Palaeoecology (with specific reference to Southeast Asia and the archaeological context)

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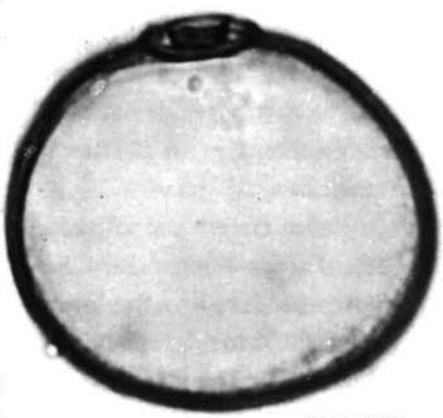
Palaeoecology is the study of the ecologies of the past and is increasingly used by archaeologists as a means of reconstructing the former environments. It is one of a range of techniques comprising environmental archaeology. Others include the study of fossil soils.

The examination of fossil bone material had an early origin in Southeast Asia with the work of Dubois published in 1894 first on dog bones (Barnes 1996), then on hominid bones, from the caves of central Java. Palaeoecological techniques have thus been used to trace human and animal evolution. Animal remains were also used to reconstruct the kind of vegetation environments in which hominids lived and evolved. So too were macrofossil remains of plants, principally leaves. Later (Polak 1933) came the examination of microfossils, initially of pollen, as well as the readily visable plant fossils embedded in peat bogs.

Pollen is the male reproductive part of the flowering plants and ranges in size from less than 5 microns to over 200 (a micron is a thousanth of a millimetre).



rice pollen

Most recently (Kealhofer and Piperno 1994; Kealhofer 1996) there has been growing concentration on the microfossil silica (**phytoliths**) which accumulates within various parts of some plants. This is particularly valuable in tracing the history of the grasses, for rice pollen (see above) cannot be readily distinguished from that of the other grasses, nor can bamboo pollen (Maloney 1994); and bamboo is a very important plant within the context of prehistoric people in Southeast Asia as it has a vast range of uses.

Phytolith analysis is complementary to pollen analysis in the wider reconstruction of past environments. However many plants which produce abundant pollen, the rhizophoras of mangrove environments for instance, do not produce phytoliths, but other mangrove plants, fortunately, do. Very close identification is not possible within the palms though as most species produce circular, spiky phytoliths which can only be distinguished as from palms, but no further. In contrast, the pollen analyst can distinguish the pollen of the sugar palms (*Arenga and Borassus*), of the coconut, and of various rattans, but even in these cases it is not normally possible to say if the pollen is cultivated or tended palms. The coconut is a possible exception because the range of wild coconuts is so restricted. A single pollen grain of *Cocos* was present in early contexts in the pollen record from Khok Phanom Di (Maloney 1991) but it is not feasible to argue that it was from a cultivar using a single occurrence and the early age suggests that it is from wild coconut. As yet nobody has studied the pollen of wild and modern coconuts to see if the cultivar differs. It might, it might not.

Unfortunately, because of peculiar the way in which the banana reproduces, it is not usually likely to produce pollen. Furthermore the pollen is large and has a very thin outer wall, or exine, so despite recent claims from Pacific contexts, it is unlikely to be preserved. The same is true of yams pollen, while on the rare occasions when taro pollen is present, it cannot be claimed to be from a cultivated plant because taro normally reproduces vegetatively; it does not flower. So, as with phytoliths, the pollen of some plants does not preserve, and that causes problems in interpreting the fossil record.

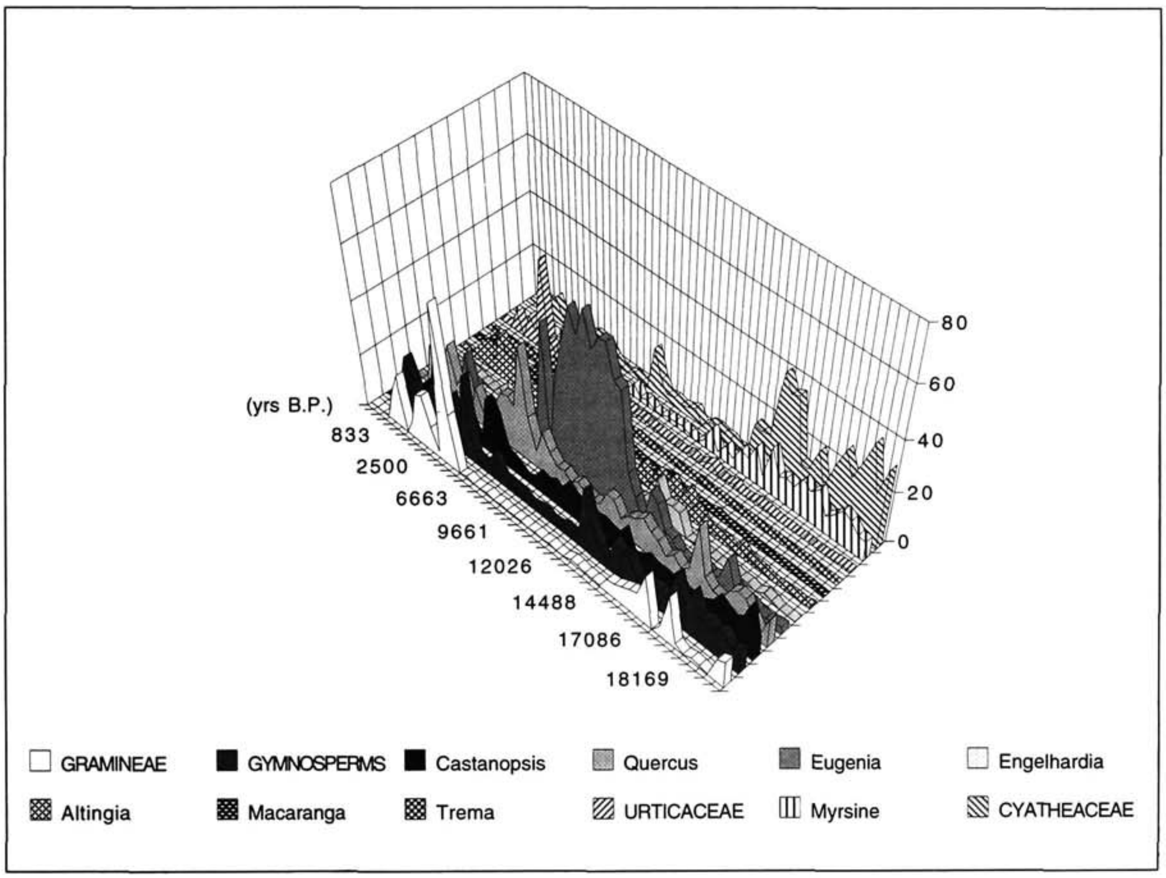
Some plants, in particular the montane trees such as oak and the tropical chestnuts are wind pollinated, and these **wind pollinated** plants dominate tropical highland records because they produce a large number of easily dispersed pollen grains. Many highland grasses are like rice, they are self-pollinating, so not much pollen is produced to be released and dispersed by wind, or, indeed, by water. In the lowlands a large number of the grasses are wind pollinated, and they tend to dominate the fossil record there, e.g. that of Lake Kumphawapi in northeast Thailand (Penny *et al.* 1996). Some of the coastal mangrove plants produce vast amounts of pollen, *Rhizophora* for instance, so they dominate the records. This was the case in my diagrams from near Khok Phanom Di. Other plants are insect pollinated, the legumes for example, and these do not contribute strongly to the fossil record at all.

Pollen analysts and palynologists also count and identify the **spores** produced by the lower plants, the ferns, lycopods and selaginellas. The identification of both types of microfossils is made by comparison with properly identified specimens from modern plants. Spores also have a reproductive function, but it differs from that of pollen. Every single spore can be regarded as a potential new plant. As soon as the spore pod ripens and bursts open, the spores fall to the ground, or are transported locally, probably by water, and new plants may arise directly from these. In a few cases, however, spores are transported over longer distances by wind and water. Those of the tree ferns are the main example. The abundance of tree fern spores in montane Southeast Asian pollen diagrams indicates that the vegetation was of sub-alpine type, and bracken spores also suggests disturbance. Bracken can reproduce vegetatively, like the root crops, and this may be its main means of reproduction, but it can suggest regrowth following burning. To detect evidence for burning more reliably, the palaeoecologist must look for fossil charcoal or microscopic charcoal and count this too. But here the phytolith analyst has a strong role to play, because phytoliths sometimes take up carbon given off during burning and this discolours them. So, it is possible to say if grasses, for instance, have been burnt, and it will require experimental work to determine at which temperature phytoliths begin to take up carbon. Then it might be feasible to say at what time of the year the burn is likely to have occurred.

Recently, and purely by chance, when counting additional pollen from a sample from Pea Sijajap, a pollen record from highland Sumatra, I found a charred leaf cuticle with rice phytoliths intact. This was 2500 years old. Grasses have long and short cells and most phytoliths align themselves along the long cells; rice differs - the phytoliths align themselves across the short cells, so we can distinguish rice phytoliths from those of other grasses, but it is far more difficult to say if we are dealing with phytoliths from wild or cultivated plants.

What the pollen analyst does is to count and identify at least 200 pollen grains (preferably more) from each sample that pollen has been chemically extracted from, then draw graphs of the percentages or absolute numbers of pollens, phytoliths, or microfossil charcoal particles present in each. In the rare cases where pollen is preserved at archaeological sites or material found at those sites, such as fossil faeces, only one sample may contain pollen, so the diagram is simple, but where pollen is preserved in a peat bog, lake mud, or estuarine clay, as series of samples often taken at 10 cm. intervals is counted and a diagram is produced showing all the graphs on a time basis from the base upwards. This diagram usually show a series of changes which relate to vegetation changes. Often now these diagrams are computer drawn, but all the existing programs are difficult to use where large numbers of pollen types occur. My 30,000-year old record from Pea Bullock, north Sumatra, contained around 350 types in counts of 90,000 pollen grains from 70 samples, but this is extreme. It is easiest to graph up the main types (see graph below) and to tabulate the rest.

The problem is to interpret what the changes mean: are they a result of climatic change, natural change of vegetation, for instance in a mangrove as a result of plant succession, or disturbance by volcanicity or by man? To be able to interpret the changes the pollen analyst has to be quite a good plant ecologist and to assess the variations in terms of probabilities (**Baesian logic**). This is the most difficult task of the pollen analyst: there is no right or wrong answer. Interpretation



depends upon how experienced the pollen analyst is and how many other diagrams there are to compare with.

In a short article like this it is impossible to evaluate the range of palaeoecological and related techniques of environmental archaeology which can be used to detect the past activities of people, but it is hoped that it has been both informative and interesting. ■

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