PHYTOLITHS FROM TROPICAL SEDIMENTS: REPORTS FROM SOUTHEAST ASIA AND PAPUA NEW GUINEA

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ABSTRACT

This paper reports the potential of quick scan studies of phytoliths as a useful preliminary step in the reconstruction of climate and vegetation history. In Southeast Asia and Papua New Guinea, few phytolith analyses have been carried out. Phytolith assemblages established by quick scan methods are reported for one non-cultural site (a lake in northeast Thailand), and four archaeological open sites (Plain of Jars and Lao Pako, Laos; Pacung, North Bali, Indonesia; Kuk, Papua New Guinea). The studies reported demonstrate that quick scan analysis can indicate the range of phytolith assemblages, as well as presence/absence, in sediments. Despite the lack of comprehensive phytolith reference collections decisions can be made from these data on whether detailed analysis would be worthwhile. A quantitative analysis of phytoliths from Gua Chawas, a large limestone rockshelter in northern Kelantan, Malaysia, is also reported. Figure 1 shows the location of sites referred to in the text.

PHYTOLITHS

The presence of biogenic silica during the life cycle of a plant is dependent on the uptake of monosilic acid from groundwater, its supersaturation, polymerisation and subsequent deposition as amorphous, hydrated, polymerised silic acid at sites within the inter- or intra-cellular vegetative structure of a plant, resulting in three-dimensional positive or negative forms. The generic name for these forms is *phytolith*. After the death of a plant and oxidation of the organic component, phytoliths may remain on the ground surface to become incorporated into the soil horizon and subsequently be buried to form part of the stratigraphic matrix. Because these buried phytoliths survive well in many environments, they can inform on past vegetation and are particularly important when reconstructing economic plant resources using material from archaeological sites. Phytoliths may be deposited throughout the life of a plant, unlike pollen, which requires a mature plant to produce a pollen grain. There is only one pollen type, although some variations occur, for each species of plant, but a plant may contain many different phytolith forms. The classification of phytoliths and construction of reference collections is time consuming and they are slow to appear in published literature. However, because of characteristic structural differences between these categories (see Figure 2) phytoliths are readily classified under the broad headings of grass, tree/shrub and palm.

METHODS

A phytolith extraction process based on a method developed by Fujiwara, for sediments from ancient rice *(Oryza)* growing areas, can be used for quick scans and may be used when time is at a premium. A sediment sample is suspended in a solution of Sodium hexametaphosphate (Calgon™) and distilled water, radiated with ultra sound for 15 minutes and allowed to stand for three minutes. The supernatant is then pipetted off. The process is repeated

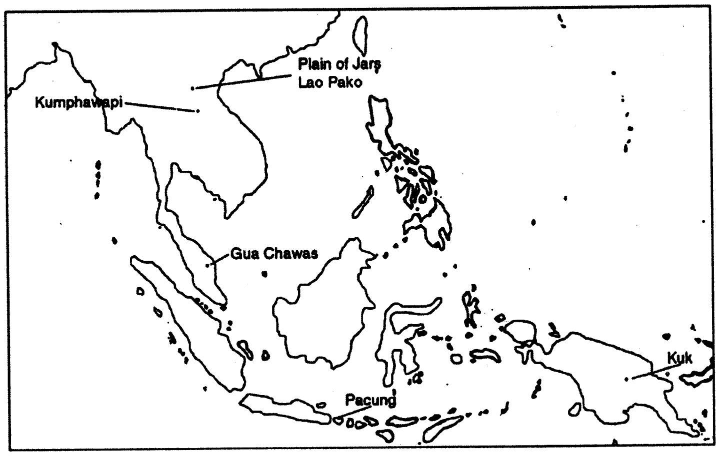
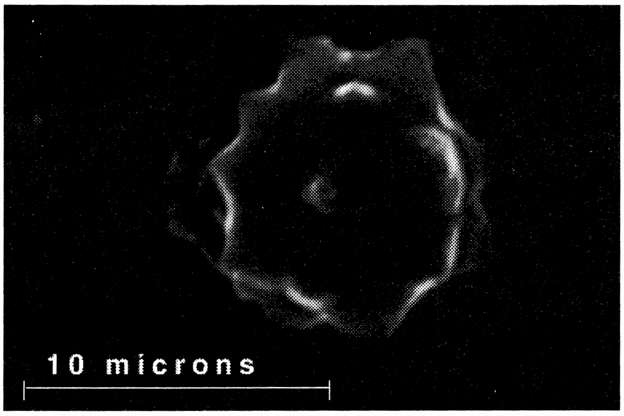
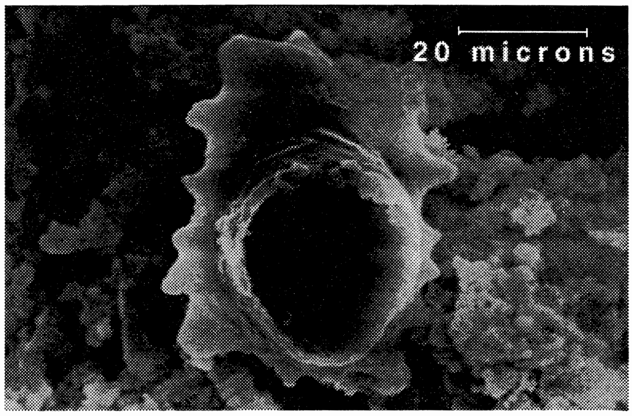


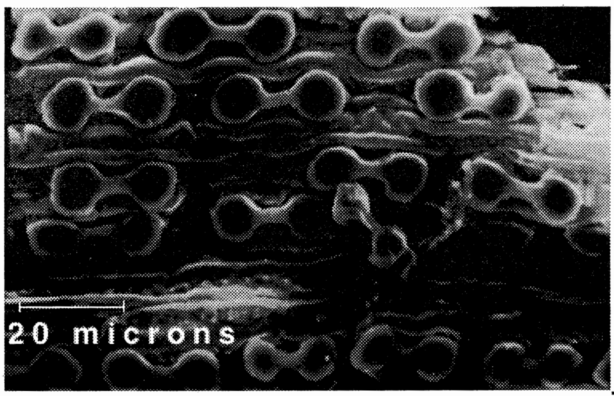
Figure 1: Location of sites mentioned in text.



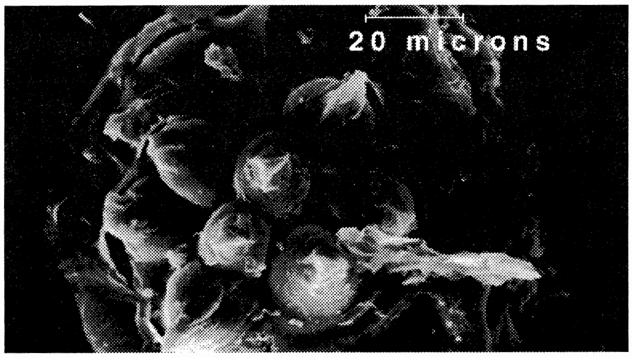
a) *Metroxylon* sp. (palm)



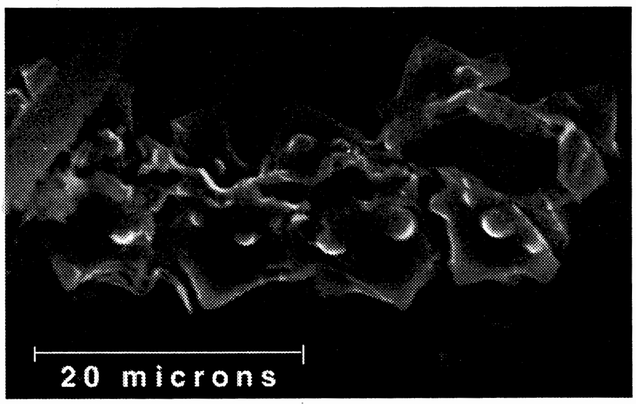
b) *Musa acuminata* (banana)



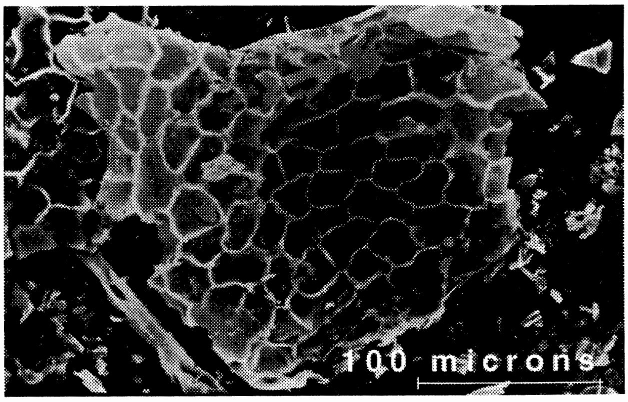
c) *Plectrachne* sp. (grass)



d) *Tetracera* sp. (sandpaper leaf tree)



e) *Fimbristylis dichotoma* (sedge)

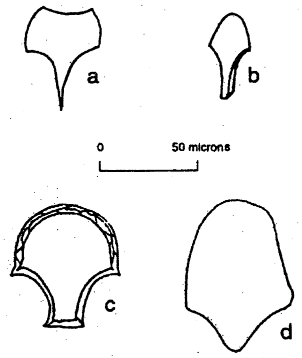


f) *Doq* (tree, unidentified to species)

Figure 2: Examples of phytolith morphology.

until the supernatant is clear of suspensions. A known amount of the remaining sediment is then mounted on a slide (Fujiwara *et al.* 1985; Bowdery 1998: Appendix 14). Small phytoliths, such as bilobes from grasses or ornamented spheres from palms, are unlikely to be recovered by this method. However, phytoliths larger than 50µ, which include many from grasses preferring a wet habitat, are retained. An alternative, heavy liquid flotation method which will extract a range of phytolith size and other microfossils, such as biogenic silica diatoms and sponge spicules, carbon particles and starch grains, is far more time consuming (Bowdery 1998: Appendix 14).

As an archaeologist I classify phytoliths extracted from sediments as an artefact assemblage and apply a morphological classification (Bowdery 1998). From this initial classification it is possible to identify phytoliths to many plant families and increasingly to genera and species. Many grasses are prolific producers of phytoliths, some of which represent readily classified forms. Broad trends in vegetation change and phytolith densities can be identified, indicating in many instances an increase or decrease in human presence at a site. Sometimes, change of phytolith size through time at a site may be attributed to an increase or decrease of water. Many grasses with a preference for a wet habitat (for example, *Bambusa, Miscanthus, Oryza* and *Phragmites)* produce a large phytolith (>50µ) which is best described as a combination of an arc and triangle (AT). (This form may also be referred to as a "bulliform" or "motor cell".) Species can be distinguished by differences in shape and ornamentation. Examples of a few AT forms are shown in Figure 3.



Key: a - *Zoysia* sp.; b -*Enneapogon* sp.; c - *Oryza* sp.; d - *Phragmites* sp.

Figure 3: Line drawings of AT phytoliths.

Cytoplasmic carbon encapsulated by phytoliths can be dated (Kelly *et al.* 1991). Prior (1998:61) reports on her protocol for AMS dating of pollen. She is also obtaining dates from phytoliths using a similar technique.

SITES

Nong Han Kumphawapi

A sediment core, KUM1, was taken by John Grindrod from Nong Han Kumphawapi, a lake in northeastern Thailand, for microfossil analysis and environmental reconstruction. I used the ultra sound method described above to extract phytoliths from these noncultural sediments. Probable loss of small phytoliths was considered acceptable because the main interest was in recovering large AT phytoliths, especially *Oryza*.

A quick scan of the phytoliths recovered noted the presence of *Zoysia,* a grass of lake margins and paddy fields, and *Bambusa* in the oldest sediment sample available (100 cm). Rice was noted at 5, 15 and 25 cm. AT phytoliths representing a wide range of grasses including *Phragmites* were noted at 25-100 cm. Table 1 lists the presence of AT phytoliths at KUM1. The range of grass species represented diminished dramatically from 20-5 cm, *Oryza* dominated those remaining. Sponge spicules were present in all samples with a species change through time. Few diatoms were noted. Radiocarbon dates (calibrated years BP of median age) are given for KUM1 as 1945, 5659, 6416 and 6858 at 40, 77, 80 and 100 cm respectively, for this section of the column (Penny *et al.* 1996:219).

Depth cm	Poaceae phytoliths									Other microfossils	
	AT forms							Others			
	1	2	3	4	5	6	7	8	9	10	11
1						x					
5		x					x		x	x	
10										x	
15		x								x	?
20										x	?
25		x			x		x		x	x	
30				x		x	x	x		x	
40				x		x	x	x	x	x	x
45							x	x		x	
50				?			x			x	
70				x	x	x	x	x	x	x	x
75							x			x	
100	x		x		x	x				x	

Key: 1 - *Bambusa* sp.; 2 - *Oryza* sp.; 3 - *Zoysia* sp.; 4 - *Phragmites* sp.; 5 - AT1; 6 - AT2; 7 - AT others; 8 - ornamented rectangles; 9 - rectangles; 10 - sponge spicules; 11 - diatoms.

Table 1: Presence of AT phytoliths and other biogenic silica microfossils, KUM1, Kumphawapi.

Since this initial scan, further phytolith analysis at Kumphawapi has been carried out by Kealhofer (1996), Penny *et al.* (1996) and Kealhofer *et al.* (1998). Little correlation can be made between the data of Table 1 and that given in the Penny *et al.* phytolith diagram (1996:221). However, the variety of grasses shown at 25-70 cm may be indicating the presence of herbaceous swamp reported by Penny *et al.* at 45-80 cm (1996: 218, 220, 222).

Kealhofer (1996) analysed KUM3, a core taken a few metres south of KUM1. The section of KUM3 analysed begins at 100 cm. Radiocarbon dates given for the 100-150 cm levels are younger than KUM1 at 80 cm. However, the stratigraphy of the relevant sections of the two cores cannot be correlated using published data.

Laos

A quick scan was made of phytoliths extracted by heavy liquid flotation from sediments excavated by Thongsa Sayavongkhamdy from two Laotian open sites. One being Colani's (1935) "Ban Ang" site on the Plain of Jars (now an area of grass with one tree species [pine] and few shrubs), the other being Lao Pako on the Mekong floodplain. At Lao Pako sediment levels higher than those taken for phytolith analysis were associated with iron smelting. Data on these excavations are presented by Sayavongkhamdy (1998 and pers. comm.). Three samples for phytolith analysis were available from each site, all discrete samples, rather than column profiles. Phytoliths were present in all sediment samples and have been classified into three groups: grasses, sedges and trees/shrubs, with subgroups in two classes. No quanti-

	Plain of Jars - 1000 m asl			Lao Pako - c.200 m asl		
DB No.	1 - 657	2 - 658	3 - 659	4 - 660	5 - 661	6 - 662
TS no.	THH P7/F4	THH 24	THH/S S3/5	LPK F255	LPK F198	LPK S34
Depth b.s. cm	Jar 7	140 cm	110 cm	Pot 13	117 cm	173 cm
PHYTOLITHS						
GRASS						
Biilobe Group 1	x	x	x	x	x	
Group 2	x	x	x			
Group 3	x	x	x		x	
Group 4	x	x	x	x	x	
Group 5	x		x	x	x	
Group 6	x	x	x	x	x	
1 lobe	x	x	x	x	x	
n-lobe	x			x	x	
Angular 1	x	x	x	x	x	x
Angular 2		x	x	x	x	x
Angular 3	x	x	x	x	x	
Angular 4	x	x		x	x	
AT	x	x (many)	x	x	x	x (many)
AT *Phragmites*	x	x	x	x	x	x
AT *Oryza*		x	x			x
AT *Zoysia*			x			x
AT bamboo				x	x	x
OR	x	x	x	x	x	x
Trichome	x	x	x		x	
SEDGE						
Carex sp.	x		x	x	x	
TREE/SHRUB						
Sphere	x	x	x	x	x	x
Ring	x					
Hair	x		x			
Hairbase	x		x			
OR	x	x			x	
Rectangle	x	x		x	x	x
Triangle				x		
Amorphous large			x			
3D chunks	x	x	x	x	x	
Interlocking			x	x		
Perforated black		x	x	x	x & w	
Polygon stained						x
Palm	x	x	x	x	x	x
Banana	x	x	x	x	x	
Carbon inclusions	x	x		x	x	x
OTHER MICROFOSSILS						
Starch grains	x	x	x (many)	x (few)		x
Sponge spicules	x	x	x	x (many)	x	x
Diatom			x			
Carbon particles	x	x	x		x	x

Table 2: Presence of phytoliths and other microfossils, Plain of Jars and Lao Pako.

tative assessment was made. Table 2 lists phytolith presence in each sample at both sites.

"Ban Ang", Phonsavan, Plain of Jars, Laos

Of the "Bang Ang" sediments, Sample 1 was recovered from inside stone Jar 7. Sample 2 was taken from the same trench as the jar at a depth of 140 cm. Sample 3 was from 40 m up a slope from the flat area of Samples 1 and 2, at a depth of 110 cm.

The three phytolith assemblages are, in general, similar and only a count can show the true differences. However, visual observation indicated that there is a higher presence of angular grass phytoliths in Sample 1 than seen in Samples 2 and 3. In sample 2 a similar observation indicates a higher tree/shrub presence than grasses. This assemblage indicated a wet habitat, perhaps a stream margin. It contained the largest phytoliths of this group of sediments and many sponge spicules. Sample 3 showed a mixed tree/shrub/grass assemblage dominated by grass phytoliths with AT morphology. The wide variety of AT types in Sample 3 and the presence of diatoms also indicates an abundance of moisture. High numbers of starch grains were observed.

In summary, the assemblage suggests a wet habitat and more varied vegetation than occurs at present. Three economic plants, palm, banana and rice, were identified in the phytolith assemblage. A wider variety of vegetation types, including economic plants, than that growing in the area now is indicated. All samples contain evidence of burning.

Lao Pako, Laos

Three sediment samples from Lao Pako, on the Mekong River floodplain, were scanned. All came from a 2 x 2 m trench. Sample 4 came from inside clay Jar 13, possibly at one time used as a burial jar. An inverted cover jar had been broken at some time in the past and both vessels were full of soil. Sample 5 was taken 1 m from the jar at a depth of 170 cm and Sample 6 less than 30 cm from the jar at 100 cm depth. Samples 5 and 6 were about 1 m apart.

The grass phytolith assemblage from inside the jar (Sample 4) and Sample 5 were similar to each other, but not to that from Sample 6. Many large AT types were present; rice was noted in Samples 5 and 6, and bamboo occurred in all three samples.

There was a greater density of trees and shrubs than of grasses in the three assemblages. Banana and palm phytoliths were noted in Samples 4 and 5.

Sponge spicules were noted in the three samples with the highest number present in the sediment from Jar 13. Many spicules were complete, indicating that they had not been subjected to very much movement.

In summary, the assemblages suggest a wet, tree/shrub environment, the carbon particles indicating burning.

Pacung, northern Bali, Indonesia

Excavations by I Wayan Ardika on the northern coast of Bali, Indonesia, indicate that trading connections had been established with the Indian subcontinent by the early first millennium AD or earlier (Ardika and Bellwood 1991, Ardika *et al.* 1997). A group of sites within 300 m of each other was excavated at Sembiran and Pacung (and visited by some IPPA members after the 1990 Congress).

Five sediments samples were taken from 156-380 cm below the surface of Pacung I; rapid soil accumulation had occurred above these levels. A quick scan identified the presence of many AT phytoliths, including rice, in the oldest two sediments (240-380 cm) dated to about 2000 years ago. Many of the phytoliths in these two sediments contained cytoplasmic carbon. All phytoliths with AT morphology were counted and are listed in Table 3.

There were very few phytoliths present in the <200-240 cm horizon which indicates a decrease in vegetation cover; those grass phytoliths that were recorded were derived from plant species which differed from those noted below these depths. The greatest density of phytoliths was present at 200 cm, with high numbers of grass and palm phytoliths also noted; the number of phytoliths containing

Sample #	Depth below surface cm	Residue s.g. <2.3* % sample	Particle size range at 250μ discard	Total AT	Poaceae phytoliths: Oryza	Probable Oryza
474.0	156-190	0.04	1.77-1.30	15	-	-
475	200	0.24	<2000 μ	40	-	1 (2.5%)
476	200-240	0.04	<250-2000μ	5	-	-
477	240-300	0.18	up to 420 v. poor sort	22	6 (27.2%)	3 (13.6%)
478	300-380	0.18	<83-1.70 moderate sort	20	12 (60%)	4 (20%)

* Includes material other than biogenic silica with specific gravity less than 2.3

Table 3: Presence of AT phytoliths, Pacung I.

cytoplasmic carbon had reduced by about 30% and few carbon particles were observed. The youngest sediment scanned, 159-190 cm, showed an increase of carbon inclusions and particles. The stratigraphy of Sembiran IV and Pacung I indicated an undisturbed layer of alluvium or volcanic ash at the 240 cm level (Ardika 1991:33).

I suggest that a local catastrophic event, which led to the abandonment of the sites about 1500 BP, is identified by the change of phytolith assemblage below the 200 cm level. The majority of artefacts were excavated from below this level. There is frequent volcanic activity in the area.

The phytolith evidence suggests that rice was growing in the area during the period covered by the accumulation of the two oldest horizons, however, it is not grown in the area now. The nearest habitation today is alongside a sealed road some 200 m to the south on the footslopes of the central range.

Kuk Station, Papua New Guinea

Phytoliths were extracted from six soil samples recovered from trench Al2a/b of the swamp site at Kuk Agricultural Research Station, Wahgi Valley, Western Highlands Province of Papua New Guinea.

A quick scan of phytoliths extracted showed a significant change of phytolith density and type occurring in the mixed sediment (*c.*96-119 cm) between Ep ash and the overlying grey clay (Table 4). This area of the profile has been interpreted by Golson (1991:484) as "possible evidence of an early phase of wetland agriculture".

Table 4 summarises phytolith presence. It records a significant percentage weight change in biogenic microfossils recovered through time. It also records a change from phytoliths representing plants with a wet habitat requirement and the presence of many diatoms in the older horizons below 127 cm to those with a drier habitat requirement above 96 cm. Phytoliths from *Saccharum* were noted in the youngest sediment scanned. In the recent past sugar and tea have been cultivated in the area.

Currently, six soil samples from profile Al0f/g, a few metres from Al2a/b, are being processed. Four samples have been taken from the mixed sediments between the grey clay and Ep horizons, and one each from the grey clay and Ep horizon, close to the interface with the mixed sediment. It is anticipated that phytolith analysis of these samples will narrow down the occurrence of the wet/dry interface and indicate whether the changeover occurred abruptly or was a gradual process over time. Identification of phytoliths in these sediments will concentrate on any economic plants present such as banana *(Musa)*. *Musa* phytoliths have a distinctive concavity (see Figure 2b) although other attributes may be very different. It may not be possible to identify *Musa* sections but it is possible to differentiate between some species.

Gua Chawas, northern Kelantan, Peninsular Malaysia

The foregoing reports have all been quick scans of phytolith presence. An initial quick scan of sediments from one of Adi Taha's sites, Gua Chawas, indicated the presence of many phytoliths which resulted in further analyses being undertaken on sediments from this rockshelter. Adi collected plants growing in the rockshelter area and a small phytolith reference collection from 20 plants was prepared. Excavations at this site are reported by Adi (1998). Unfortunately, because sediments available for analysis were not taken from the profile at regular intervals, it follows that some fluctuations in phytolith presence/absence may not have been observed.

A quantitative analysis, based on a count of 500 phytoliths for each sample slide, showed changes in density of phytoliths indicating high and low occupation of the site. A variation in size of phytoliths with similar morphology through the profile suggested a change in water availability.

The summary page of a phytolith diagram, constructed by use of the TILIA programme, is shown as Figure 4. From excavated artefacts, Adi (1998) has identified three culture periods, Hoabinhian, Neolithic with Buddhist, and Orang Asli. A correlation between the culture periods identified by artefacts and vegetation change indicated by phytoliths is shown by a dendrogram drawn from total sum of squares (final column of Figure 4).

The presence, not a count, of 24 cuticle type phytoliths was noted throughout the profile in an attempt to reduce the unidentified "others" components of the count. Cuticles are located in the woody parts of plants. Since, to date, only leaves from the Gua Chawas plant collection have been processed to construct a comparative phytolith collection, no identification of cuticles can be attempted. Other cuticles observed during the scans are not included because their morphology was not as distinctive as the 24 types listed in Table 5. Cuticle presence or absence indicate a change of the arboreal component of the vegetation in the area of the site through time.

Only three of the cuticle types present at 270 cm are present at 50 cm, and by 40 cm only one. No cuticle type was recorded at all levels. The presence of only one cuticle type at 180 and 260 cm suggests clearance of the canopy by human activity or alternatively by environmental action.

The cuticle presence at 50 cm is similar to the cuticle presence at 240 cm and suggests recurrence of an earlier

Slide no.	Approximate depth below surface cm: cm	Approximate depth below surface cm: Tin ID	Approx. date BP	Sediment	Drainage phase	% biog. silica	Phytoliths: Grasses group 1	Phytoliths: Grasses group 2	Phytoliths: Sedges	Phytoliths: Tree/shrub group 1	Phytoliths: Tree/shrub group 2	Phytoliths: Tree/shrub group 3	Diatoms	Starch grains
182	32-39	Tin 1T				6.3	x			?	x	x		x
				black clay	3									
183	63-79	Tin 3T	6000	grey clay	2	3.1	x			x	x	x		x
184	86-96	Tin 4B				2.2	x			x	x	x		x
			9000	mixed black and grey clay	1									
185	119-127	Tin 6B				8.4	x	x(a)	x(a)	x	x	x	x(a)	x
			12000-14000	EP volcanic ash										
186	136-143	Tin 7				9.8	x	x(a)	x(a)	x	x		x(a)	x
187	152-161	Tin 8T		mixed black and grey clay										
						9.6	x	x(a)	x(a)	x	x		x(a)	x
	170			volcanic ash										

Key: Tree/shrub group 1 - *Casuarina* sp., 2 - Palmae sp., 3 - *Musa* sp.; (a) phytoliths from plants with aquatic habitat
Note: Sediment samples taken from centre of tin.

Table 4: Presence of phytoliths and other microfossils, Kuk.

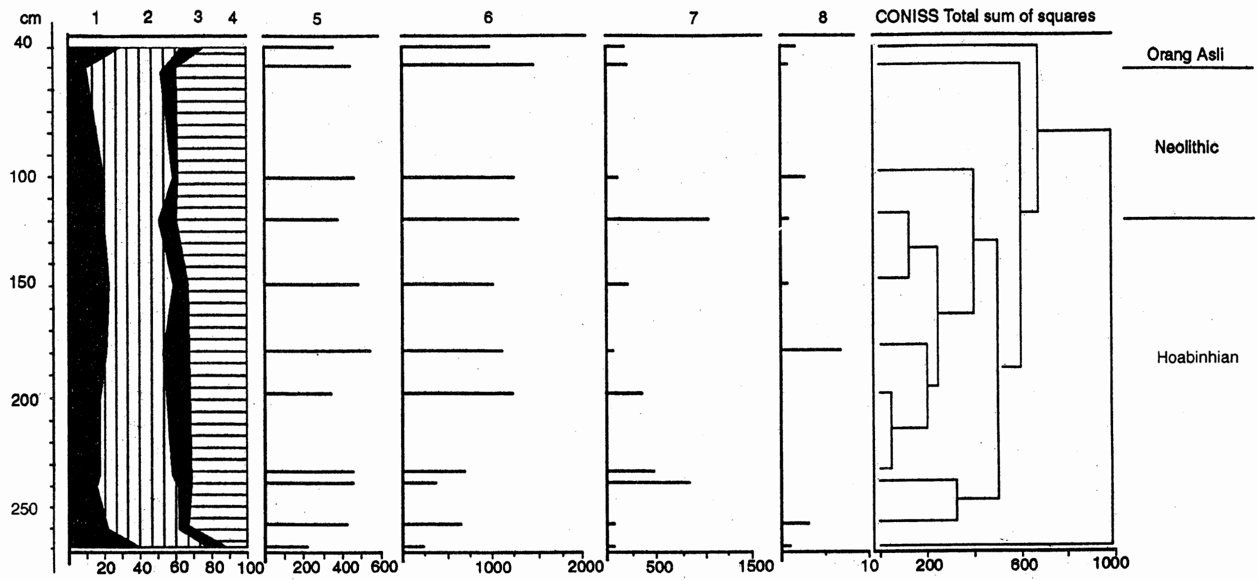
forest flora, possibly during low occupation associated with culture change. However, finer sediment sampling between 50-150 cm is required to identify vegetation trends during the period represented at these depths. A low cuticle presence at 40 cm accompanied by a wide range and high numbers of grass phytoliths indicates the greatest forest clearance recorded in the profile.

As well as a count and note of cuticle presence a full scan of each slide was made for phytolith presence. A summary of changes through time indicated by phytolith analysis is given in Table 6.

Two species of rattan were noted at all levels but the presence of other species was sporadic. Many types of palm and bamboo phytoliths, other than in the reference collection, were observed.

Banana phytoliths were recorded at all levels, with possibly more than one banana species present in the oldest levels.

When botanical names are available for the reference collection an attempt can be made to reconstruct vegetation history and local ecological changes through the period of occupation at the site. Still to be addressed is



Key: 1 Palmae; 2 Dicot/monocotyledons; 3 Poaceae; 4 other phytoliths; 5 phytolith /g; 6 carbon particles/g; 7 starch grains/g; 8 sponge spicules/g

Figure 4: Summary phytolith diagram, Gua Chawas.

whether human intervention, the changing use of the rockshelter through three different culture periods or environmental factors were the cause of the observed vegetation changes. Certainly increases in the grass phytolith component would indicate opening up of the canopy by clearance of the immediate shelter area. Phytolith analysis indicates that the vegetation of the Hoabinhian occupation levels changed gradually over some 7000 years. However, there was a dramatic change in less than about 800 years from the 100 cm level (Neolithic) and at 40 cm (Orang Asli), the latter levels in particular when the grass phytolith component represented 50 per cent of the total phytoliths counted.

CONCLUSION

Phytolith analysis, whether quick scan indicating presence/absence or detailed quantitative analysis, has provided data not previously available from tropical sediments. Results of further analysis of sediments allow a correlation to be made between cultural artefacts and plant presence through time and assessments to be made of vegetation history. Economic plants identified ethnographically can

Slide #	Depth below surface cm	Cuticle number 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	23	21	22	24	Total	
576	40		x	x	x		x	x																		5	Orang Asli
577A	50	x	x	x	x	x	x	x	x	x	x										x					11	
578	100	x	x	x				x				x			x	x						x				8	
579	120	x	x	x		x			x			x	x				x	x								9	Neolithic
580	150	x				x	x			x	x	x		x	x	x			x							10	
581	180												x													1	
582	200				x				x																	2	
583	235				x	x								x			x			x			x			6	Hoabinhian
584	240	x	x	x		x	x	x	x	x	x															9	
585	260												x													1	
586	270	x			x					x				x				x	x	x				x	x	9	

Table 5: Presence of phytolith cuticles, Gua Chawas.

Depth below surface cm	
270	Highest diversity (high palm, highest arboreal) but lowest number of phytoliths recorded at this level. A high diversity of phytoliths can indicate much human activity but this is negated here by the lowest number of phytoliths recorded in the profile. I suggest that in this instance low numbers and diversity are signalling little human occupation. *Doq**, bamboo and banana were identified. Lowest number of carbon particles.
260	*Doq, Pokok cucuh**, Tetracera* sp.***, bamboo and banana were identified. One cuticle type and high numbers of AT phytoliths recorded. An increase in grass phytoliths signals forest clearance and human occupation of the shelter.
240	Reduction in the diversity of all phytolith forms and a high number of cuticle types. *Tetracera* sp., *Pokok cucuh,* and banana were identified. Largest forms of profile. High numbers of starch grains.
235	*Doq,* bamboo and banana were identified. Increase in grasses (angular) phytoliths.
200	Low cuticle and grass presence. *Pokok cucuh* and banana were identified. Increase in carbon particles.
180	Highest numbers of phytoliths recorded, low cuticle and grass presence. Bamboo and banana were identified. Lowest starch grain presence recorded.
150	Diversity of phytoliths increases indicating an introduction of different flora. *Pokok cucuh,* bamboo and banana were identified.
120	*Tetracera* sp., bamboo and banana were identified. Highest number of starch grains recorded.
100	Reduction in size of all phytoliths at this level may reflect a period of less rainfall in the area, however sponge spicules were observed. Lowest grass count of profile. *Pokok cucuh,* bamboo and banana were identified.
50	Highest diversity of cuticle types. Phytoliths from leaves known ethnographically to be used for food wrapping identified. Increase in grass (angular) phytoliths. Highest AT, lowest palm phytoliths recorded for the profile. *Pokok cucuh,* bamboo and banana were identified. Highest number of carbon particles recorded.
40	An increase in palm and grass (angular) phytoliths accompanied by a 50% reduction of the phytolith back ground noise was recorded, indicating canopy clearance to a greater extent than any other time. *Pokok cucuh* and banana were identified.

**Doq* – unidentified tree species from which poison can be extracted.

***Pokok cucuh* – unidentified tree species, leaves known to be used as thatch.

*** *Tetracera* sp. *(Pokok pasen)* – sandpaper leaf tree. Leaves of this tree were used as a substitute for sandpaper during World War II when the commercial product was not available (Adi pers. comm.). Figure 2d illustrates a phytolith rosette extracted from a *Tetracera* sp. leaf. Rosettes cover the surface of the leaf, each may contain up to ten sharp silica points.

Table 6: Summary of changes through time at Gua Chawas indicated by phytoliths

be matched with phytoliths extracted from sediments to indicate their use throughout periods of site occupation.

This report outlines one facet of phytolith analysis. Phytoliths from contexts which range from micro to macro environments, such as those of tooth cavities, in the temper of clays, in pot residues and on stone artefacts, can be studied and can lead to identification of early agriculture, categorisation of historical landscapes and climate reconstruction.

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