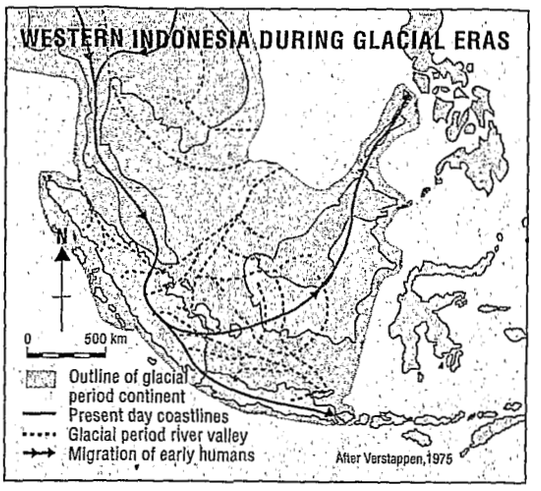
Pleistocene and Holocene Environmental Changes

Geologists refer to the last two million years as the Quaternary. The Quaternary is divided into the Pleistocene (2 million –10,000 years ago) and Holocene (10,000 years ago to the present). During this era several worldwide climatic changes called glacials and inter-glacials occurred. During the glacial periods sea levels dropped, sometimes to 100 metres below today's levels.



Sea Level Changes

A system called oxygen isotope analysis of deep sea sediments has enabled scientists to map variations in sea levels which had major repercussions on the physical geography of the archipelago. Large areas of the shallow South China Sea and Java Sea, (Sunda Shelf), became periodically dry land. In fact large river valleys can still be observed on submarine maps of the Sunda shelf. These land bridges did not extend east of Wallace's line – the natural zoogeographical barrier which separates, because of the depth of the sea, the western part of Indonesia under Asian influence from the eastern part under Australian influence. Climate (precipitation and seasonal patterns) underwent drastic changes throughout the Quaternary, as did the natural environment (palaeogeography and vegetation).

Death and Rebirth. Anak Krakatau, a new volcano, rises from the sea where in 1883 Mt. Rakata, popularly known as Krakatoa, exploded in a mighty blast. Volcanic activity in Indonesia has increased during the last two million years, and may have had a significant effect on the world's climate.

Land Bridges and Migrations

When the seas retreated they created land bridges between mainland Southeast Asia and the western part of Indonesia. These bridges allowed animals to reach as far south in the archipelago as the island of Java. By successive steps during the Quaternary era, the mammal fauna of Java was successively enriched by new species. The oldest fossil fauna, circa 1.8 million years old, yields only proboscidians (related to modern elephants), hippopotamus, and cervids (members of the deer family). Then other herbivorous mammals and several carnivores arrived. *Homo erectus* (man) probably reached Java more than one million years ago.

The fauna had to adapt to these peculiar geographic and ecological conditions. During interglacial periods, the sea level rose and the islands of the archipelago became isolated both from the mainland as well as from each other. The fauna also developed specific characteristics, exemplifying an evolutionary phenomenon called endemism. In the most extreme cases, pigmy forms could appear. Such forms are found most commonly in eastern Indonesia, especially among animals like the proboscidians (pigmy *Stegodon* or elephant) of Flores and Timor.

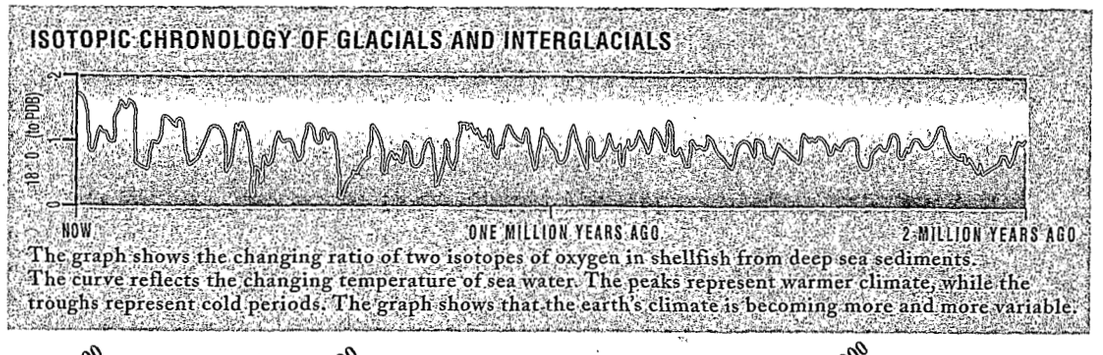
Reconstructing Prehistoric Vegetation Patterns

A useful method for reconstructing the vegetation of the past is the study of pollen grains that have become fossilised in ancient sediments. The microscopic pollen grains of each species of plant have a specific morphology which allows us to identify the plants from a particular time and region. Such studies give a good picture of the older vegetation pattern and its changes during the Quaternary. These studies also provide us with a clear picture of the climate pattern.

Humid conditions prevailed during the interglacials. Tropical rain forest covered the area, with

GEOLOGY AND HUMAN EVOLUTION

The last two million years are known to geologists as the Quaternary era. Most of human prehistory falls into the geological period known as the Pleistocene, except for the last 10,000 years which are called the Holocene or Recent.



The graph shows the changing ratio of two isotopes of oxygen in shellfish from deep sea sediments. The curve reflects the changing temperature of sea water. The peaks represent warmer climate, while the troughs represent cold periods. The graph shows that the earth's climate is becoming more and more variable.

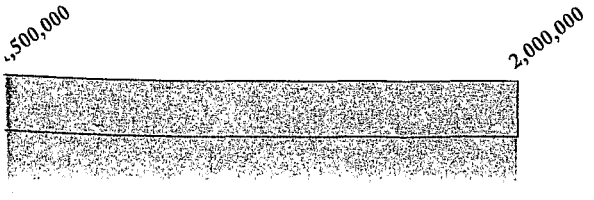
Schima and *Altingia* (shrubs), *Podocarpus* (firs) and *Quercus* (oaks).

During the glacial periods, Indonesia's mean air temperature is believed to have dropped a few degrees Celsius, while sea temperatures, as inferred from recent studies, would have been only two degrees lower than today. This cooling, however, was enough to cause a downward shift of vegetation zones on mountains: trees like *Podocarpus imbricatus*, which presently grow only higher than 2,000 metres above sea level could be found at lower altitudes. But the main change during these glacials related to the precipitation pattern: the dry season was longer and more severe, and the tropical rain forest shrank, replaced in many areas by a more open monsoon-like forest with an abundance of *Leguminosae*, and *Mimosaceae*. Grass-lands developed during those drier periods and several studies even give evidence of the existence of *Gramineae* (grass)-dominated savanna-like environments in Kalimantan and Java. The vegetation had a mosaic-like character at such times, as rain forest galleries persisted along the rivers and also on the upper parts of the mountain slopes where the climate was constantly wet.

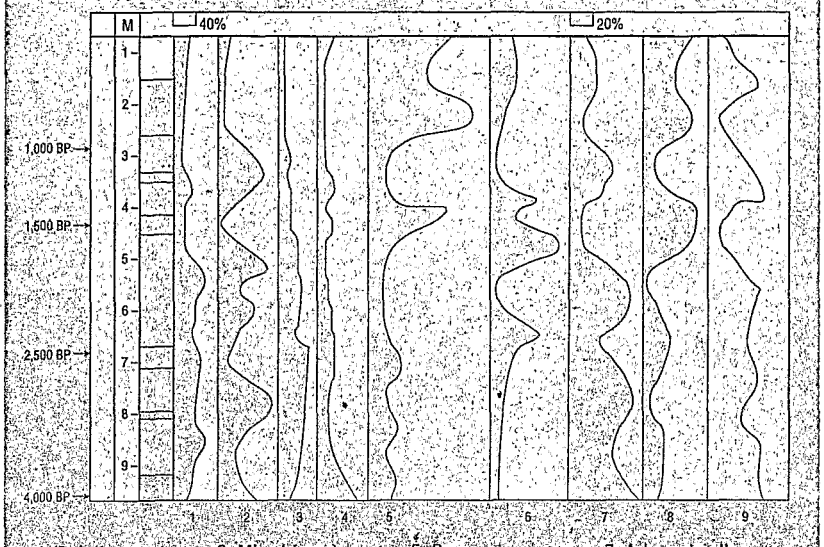
Palaeoenvironmental evolution was not only affected by climatic changes. Geological phenomena like volcanic eruptions also deeply changed the landscape. These eruptions periodically disturbed the vegetation and led to the colonisation of the mountain slopes by pioneer plants. At the same time, tectonic uplift – which has given Java its present shape – also caused great changes in the landscape. As the sea receded, large mangrove and swamp forests were created on the lowlands of Java, only to vanish as they were filled in by the products of volcanic eruptions and erosion.

The First Humans and their Environment

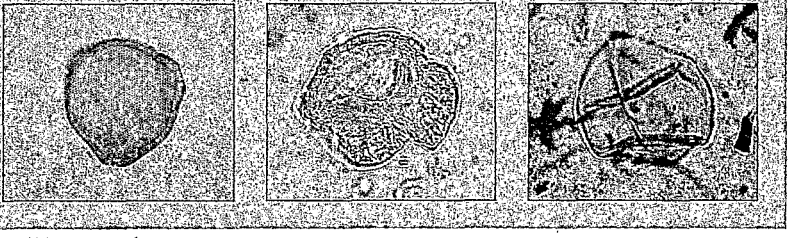
Pithecanthropus (the scientific name given to Javanese fossil hominids) were the first humans to cross the equatorial area. As the sea levels rose and fell he became – periodically – an islander. Human evolution on Java lasted approximately one million years. These early humans had to adapt to a frequently changing environment, which is likely to have deeply influenced their subsistence and culture. How did they use the natural resources offered by the rain forest? Did they develop a unique culture in such an unusual environment? Current studies are attempting to correlate palaeoenvironmental reconstructions with other aspects of prehistoric life, including the use of stone tools; vegetal resources like bamboo; and the significance in terms of diet of wear features on the fossil teeth such as striations and enamel chips.



EVOLUTION OF THE LANDSCAPE IN THE AMBARAWA BASIN DURING THE LAST 4,000 YEARS BP



The pollen record of a Holocene core from the Ambarawa swamp, central Java, gives evidence of several recession periods of the swamp forest. The base of the core (carbon 14 dating gives 4,000 years BP) reflects a severe dry season (See Open Forest Curve). During the second event (1,500 years BP) the trees almost disappear. This event probably reflects the first clearing activity in the area. The last event, which postdates the 13th century, is likely to represent human colonisation of the Ambarawa plain and the beginning of intensive agriculture (rice fields). *Pollen Grains (below left to right): Casuarina* (*Cemara* or filao tree) pollen grain; *Podocarpus imbricatus* pollen grain; *Poaceae* (grass) pollen grain.



The Upper Pleistocene and Holocene Environmental Changes

The Pleistocene–Holocene transition corresponds to the most recent major climatic change from glacial to the interglacial conditions which persist today. Pollen analysis has been widely used for research into this era and gives excellent results for such a period of changing climate; the study of pollen preserved in lake and swamp deposits, together with good chronological control of carbon 14 dating, enables scientists to put together a detailed picture of paleo-environmental evolution. The precise quantification of vegetation zone shifts between higher and lower elevations indicates the magnitude of the decrease and increase in temperatures in Indonesia during the glacial event. The influence of man upon his environment during the later periods of prehistory is also reflected in the pollen diagrams.

Stilt Roots of Mangrove mucronata, Sungai Sembilang, South Sumatra.

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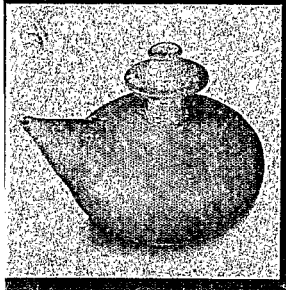

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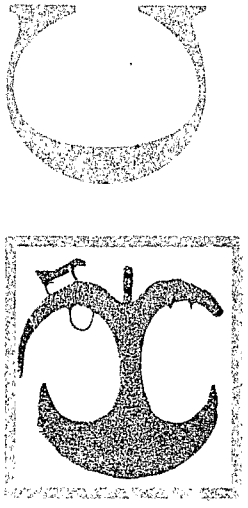

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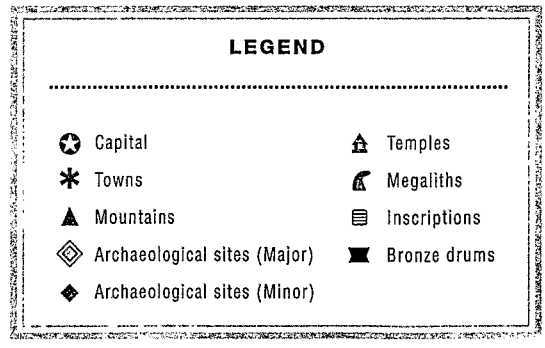

Note: This legend applies to all the maps in this volume.