Pollen Analysis :

An appraisal of the potential of limestone caves and sediments (from areas of calcareous drainage)

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As there is now increased interest, both from within and outside Thailand, in the potential of pollen analysis for tracing past human activities, it is probably timely to examine the potential of cave sediments and sediments from areas of calcareous drainage in general for palynology. The Lang Rongrien cave (Anderson 1988; 1997), a cave site with a long occupation sequence, offers this opportunity, while the macrofossil plant remains from Spirit Cave (Yen 1977), which have been the subject of much debate, continue to raise interest.

A cave in Trat province.

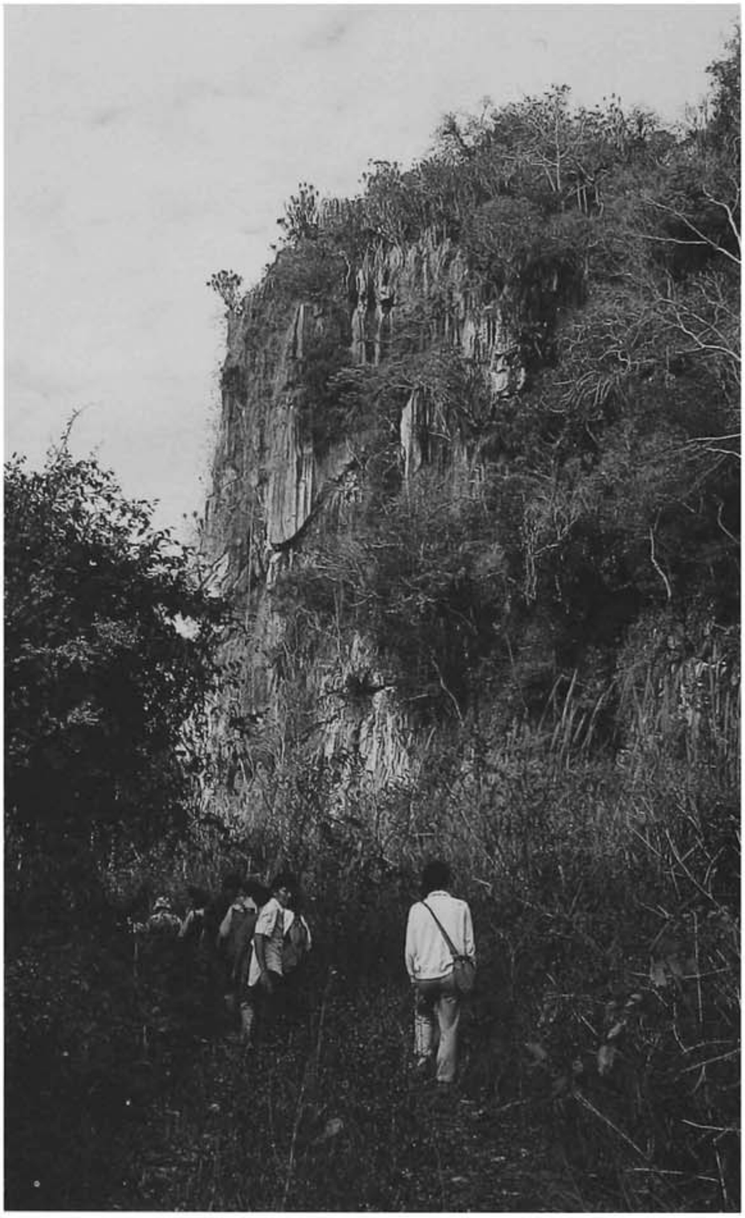
Firstly, areas with calcareous drainage, unless the sediment has accumulated very quickly, are not good places to try and recover pollen from. Where there has been rapid accumulation, the pollen content of sediments will be diluted, but with careful chemical pretreatment high resolution sequences might be obtainable. So far, pollen has been recovered from only two caves in Southeast Asia: Niah, and Mulu, both in Sarawak, but the pollen (of mangrove) found at Niah was embedded in marine sediment deposited within the cave, not in cave sediment (Muller 1972: 33 [response to questions]).

Pollen has been extracted from a single sample of possible Pliocene age from c. 1050 m altitude from Hole in Time cave in the Clearwater Cave complex at Gunung Mulu. This, and six other samples, with ages ranging from c. 2.9 m years ago to quite modern, also contained phytoliths (microscopic plant silica), in the case of the sample with pollen, including those from grasses. Some of the phytoliths had carbon inclusions, thereby proving that the vegetation had been burnt. Pollen was not abundant but Meliaceae (tree) pollen was the most frequent. This information has not been published before because the sample was the only one of those submitted for analysis, which had not been collected by the University of Bristol's Dr. Peter Smart, so he could not guarantee that it was uncontaminated by modern pollen. The results suggested that there had been greater climatic seasonality in the Pliocene; heresy at the time of analysis, but now more acceptable. Unfortunately no modern pollen samples were available for analysis to see what they might contain, but the fossil sample showed similarities with one from 1600 m collected at Mount Kinabalu (Flenley 1979).

Samples from Tianko Panjang, the oldest archaeological site in Sumatra (Bronson and Asmar 1976), and the excavation square at Khok Phanom Di, Ban Don Tha Phet and Tha Kae in Thailand have been examined for pollen in the past. The three sites are not cave sites; the last two sites are in areas of calcareous drainage, and Khok Phanom Di had shell inclusions.

Some pollen was present in the samples from Tha Kae, which may indicate that there was rapid sediment accumulation, although there was not enough to concentrate sufficiently to obtain statistically valid counts. Areas of limestone drainage are associated with oxidizing rather than reducing conditions, thus the pollen flora may be biased toward types more resistant to destruction by the air, i.e. there may have been selective preservation of pollen and all the fragile types may have been lost. This would have made interpretation of the results extremely difficult, especially without field knowledge of the existing vegetation, in terms of vegetation change, and from this deduction about plant succession, climatic change and the impact of people on the vegetation. Most samples, therefore, remain in my deep-freeze but may be re-investigated at some time in the future if preparation techniques improve, and the writer has the opportunity to visit the field area.

Limestone outcrops (in Trat province) which contain cave sites

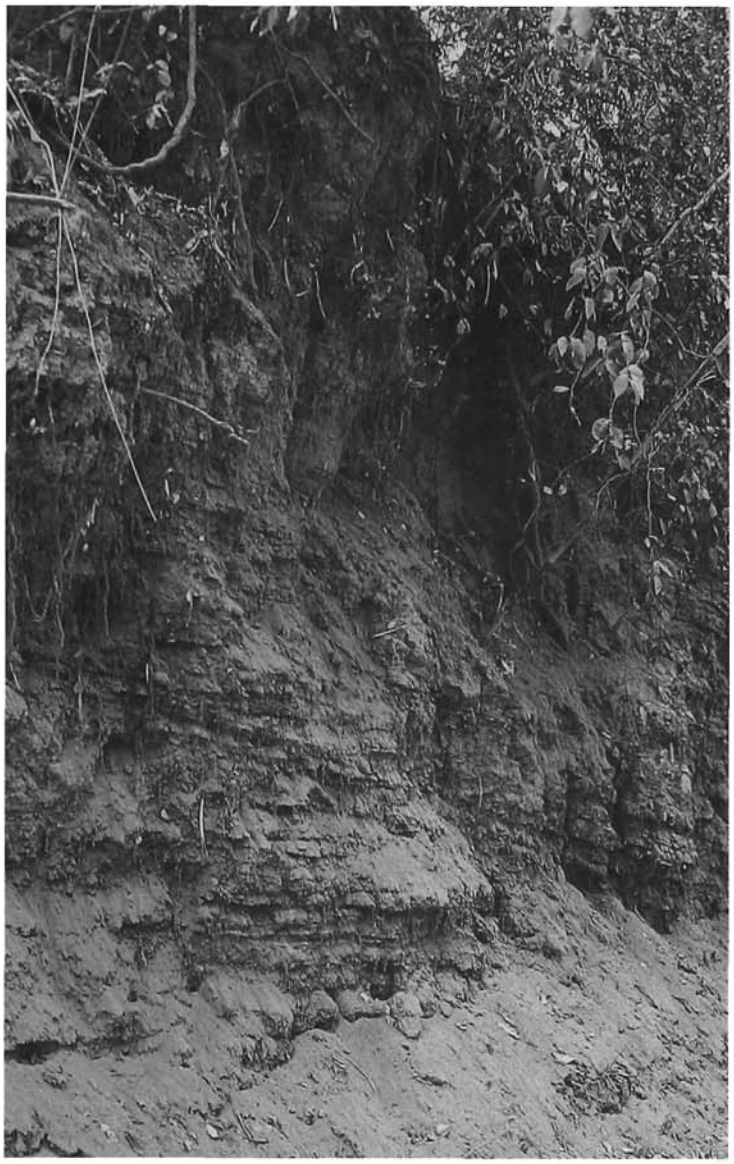


The samples which were prepared were treated with hot hydrofluoric acid, so any siliceous material would have been destroyed. Those from Khok Phanom Di were not treated with HF and contained phytoliths, sponge spicules, diatoms (all composed of SiO^2), and infrequent vermilion coloured clay minerals, as well as partly oxidized organic material. Investigations of this sort, which can be carried out without elaborate chemical pre-treatment, are now given the fancy name of **facies analysis**!

The intent here is not to throw the baby out with the bath water by saying that pollen does not normally preserve in limestone areas, although the baby might need to be thrown out later. More research is needed to assess the viability of cave pollen analysis in tropical areas, and such research needs encouragement. It may prove to be successful, and we will not know until we try. What would be interesting is to analyse any guano that may be present as this is likely to be composed of fruit bat droppings, and its pollen content could give an indication of which fruit trees were nearby.

Dunn (1964) mapped guano deposits in the vicinity of the Gua Kechil site in Pahang, Malaysia. Such material may also be amenable to radiocarbon dating, using atom counting methods. Anderson (1997) deplored the activities of phosphate collectors but environmental archaeologists could profitably become phosphate collectors.

Analysis of cave sediments from limestone areas has sometimes met with success in temperate areas, e.g. at Kirkhead Cave in the English Lake District (Gale *et al.* 1984), Marble Arch Caves, Co. Fermanagh, Northern Ireland (Jones and McKeever 1987), and Coolarkin Cave in the same county where phytoliths (Thompson and Maloney 1993) were also abundant. The Belgians, too, have recovered pollen from flowstones, from stalactites which grow downward from the roofs of caves, and stalagmites growing upward from the cave floors (Bastin 1978).



Khok Phanom Di : a shell midden seen in an uncleaned up road section.

If pollen is preserved, there are problems of deciding what it means, quite apart from the difficulties which arise as a result of possible partial oxidation of the sediment. Principally, we need to know about **taphonomy**: how the pollen, phytoliths, etc. got there. If the sediment is derived from near the cave mouth, the pollen might have blown in, or been carried short distances by insects, and might reflect the composition of the local vegetation quite accurately. Otherwise, as at Mulu, it is likely to have been brought in by water percolating downward through the limestone or by subsurface streams. Regrettably, interpretation of pollen diagrams from limestone areas is not at an advanced stage as so few have been published.

Sediments from limestone areas are difficult to radiocarbon date unless atom counting techniques are used, but pure flowstones can be radiometrically dated, using uranium series methods. Indeed some Southeast Asian flowstones have already been dated by this method (Smart *et al.* 1984). Unfortunately, where they contain sedimentary inclusions the level of these impurities may be too great to allow dating. Dated flowstones provide very useful palaeoclimatic information because they only form under wet conditions (Atkinson *et al.* 1978). In recent years, they have been extremely valuable in establishing the ages of European interglacial periods. Flowstones are preserved when interglacial materials from the surface have been eroded away by later ice advances.

Let us finally look briefly at the macrofossil plant evidence from Spirit Cave from a pollen point of view, disregarding those taxa for which identifications are very uncertain. Yen (1977) reported the remains of the candlenut, *Aleurites*. This plant had not been found in a local forest survey and Yen hints that it may have been brought in from coastal areas a considerable distance away. The pollen is large, distinctive, but has not been reported fossil from any Southeast Asian pollen site, nor has it been recovered from surface samples. On the face of it, this is depressing, but no attempt has been made to concentrate larger, rarer pollen grains by selective sieving (use of a mesh which allows small pollen grains through but traps larger ones) during preparation, and this may be necessary to recover such pollen taxa. Of course this biases the sample count, so two preparations are needed; one to give a general impression of the vegetation, and the second to concentrate the larger pollen grains for counting and identification. Diatom analysts already do this to provide more detailed information.

Pollen grains of Trapa natans

Aleurites is used for its edible seeds, and for its oil, so is *Canarium*, another of Yen's plant macrofossil types. A *Canarium*-type pollen occurs in highland North Sumatran pollen diagrams (Maloney 1996) and, apart from Spirit Cave, macrofossil remains have been reported from archaeological sites ranging in distribution from Sri Lanka, Java, Vietnam, to Melanesia. However, the pollen identification is not certain to the genus, and identification at the species level is not possible. There are indications, though, that *Canarium* might have been on the path to domestication by 14,000 B.P. in lowland northern Papua-New Guinea and offshore islands of Melanesia. It is a tree which might have been selectively conserved during periods of anthropogenic deforestation, but Yen (1977: 574) noted that it was fire tolerant in north west Thailand, surviving burning during swiddening. The pollen of *Madhuca*, a tree in the Meliaceae family, and a possible source of poison (Yen 1977: 575) cannot be distinguished from that of other genera in the Meliaceae found in Thailand. Similarly,*Terminalia* pollen cannot be reliably separated from *Combretum* and many taxa in Melastomataceae, nor can *Prunus* from other genera in Rosaceae or *Castanopsis* from *Lithocarpus*. *Celtis* pollen occurs in the records from various Thai pollen sites, and two types are recognisable, but species identification is not possible.

The Gua Chawas archaeological site, Kelantan, Peninsular Malaysia, photographed in July 1998 during an Indo-Pacific Prehistory Congress field-trip.

Ricinus, the castor oil plant, has been reported fossil and in recent pollen spectra from Indian sites, but the monograph on Euphorbiaceae pollen by Punt (1962) groups it under a *Ricinus* type which includes *Homonoia*.. Notably, a single pollen grain of this type occurred in the 2,20m sample from the undated Khok Phanom Di FP3 core but it also occurs at Nong Thale Song Hong and Kumphawapi (Penny *et al.* 1996), and both Penny and myself have preferred to call it a *Homonoia* type. To date, one species of each genus has been recorded from Thailand.

Areca palm pollen is rather distinctive and is present at Khok Phanom Di and the three sites so far analysed from peninsular Thailand (Satingpra, Narathiwat and Nong Thale Song Hong). There are indications from the pollen records that at times it may have been selectively conserved or deliberately planted. A more complete account of the findings from Nong Thale Song Hong will be published in the Journal of the Siam Society in due course.

It was suggested that betel chewing may have been associated with the latter part of the Spirit Cave sequence. *Piper* has an extremely small pollen grain (it is spheroidal, and about 5 microns in diameter) but occurs in the fossil pollen record from Sumatra (Maloney 1985), Nong Thale Song Hong (south Thailand), and Panama (Bartlett and Barghoorn 1973). Unfortunately, the pollen of *P. betle* cannot be distinguished from that of other species in the genus.

Cucumis, *Lagenaria* and *Luffa* all have large, three pored pollen grains, with a reticulate surface pattern (well illustrated in Ayala-Nieto *et al.* (1988)) but have never been reported fossil from peats and lake sediments. *Lagenaria*, the bottle gourd, may have been used for containers at Spirit Cave, and *Luffa* for its fruit, or as a source of cloth. However, Cucurbitaceae pollen has been reported once from archaeological contexts in South America (Whitaker and Cutler, 1971) and an undated Indian quarry section (Bhattacharya and Chanda 1992).

Trapa has not been shown on published Southeast Asian pollen diagrams, but does occur at Pea Sijajap (1300m altitude) in North Sumatra. It has a large, very distinctive pollen type (Figure 1) with a crest which follows the pattern of the germination colpi), and has been found at European pollen sites (Flenley *et al.* 1975).

Momordica is often a rice field weed, but not exclusively so. Its pollen was present in recent samples from Khok Phanom Di. *Eichhornia crassipes* (the water hyacinth), which was introduced to Thailand from Java in 1901 (Kerr 1931), has a similar pollen type.

There have been numerous attempts at trying to identify rice pollen (Maloney 1990) but none of them have been successful, although Tsukada *et al.* (1986) claimed that they could identify fossil rice pollen in Japan. They do not say how, though, and the body of evidence is against them as rice is self-pollinating and does not produce pollen; furthermore, what is produced is not transported very far, except, perhaps, if it gets into drainage waters. Rice phytoliths, however, can be identified, and cultivars may be distinguishable from wild species.

So, it can be said in conclusion that pollen analysis of appropriate samples could substantiate the plant macrofossil evidence in some instance, but what is most valuable is in its provision of a more general picture of what the vegetation was like. Phytolith data is less precise in many ways, but more revealing in others. Most phytoliths cannot be identified to genera or to species but can provide very valuable evidence complementary to that from pollen; its particular strength at present is in providing more detail than is possible with grasses, and about what grasses were present. To give an example, a sample from Mulu with a magneto-stratigraphic age of 1.5m years before present contained some Chloridoid/Eragrostoid grass phytoliths, and the sample which contained pollen also included Panicoid grass phytoliths. Bowdery (1998) has recently recovered phytoliths of the banana genus and other taxa from Gua Chawas, a Hoabinhian cave site in Kelantan, West Malaysia. Banana pollen is unlikely to be found in Southeast Asian deposits because of the way in which bananas reproduce and the structure of the pollen grain: which has a very thin outer wall that can be easily destroyed.

In conclusion, pollen can sometimes be extracted from limestone cave samples and sediments from limestone areas but to achieve this, it will probably be necessary to pretreat larger amounts of sample than is traditionally the case. It is only when this has been carried out that problems of interpretation of what the fossil record can tell us may be tackled. The likelihood of being able to find pollen of cultivated plants in cave sediments is not strong, as the discussion in relation to the plant macrofossil record from Spirit Cave shows. The problem might not prove to be recovery of the pollen itself, but the ability to identify it closely enough. Phytolith analysis has greater potential for identification of remains from cultivated plants, and it is worth noting that phytolith analysts normally pretreat larger amounts of sediments than that which pollen analysts customarily pretreat.

It will only be possible to assess the potential of limestone cave deposits for pollen analysis when attempts have been made to recover pollen which has been preserved more effectively than has been the case so far. In this respect, perhaps, palynologists can learn from phytolith analysts.

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