Peat destruction in the tropics is increasing and the potential contribution to climatic warming is considerable. The adverse chemical and physical properties of tropical peat, especially tree remains, high water holding capacity, acidity, low nutrient content and toxicity, make it an unsuitable substrate for most economic uses. Following drainage, oxidation and shrinkage can lead to waterlogging, salinity or acid sulphate soil toxicity. Already large areas of tropical peat swamp forest have been drained, settled and converted to agriculture; pilot studies have been carried out to assess the potential of this resource for the generation of electricity.

Tropical peatlands are being exploited without first evaluating the resource. There is a dearth of ecological information on, and understanding of, the species within this ecosystem or their community relationships. Little is known about the genesis, hydrology and hydrochemistry of, or nutrient cycling within this complex and vulnerable ecosystem. There is an urgent need for multidisciplinary projects to rectify the deficiencies in knowledge before these pristine peatlands are damaged irreparably.

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