# *Chapter 8 – Supplementary Materials*

# The Pollen, Palynofacies and Phytolith Assemblages from the West Mouth

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The pollen palynofacies and phytolith assemblages are described below, organized approximately chronologically. The locations of the samples are shown in Figures 3.6 and 3.7, the identified pollen zones in Table 8.5, and the likely climatic correlations in Figure 8.9.

**Section 3.1(2000) (Area A): Monoliths A1M-A3M**

The earliest samples from Lithofacies 2C, the 'Yellow Colluvium' (Volume 1, Chapter 3), come from under the rock overhang in Area A where Monoliths A1M-A3M from Section 3.1(2000) (Volume 1: Fig. 3.21) are stratified below two radiocarbon dates in stratigraphic order: 44,750 ± 650 bp or 46,321–49,593 cal. BP (OxA-V-2076-15) and 36,960 ± 300 bp or 41,345–42,325 cal. BP (OxA-V-2076-14). Considerable incompatibility between the assemblages in these monoliths (Fig. S8.1) and those from monoliths from the Hell Trench (Hunt *et al.* 2007, 2012 and described below) suggests that it is very unlikely that the Hell Trench monoliths, which are stratified below dates of 42,487 ± 657 bp or 44,654–46,820 cal. BP (Niah-310) and 41,800 ± 620 bp or 44,344–46,137 BP (Niah-311), are synchronous. It is therefore likely that the record in the Area A monoliths is derived from the equivalent of the later part of NGRIP Interstadial 14 (Fig. 8.9) although it could be older. An age of *c.* 53,000–52,000 BP is thus likely.

Back-mangrove taxa including *Bruguiera, Sonneratia* and *Rhizophora* are present in the lower part of the record (zones A-1 and A-2). Through zones A-1 to A-3, the assemblages show a wide range of swamp forest species, but wetland taxa are rare in higher zones, with *Sphagnum* most prominent. Lowland forest species are common throughout but very common in zones A-3 to A-5, while upland species are prominent except in zones A-3 and A-4. Throughout this sequence, but especially Zones A3-A6, there are high values for dryland species, especially *Dodonaea*. The high percentages of dryland species in these assemblages are unique in the record from the West Mouth. Open ground and regeneration species are generally present only in low percentages, but rise in zone A-2 and are still over 20 per cent in zone A-3, then rise again in A-6. In A-2, herbaceous taxa such as Cyperaceae and Liliaceae rise, with regeneration taxa also rising in the latter part of zone A-2 and zone A-3 involving Poacae, then *Macaranga*, Lactucae, *Kleinhovia* and then *Callicarpa*. *Justicia* is very high in zones A-1 to A-5, comprising over 80% of the pollen in these zones and immature pollen, much of it likely to be derived from Palmae, is also present in zones A-2 to A-4. The palynofacies (Fig. S8.2) shows that thermally mature (burnt) woody material is present from the base of the exposure, suggesting the presence of fire.

The declining back-mangrove taxa in zones A-1 and A-2 suggest that marginal marine waters initially extended into the valley system of the Sungai Niah adjacent to the Great Cave, but that coastal progradation and/or marine regression excluded them by the end of zone A-2. Similar back-mangrove habitats were documented for the Holocene adjacent to the Great Cave (Hunt & Rushworth 2005b). The timing of the disappearance of mangroves and the rise and succession of herbaceous and then regeneration taxa might be taken to suggest that the death of the back-mangrove trees created ecological space where early successional species could flourish before encroachment of lowland forest taxa could occur. The wide range of lowland forest taxa through the sequence is suggestive of temperatures broadly similar to those of the present day, but very low precipitation in zones A-2 to A-6 is suggested by the very high incidence of dryland taxa and particularly *Dodonaea,* which is today confined to very well-drained coastal dunes (Yapp 1989, 40). Temperature decline is suggested by the general decrease in lowland forest and swamp forest taxa and the rise in upland and herbaceous taxa in A-5 and A-6. It is suggested that the high incidence of *Justicia*

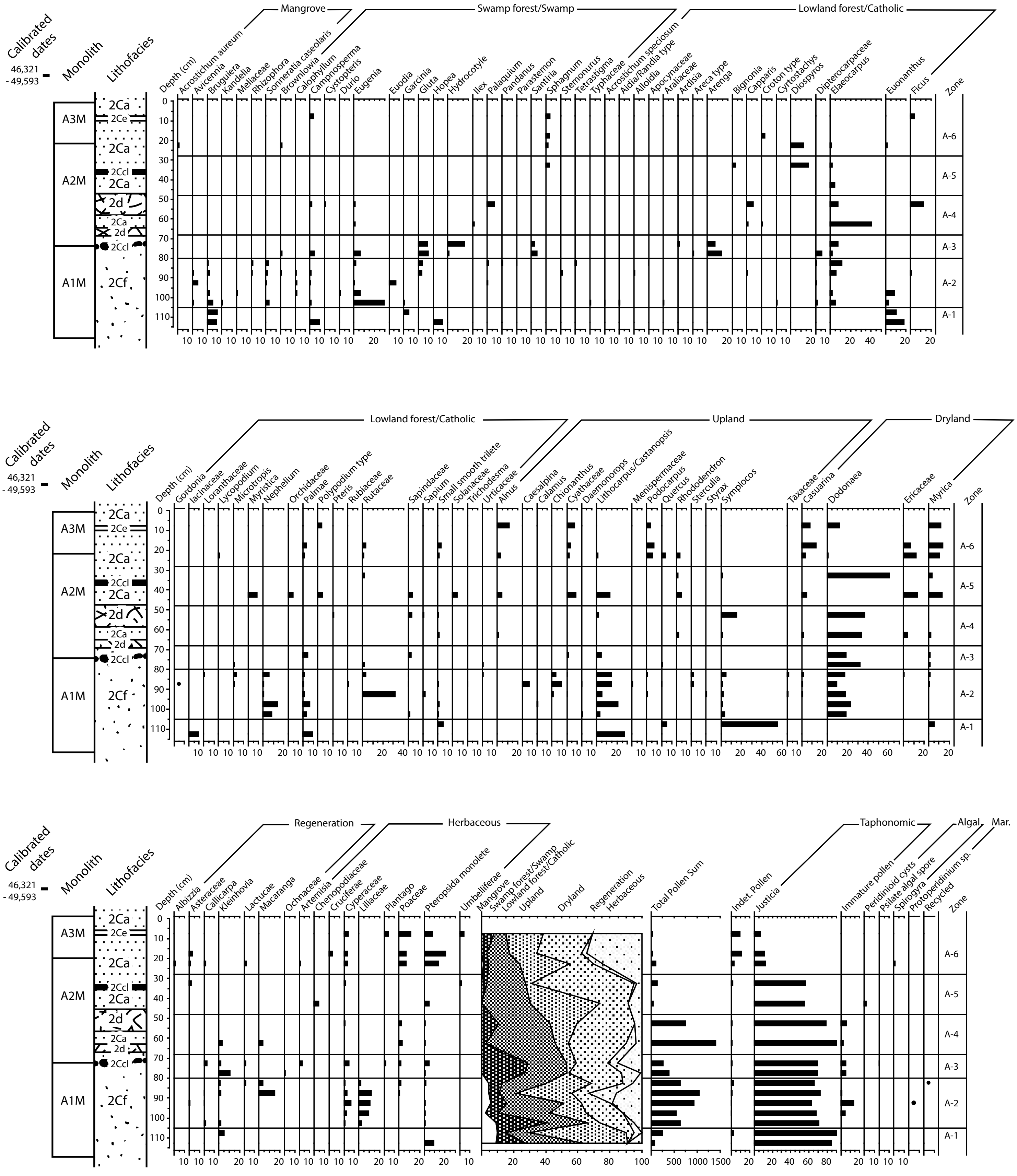



**Figure S8.1**. *Pollen diagram from Monoliths A1M to A3M, Section 3.1(2000) in Area A. (After Hunt* et al. *2012.)*

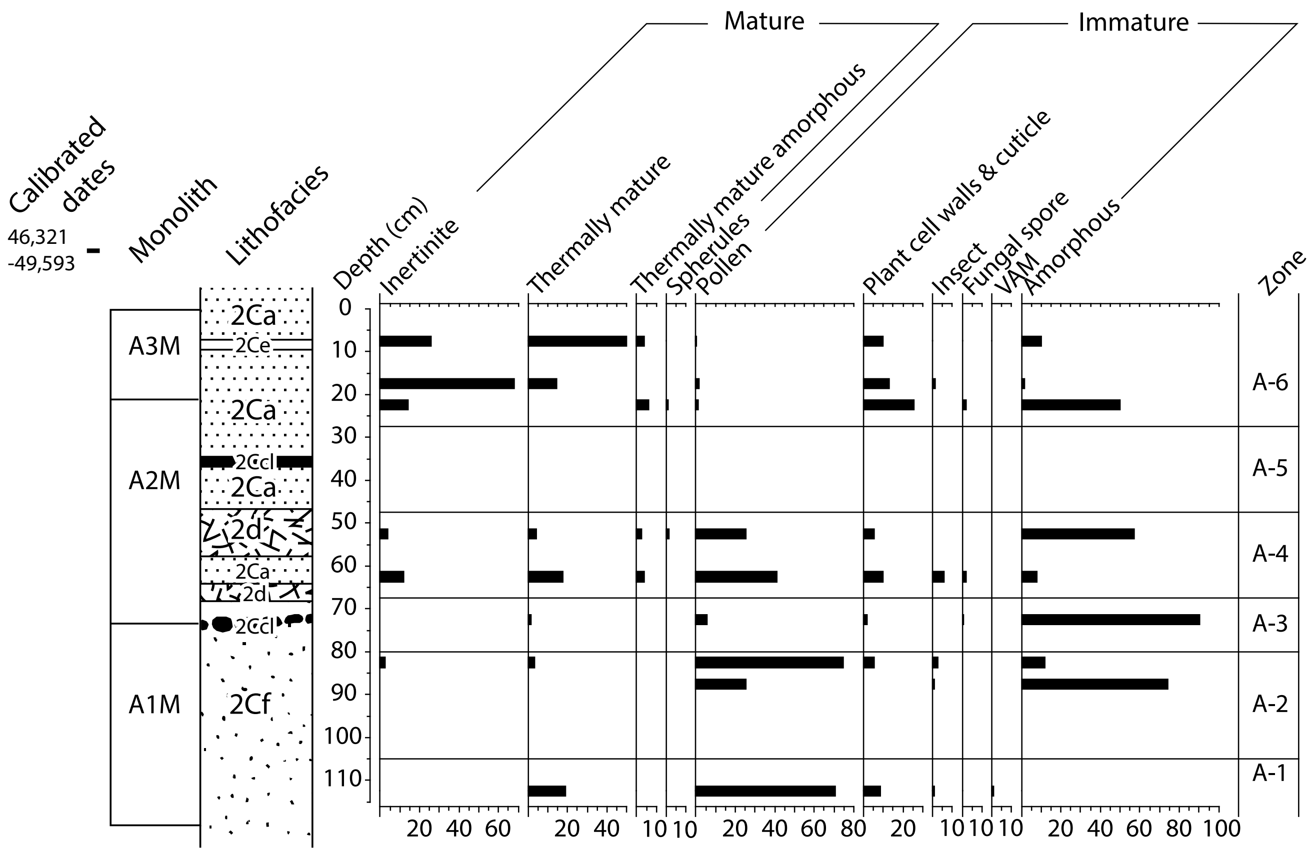



**Figure S8.2**. *Palynofacies diagram from Monoliths A1M to A3M, Section 3.1(2000) in Area A. (After Hunt* et al. *2012.)*

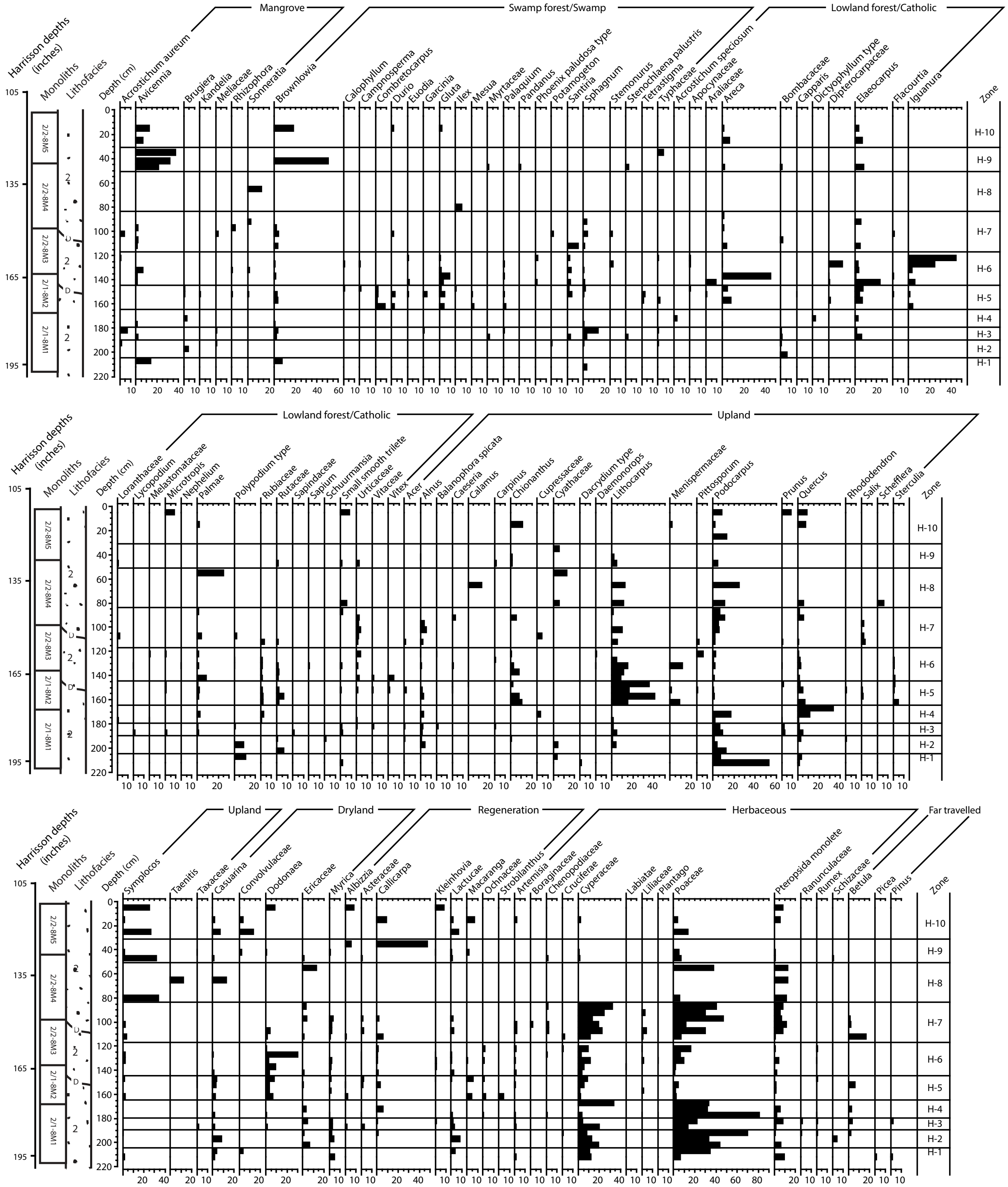
and of immature pollen in this sequence is the result of taphonomic factors, possibly that inflorescences were brought into the cave by some vector. Although thermally mature material is present from the base of the sequence, thermally mature amorphous material is not present until zone A-4. Thermally mature amorphous material is likely to reflect the presence of fires within the cave, as it forms in soils and sediments below fires. Its presence here most probably reflects anthropogenic burning within the cave (Hunt *et al.* 2007).

Samples from Monoliths A2M and A3M were analysed for phytoliths but did not contain any. All of the samples, however, did have at least a few starch grains, including those in the larger size ranges (15–20 μm). It is likely that these remains are from food plants, either as root or fruit. There was no evidence of burning in these samples. The sample at greater depth, in the interstadial, had more starch grains, suggesting that depositional processes (such as rate of deposition) may be significant or that human activity waned as temperatures started to decline at the end of the temperate phase.

### Sections 7.1(2000), 1.2(2000), 8.1(2000) (Hell Trench): Monoliths 2/1-8M1 to 2/2-8M5

Chronologically, the next set of samples is from the monoliths from Lithofacies 2 ('red-brown silts and sands') in the Hell Trench (Hunt *et al.* 2007; Volume 1: Figs 3.14 and 4.4), presented in revised form here (Figs S8.3, S8.4). The monoliths are stratified below two radiocarbon dates: 42,487 ± 657 bp or 44,654–46,820 cal. BP (Niah-310) and 41,800 ± 620 bp or 44,344–46,137 BP (Niah-311) and thus the interstadials in this sequence are unlikely to be younger than NGRIP Interstadials 12 and 13, although they could be older. An age of *c.* 52,000–47,000 BP is thus possible, although correlation with the NGRIP interstadials has been slightly revised from Hunt *et al.* (2007).

Pollen grains of mangroves are present in all zones. The base of the sequence is marked by very high (54%) *Podocarpus.* The rest of zone H-1 and all of H-2 are marked by very high counts for herbaceous taxa such as Poaceae and Cyperaceae. H-3 is marked by a fall in herbaceous taxa and a peak of *Sphagnum.*



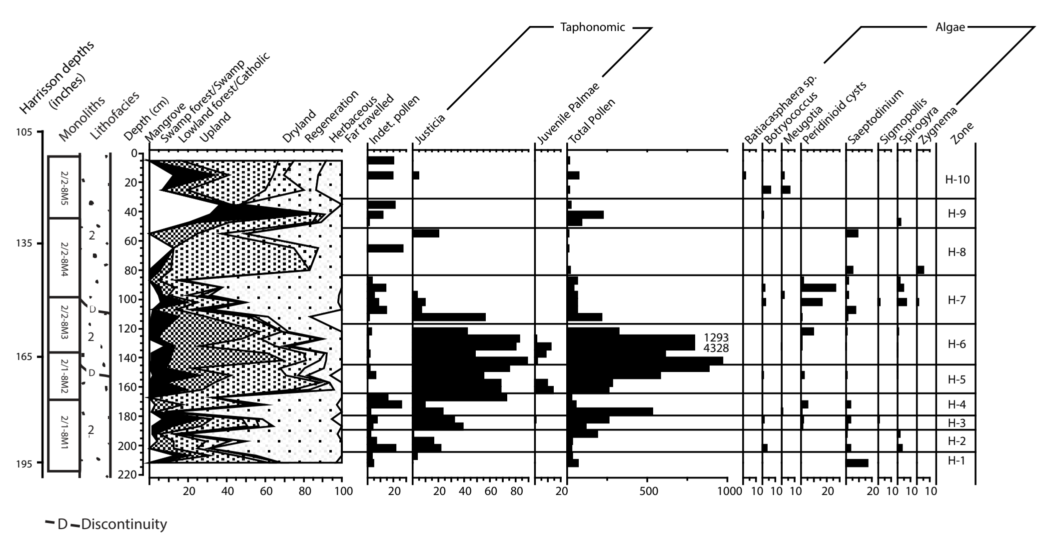



**Figure S8.3**. *Pollen diagram from Monoliths 2/1-8M1 to 2/2-8M5, Sections 7.1(2000), 1.2(2000), and 8.1(2000) in the Hell Trench. (After Hunt* et al. *2012.)*

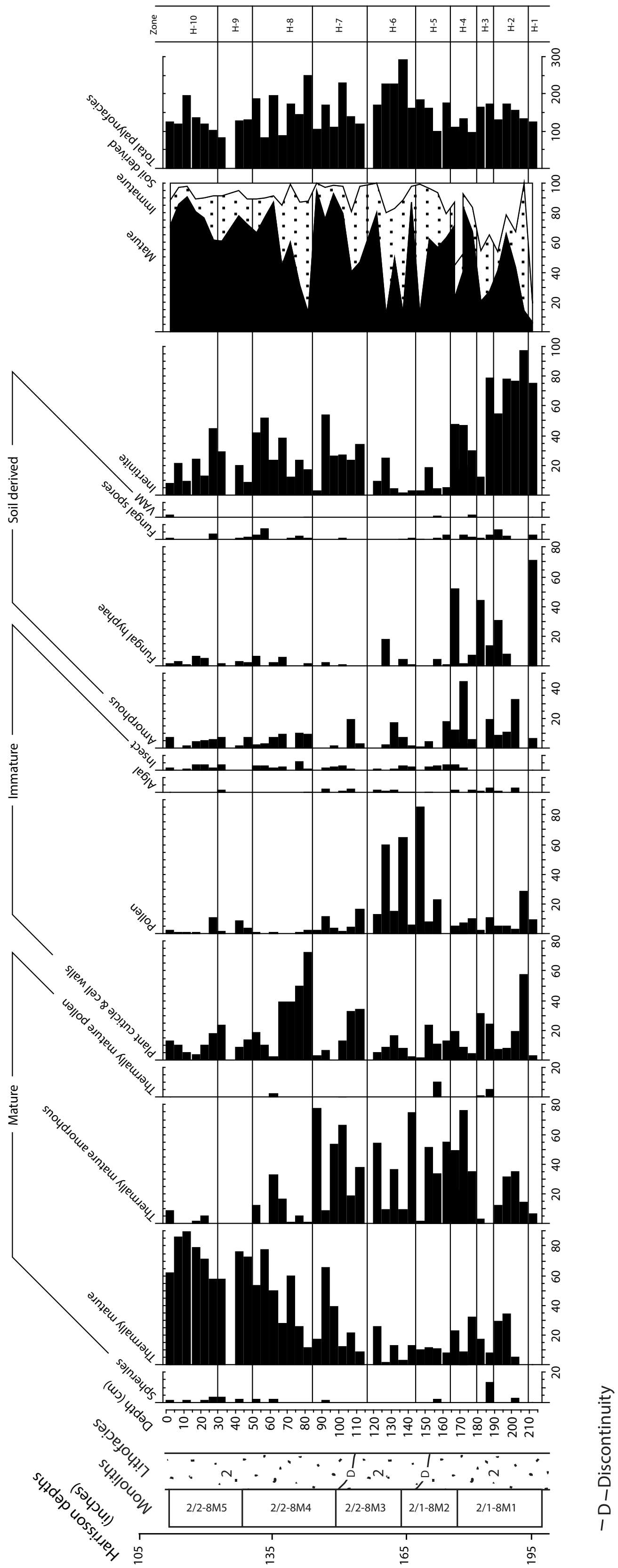



**Figure S8.4**. *Palynofacies diagram from Monoliths 2/1-8M1 to 2/2-8M5, Sections 7.1(2000), 1.2(2000), and 8.1(2000) in the Hell Trench. (After Hunt* et al. *2012.)*

H-4 sees a return to very high counts for herbaceous taxa, and ends with a peak in *Quercus*. *Lithocarpus* is well-represented in zones H-5 to H-6, and swamp forest species such as *Combretocarpus, Gluta* and *Santiria* and lowland forest/catholic species including *Areca, Elaeocarpus, Iguanura* and Rutaceae are frequent in zones H-5 to H-7. Pollen is very sparse in zone H-8 and seems to be dominated by upland taxa. The front-mangrove *Avicennia* is prominent in zones H-9 and H-10. Estuarine diatoms have been recovered from these levels (S. Davies, *pers. comm*., 2008). Lowland forest and dryland taxa are also reasonably prominent in zones H-9 and H-10 and regeneration taxa such as *Callicarpa* (Bramley 2009) are intermittently common. *Justicia* is very common in H-2 to H-7 and occurs intermittently in H-8 and H-10. Frequently this species is present in tetrads and aggregates of 20–100 grains. Aggregates of immature palm pollen are also present in H-3, H-5 and H-6.

The near-continuous presence of mangrove pollen suggests that the coast was never very far away during the deposition of this sequence. The pollen assemblages in the basal samples, characterized by very high *Podocarpus,* are not easily comparable with any known modern pollen assemblages. *Podocarpus* has an enormous altitudinal range in Borneo, occurring from sea level to 3410 m (Smith 1980), but is usually rare, characteristic of kerangas vegetation on well-drained substrates. Even high on Mount Kinabalu, its pollen fallout only reaches 9% (Flenley 1973). It is tentatively suggested that the high counts for *Podocarpus* reflect drier conditions and that this relative aridity created conditions in which herbaceous plants could flourish in H-1 and H-2. Declines of herbaceous taxa, a rise in *Sphagnum* and a general rise in tree pollen suggest significant increases in precipitation in H-3. It is possible that this was accompanied by a rise in temperature since a number of swamp forest and lowland forest taxa appear in this zone. The renewed rise of herbaceous taxa in H-4 would suggest a return to cool relatively arid conditions. High *Quercus* in the upper part of H-4 and high *Lithocarpus* in H-6 invite comparison with the high counts for these taxa in the 'oak zone' between 1400 and 2100 m on Mount Kinabalu (Flenley 1973) characterized by mean annual temperatures of 20–16°C (Kitayama 1992). The presence of significant *Dodonaea* in these zones may be indicative of relative aridity, since this species is today confined to coastal sand dunes. A rise in lowland taxa such as *Iguanura* might suggest rising temperatures at the end of H-6, and rising herbaceous taxa in H-7 may indicate renewed coolness and relative dryness, which probably continues in the rather sandy sediments of H-8 where the sparse counts are characterized by high montane and herbaceous taxa. H-9 is marked by the front mangrove *Avicennia*, suggesting marine incursion to close to the cave. Vegetational instability otherwise appears to have been marked, with very variable assemblages and one very high count for *Callicarpa*, but the appearance of lowland taxa is consistent with warming. The disappearance of *Avicennia* and rise of *Quercus* and the altitudinally restricted *Prunus* (not reported below 800 m in Borneo) in H-10 are likely to reflect marine regression and cooling.

Phytolith samples were taken from the Hell Trench sequence in Monoliths 2/2-8M4 and 2/2-8M5 (Fig. S8.5). The three samples in 2/2-8M4 included a diverse range of arboreal dicots, plant epidermal tissue, and starch. Arboreal diversity is great in these samples, and starch grains are particularly common. Unidentified arboreal types are also relatively more abundant in this section as well, particularly at the bottom. Forms consistent with Annonaceae, Moraceae, Euphorbiaceae, Arecaceae, arboreal forms (sclereids, spheres, blocky forms), epidermal and mesophyll tissue are present in the bottom sample. Starch (*c*. 30 per cent), spores and burnt silica are also present. The middle sample in this sequence had the highest palm count (and starch grains) as well as being much lower in other arboreal forms and tissue. The top sample is very similar to the bottom sample in this sequence, whereas the microcharcoal count is much higher. All samples have a handful of grass (panicoid) phytoliths (<1 per cent) and *c*. 2–8 per cent palms. These samples include taxa that are again dominated by potential plant foods, particularly fruit (Annonaceae, Moraceae) as well as Palm. The abundance of starch supports this interpretation. Indirectly, these provide some local environmental evidence of mainly lowland rainforest species.

The three samples from 2/2-8M5 revealed similar patterns, arboreal forms, tissue and starch grains again being the most abundant forms represented overall. Phytoliths are most abundant in the lowest sample of this sequence, and the pattern of phytoliths is very similar to the 2/2-8M4 sequence below it (including evidence of burning). Forms consistent with Urticaceae, Arecaceae (*Caryota* and others), Zingiberaceae, Bambusoideae (Poaceae), Panicoid glume tissue, Cyperaceae tissue, possible *Dioscorea*, and Annonaceae are present. The upper two samples contain relatively few phytoliths, but starch grains are relatively common, particularly in the top sample. Unidentified arboreal forms and diatoms are also found in all samples. Forms consistent with Urticaceae, Burseraceae, *Diospyros*? sp., MFPs, Euphorbiaceae, and arboreal tissue are present. Poaceae phytoliths were only found in the bottom sample. Starch grains were most common

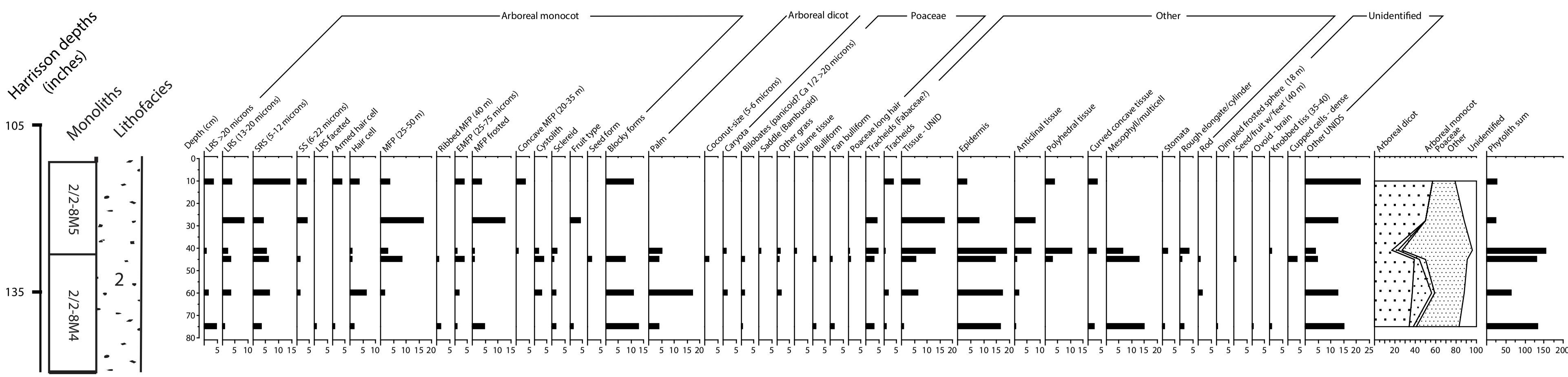



**Figure S8.5.** *Phytolith diagram from Monoliths 2/2-8M4 to 2/2-8M5, Sections 1.2(2000) and 8.1(2000) in the Hell Trench. (After Hunt* et al. *2012.).*

in the 15–20 μm range. Phytoliths were least common in this section.

Diatoms were present in the samples from 2/2-8M4 and 2/2-8M5. In 2/2-8M5 and the highest part of 2/2-8M4 the diatoms are a mixture of planktonic and benthonic, freshwater and estuarine forms, with *Diploneis* sp. prominent. Lower in 2/2-8M4 the diatoms are all freshwater forms.

**Sections 26.1 and 26.2 (Hell Trench)**

Six phytolith samples (Fig. S8.6) were analysed from Lithofacies 2C (the 'Yellow Colluvium') in Sections 26.1 and 26.2 (Volume 1: Fig. 3.19). Most yielded no phytoliths, but sample 3144 contained sparse silicified tissue, diatoms and starch and a few forms consistent with Palm tissue, Fabaceae, and Burseraceae. Burseraceae species produce resins useful for a range of medicinal purposes as well as for torches, hafting tools, etc. Sample 3150 contained a rich phytolith assemblage together with diatoms including the highly distinctive *Diploneis* sp. and other planktonic forms. This sample contained the largest number of phytoliths ($n$ = 244). While grasses are still not common in this sample (*c*. 10 per cent), they are more frequent than in any other samples. This sample included the fewest tissue fragments. Palms made up *c*. 25 per cent of the sample, which was dominated by arboreal forms including regrowth taxa such as Euphorbiaceae/*Macaranga* sp.. Phytolith forms consistent with Sterculiaceae (*Heritiera* sp.?; *Melochia*? multiple), Zingiberaceae, Euphorbiaceae (*Macaranga*, *Cleistanthus*?), Annonaceae, Fabaceae, Panicoid (Poaceae; multiple), Apocynaceae, Dilleneaceae, Burseraceae, Campanulaceae, and Arecaceae are present. In general terms, this very diverse assemblage looks more 'environmental' than the other samples, perhaps more accurately reflecting cave mouth vegetation. If it is an environmental signature, it reflects a lowland forest with some degree of disturbance/regrowth (grass, *Macaranga* sp.) in addition to mature forest species (Annonaceae, Dilleneaceae, Zingiberaceae, etc.), although there is no evidence of burning (one potential cause of disturbance).

**Sections 10.1(2000) and 10.2(2000) (Area A, Block B): Monoliths 2/2-7M1 and 2/2-7M2**

These monoliths (Figs S8.7, S8.8) lie higher in Lithofacies 2, just below the locally highly eroded top of Block B in Area A (see Volume One: Fig. 3.25). Incompatibilities with the pollen assemblages discussed above can be taken to suggest that there is no stratigraphical overlap with the A1M-A3M and Hell Trench sequences. It is possible that the assemblages from 2/2-7M1 and 2/2-7M2 relate to GRIP interstadial 11 or 10 (Fig. 8.9). Considerable similarities with assemblages in monolith 5-M1 suggest possible correlation (discussed further below).

Poaceae and Asteraceae are prominent in the basal sample, but assemblages in RS-1 are dominated by swamp forest taxa, principally *Santiria*, also *Stemonurus* and *Palaquium*, and lowland forest species, mostly *Elaeocarpus*. It should be noted that these taxa, with the exception of *Stemonurus*, are also prominent in hill and lower montane forest (Aiba *et al.* 2006; Kitayama 1992). In RS-2 to RS-4, dryland species, especially *Myrica* and *Casuarina*, lowland forest taxa such as Sapindaceae, and herbaceous taxa such as Poaceae and Pteropsida, are all common. *Justicia* is intermittently very common in RS-1 and RS-2.

The opening of this sequence appears to relate to a time of encroaching lowland vegetation as herbaceous and regeneration taxa are replaced in RS-1 by lowland forest species, which remain important until the end of RS-3. Rising swamp-forest taxa in RS-1 would be consistent with relatively high precipitation and the appearance of wetland or raised bog habitats. Their decline and rise, and the rise of dryland species in RS-2, suggest, however, that precipitation levels may have been unstable. Herbaceous taxa rise sharply and lowland forest and swamp forest species decline in RS-4 at the top of this sequence, probably as the result of cooling and desiccation.

**'Soil from around Skull at H/6 107" Niah 15-2-58' (Hell Trench)**

Though undated, this level can be assigned to Lithofacies 2 from its recorded position in the cave fill. The pollen assemblage (Fig. S8.9) is similar to the basal assemblage in 2/1-8M1, but the sample lies at least two metres higher in the stratigraphy, and it is totally dissimilar to samples at the top of 2/2-8M5, which is from the same approximate altitude and at most 3 m away horizontally. It is very different from both the assemblage from the fill of the 'Deep Skull' and the altitudinally comparable assemblages from Monoliths 2/2-7M1 and 2/2-7M2. The sparse assemblage is dominated by upland taxa, principally *Podocarpus*, with some dryland, regeneration and herbaceous species. Mangrove, lowland and swamp forest taxa are absent. The small size of this assemblage makes interpretation problematical, but it is likely to reflect dry, somewhat open, vegetation. It is unlikely that lowland or swamp forest was present locally. The presence of the montane taxon *Albizzia* suggests lower temperatures than occur around Niah today, so it is

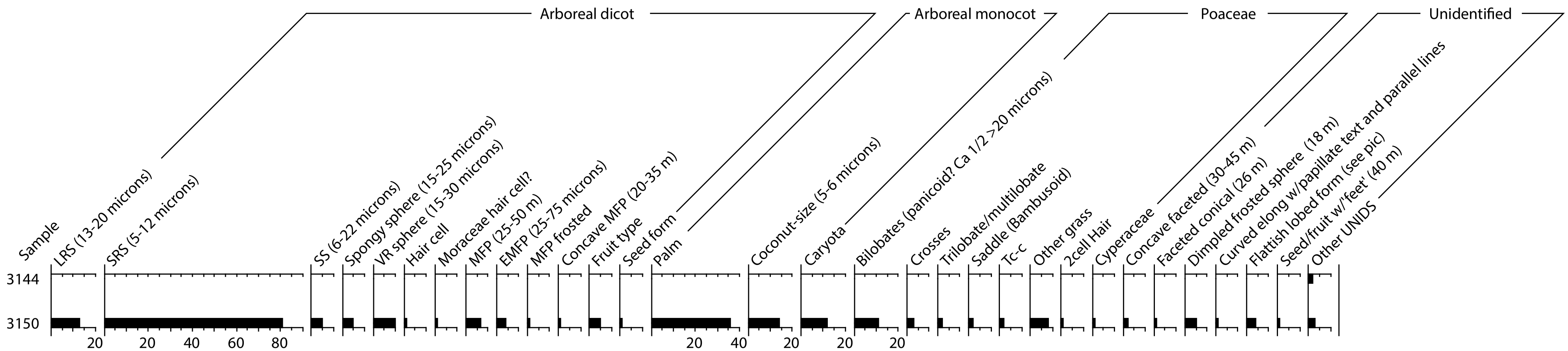



**Figure S8.6.** *Phytolith diagram from Sections 26.1 and 26.2 in the Hell Trench. (After Hunt et al. 2012.)*

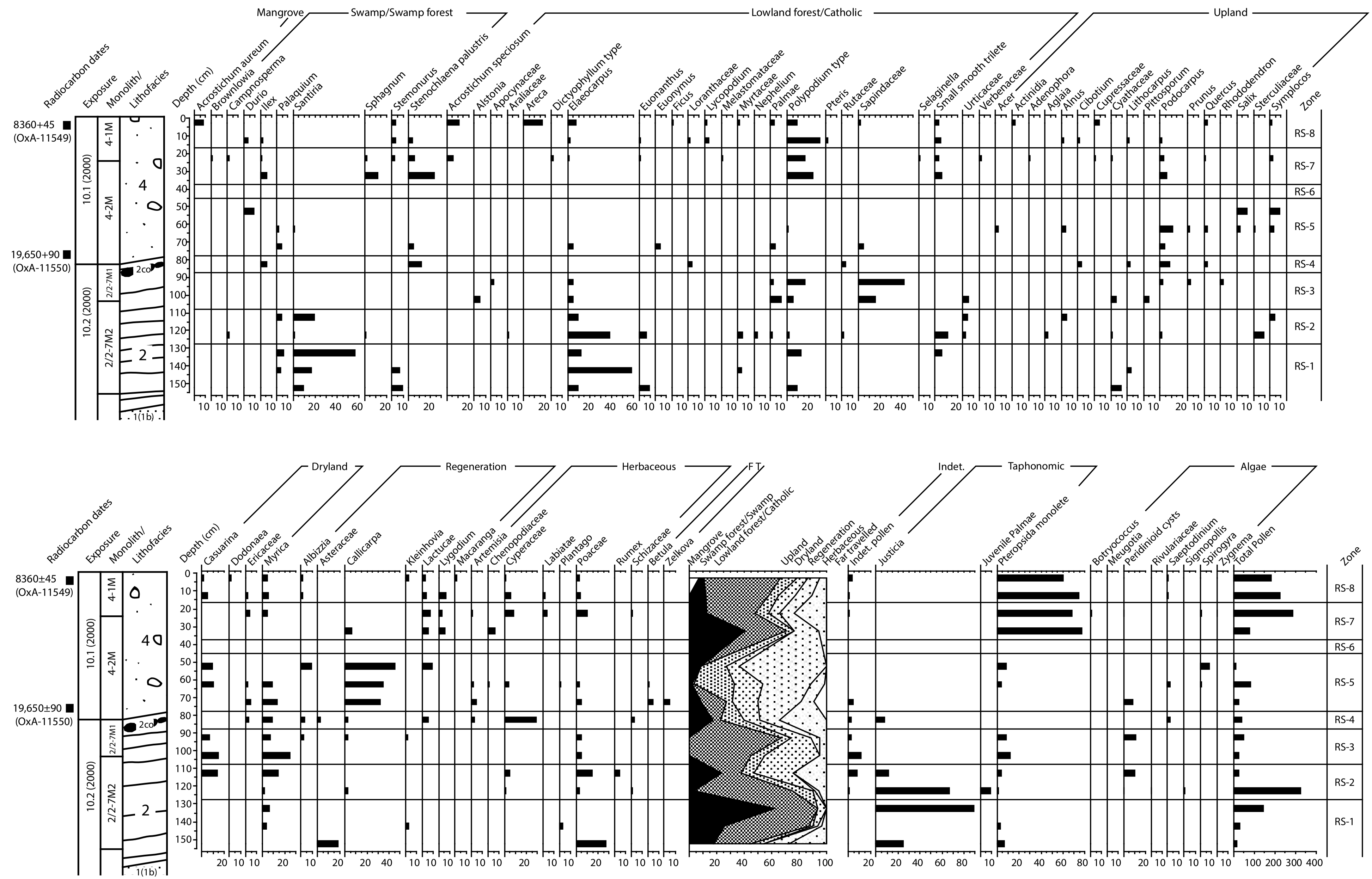


**Figure S8.7**. *Pollen diagram from Monoliths 2/2-7M1 and 2/2-7M2 in Sections 10.1(2000) and 10.2(2000) in Area A, Block B. (After Hunt* et al. *2012.)*

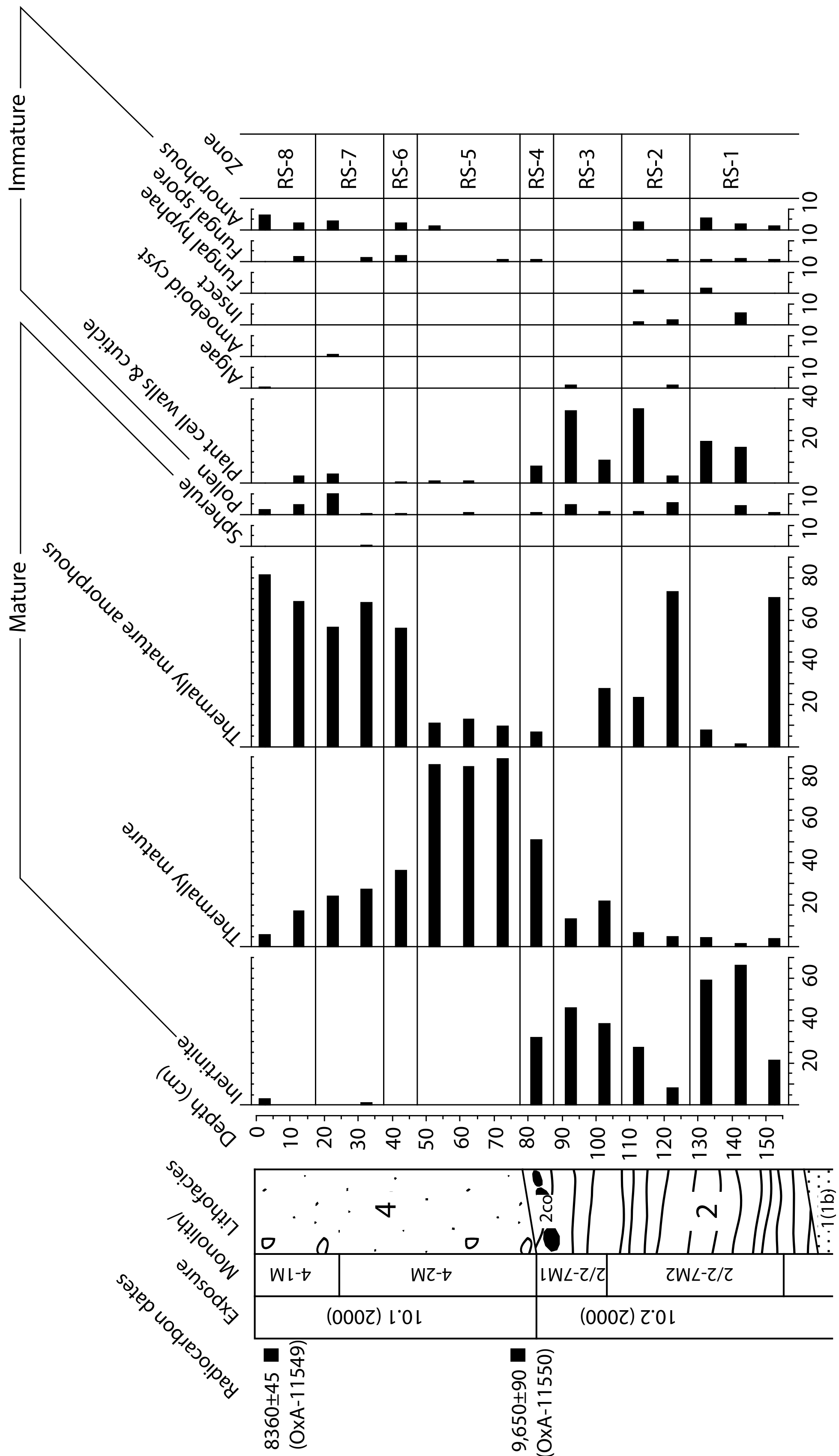



**Figure S8.8**. *Palynofacies diagram from Monoliths 2/2-7M1 and 2/2-7M2 in Sections 10.1(2000) and 10.2(2000) in Area A, Block B. (After Hunt* et al. *2012.)*

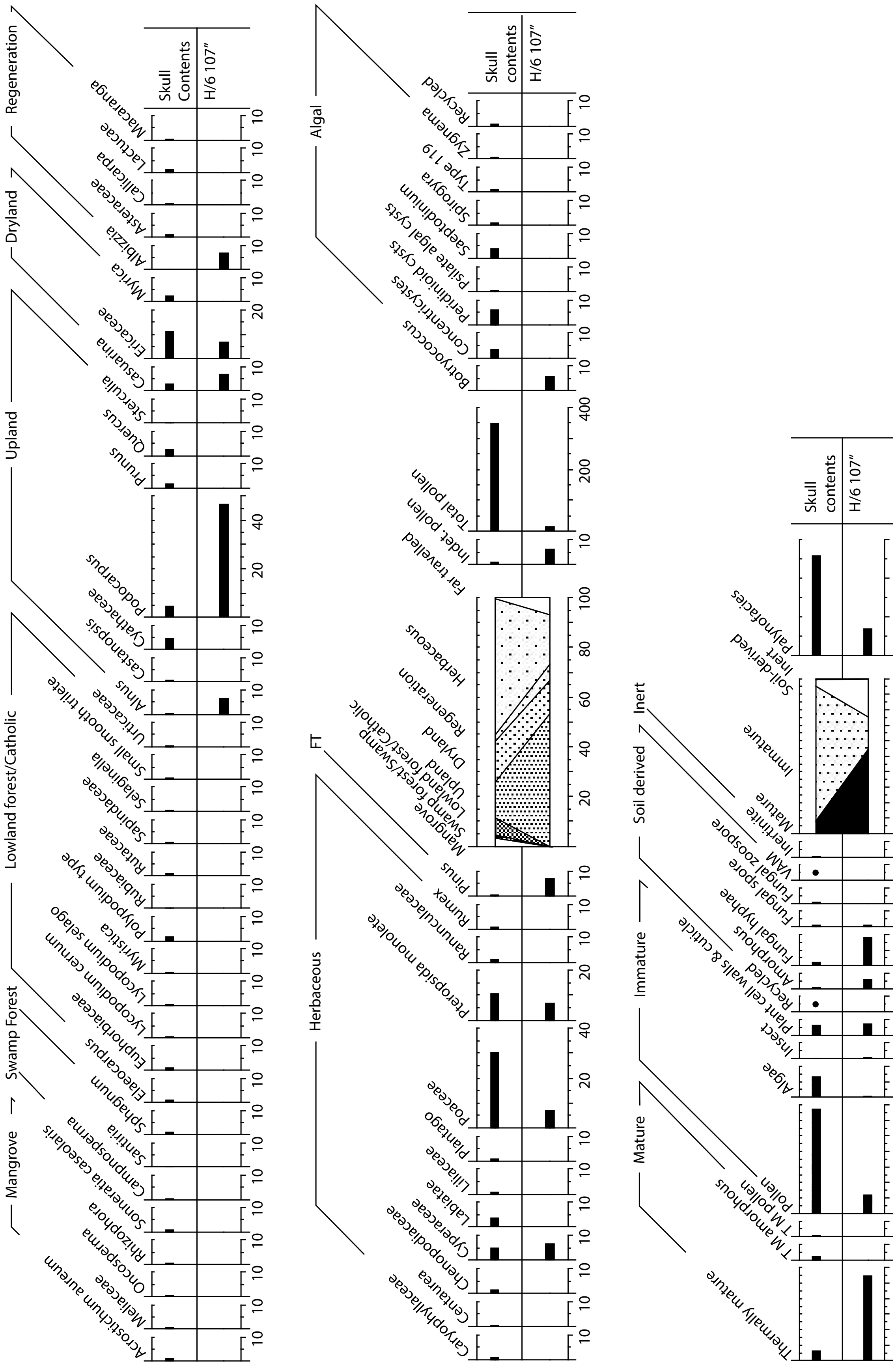



**Figure S8.9.** *Pollen and palynofacies diagram from the 'Deep Skull' and from a nearby context ('Soil from around Skull at H/6 107" Niah 15-2-58'). (After Hunt* et al. *2012.)*

probable that the material in this sample was laid down during a stadial.

**The Deep Skull contents (Hell Trench)**

The location of the 'Deep Skull' is well-resolved spatially (Barker *et al*. 2007), but its stratigraphical affinities are unclear from the available information, since if taken at face value the U/Th date of 35.2 ± 2.6 ka on bone from the skull (Chapter 13) is significantly younger than the dates for Lithofacies 2, from which geometric reconstructions of the stratigraphy would suggest it derives. The assemblage (Fig. S8.9) is dominated by herbaceous taxa, mostly Poaceae, but also Pteropsida, Cyperaceae, Labiatae, Caryophyllaceae, Chenopodiaceae, Ranunculaceae and *Rumex*. Dryland species – Ericaceae, *Casuarina* and *Myrica* – and upland species such as *Podocarpus*, *Prunus* and *Quercus* are also apparent, with a wide variety of other taxa from mangrove, swamp forest and lowland forest also present. The high incidence of herbaceous taxa and the presence of altitudinally limited taxa such as *Prunus* and *Alnus* suggest stadial conditions and depressed temperatures (below 23°C) compared with the present day. The presence of back-mangrove, lowland forest and swamp forest taxa might be taken to suggest that lowland and coastal vegetation was not far away but an alternative explanation is that this is a mixed assemblage as a result of the secondary burial of the skull (Hunt & Barker 2014).

**Exposure W/X1: Monoliths 3/2-1M and 3/2-2M (Area A)**

These monoliths lie in the upper part of Lithofacies 3 (the 'pink and white silts') and the base of Lithofacies 4 ('brown silts with anthropogenic deposits'), and thus lie stratigraphically above the Deep Skull and monoliths discussed above. It is likely that the base of Lithofacies 4 relates to NGRIP interstadial 8 and Lithofacies 3 to the preceding stadial, since these are cut into by pits of Lithofacies 4 (Fig. 8.9).

Pollen assemblages are sparse in Lithofacies 3 (zone M-1) and are characterized by high values of *Callicarpa* (Fig. S8.10). Herbaceous, dryland and montane species are also fairly common. The assemblages of the overlying Unit 4 (zone M-2) are characterized at first by relatively high *Callicarpa* and high values for the lowland forest *Elaeocarpus* and then by lower *Elaeocarpus* and high values for the front-mangrove *Avicennia*.

Dykes (2007; and this volume, Chapter 5, Supplementary Material 2) suggests that the mudflow deposits of Lithofacies 3 accumulated as the result of a very shallow but widespread failure and liquefaction of what were then recently deposited sediments on the cave floor. It is thus suggested that the pollen in the Lithofacies 3 mudflow deposits relates to deposition in the period immediately before the emplacement of the deposits. A number of taxa, such as *Acer, Alnus, Albizzia* and *Prunus*, today appear to be restricted altitudinally in Borneo to above 400–1000 m, perhaps suggesting temperatures no higher than 22°C. *Callicarpa* is often associated with regenerating forest (Bramley 2009) and appears to be characteristic of the late stages of regeneration in Area A at Niah (as discussed above). It is also extremely common in deposits relating to the Last Glacial Maximum at Niah (discussed below). Tentatively, it is suggested that the Lithofacies 3 assemblage reflects the aftermath of climatic disturbance of vegetation around Niah during a period of stadial climate. The contact with Lithofacies 4 was probably erosive, so it is likely that the basal assemblage in Lithofacies 4 is partly recycled, but the high *Elaeocarpus* probably reflects the development of lowland forest. High *Avicennia* in the higher sample probably reflects a marine highstand with the sea close to the cave mouth.

Five phytolith samples were analysed from Monolith 3/2 1M, of which only the bottom three (20–50 cm) had more than 100 phytoliths per sample (Fig. S8.11). These samples contained a diverse set of phytolith types. All samples included arboreal dicotyledon forms, tissue, and starch. The 20–30 cm sample included the most diverse range of taxa, including Panicoid grass (several, some burned), other grass, Arecaceae (many, some burned), Burseraceae, Urticaceae, Fabaceae, Sterculiaceae, Lamiaceae, arboreal tissue, LRS (*Dioscorea* sp.), MFP (many; possible *Lithocarpus*), Moraceae; possible Marantaceae, arboreal tissue (many). Two samples had a few Poaceae (Panicoid and Bambusoid) phytoliths. Starch grains were present in all five samples, but abundant in two (20–30 and 40–50 cm). The 20–30 cm sample had very abundant epidermal tissue, palms, burned silica, and diatoms. The samples with the most abundant phytoliths also contained the most diversity, potentially suggesting sampling issues. The diatoms may relate to ponding episodes in the depositional process but were more likely introduced from outside the cave. The mix of plant material, including starch, evidence of burning, and diatoms suggest a combination of cultural and environmental processes. While the arboreal component remains strong in these samples, a few possible additional taxa are herbaceous: Lamiaceae, Marantaceae, *Dioscorea*. This mix would seem to include at least multiple activities, if cultural, and possibly a sample of the local vegetation.

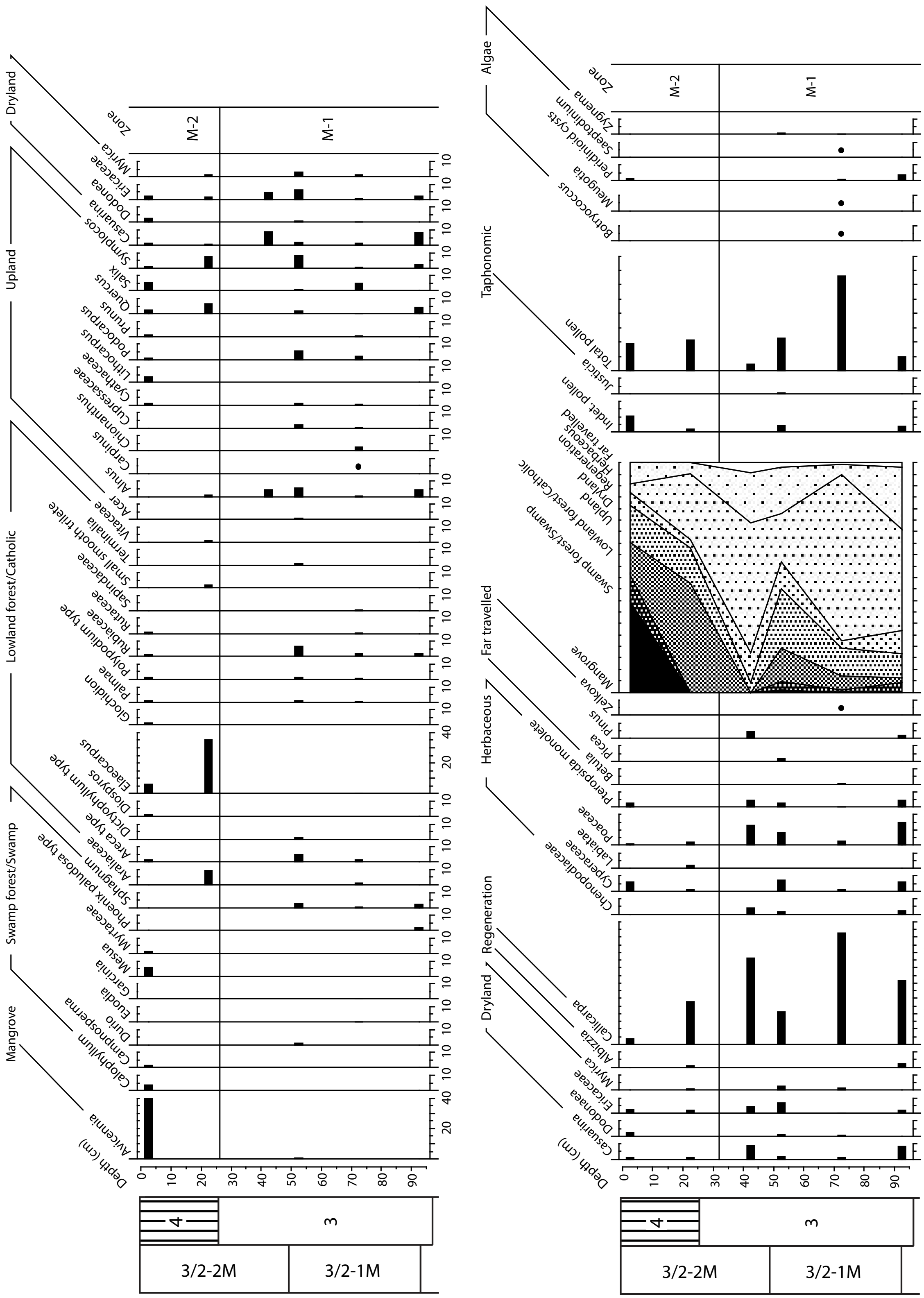



**Figure S8.10**. *Pollen diagram from Monoliths 3/2-1M and 3/2-2M in Section W/XI. (After Hunt et al. 2012.)*

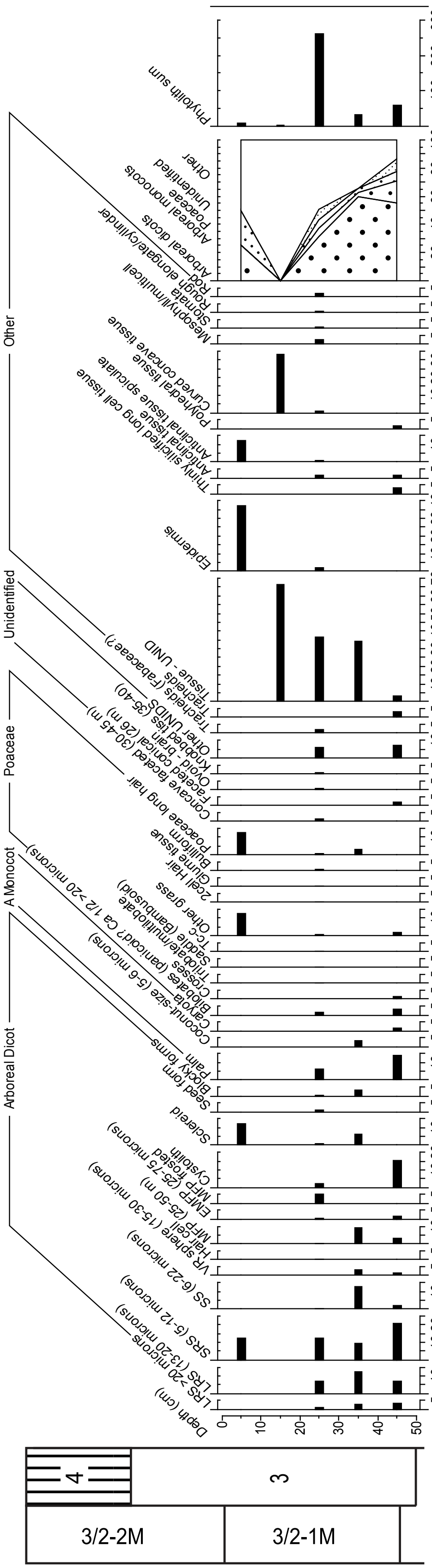



**Figure S8.11**. *Phytolith diagram from Monolith 3/2-1M in Section W/XI. (After Hunt* et al. 2012.)

The overall distribution of general types of phytoliths is uniform. Grasses are very rare in this assemblage. Given the abundant production of grass phytoliths relative to dicot taxa, their rarity reflects a real rarity of grass use, and likely a rarity of grass in the immediate area contemporary with these samples. Arboreal dicotyledon forms and tissue are the most abundant phytolith forms (various spherical and multifaceted forms). Palm phytoliths are relatively common, as are starch grains, but within these broad categories the diversity of tissue and phytolith types is great. This suggests two possible interpretations of this type of assemblage (or a combination of both): a very diverse set of cultural activities, sometimes (early in particular) dominated by starch and food plants, and sometimes a mix of botanical material culture and food, or deposition of plant materials from outside the cave in these deposits (by way of wind, water, or animal vectors). As these assemblages derive from mudflow sediments, the assemblages may be mixed, since the flow may have incorporated material from different contexts. Nevertheless, the phytoliths provide important evidence of human activity in the cave prior to the depositional event.

**Section 2.1 (Area B)**

Four samples from Section 2.1 in Area B were analysed for phytoliths (Fig. S8.12). The section is in sediments of Lithofacies 4 dated between *c.* 39,000 and *c.* 29,000 BP and contains a series of intercutting pits (Volume 1: Fig. 3.29; this volume: Fig. 3.21).

A range of individual phytolith forms in Context 2091 were consistent with Urticaceae/Moraceae (cystolith and hair cells), Urticaceae (cystolith), Bambusoid saddle (leaf), palm tissue, and 5–6 types of unidentified arboreal and dicot tissue. Additionally, this context contained significant quantities of starch grains (over two thirds of these were >10 microns) together with relatively abundant micro-charcoal. Bamboo species have a variety of uses from tools (sharpened) to fibres. Context 2151 in the ‘pit’ sequence had very small counts of plant tissue and starch and burned silica. Context 2084 is one of the uppermost layers that cap the residual baulk containing the ‘pit’ sequence. While undated, it lies immediately above Context 2085 which is dated to 29,070 ± 220 bp or 33,121–34,518 cal. BP (OxA-11303). It had few phytoliths but a considerable number of starch grains. Phytolith forms were consistent with Urticaceae, Moraceae, Myrtaceae, *Macaranga* sp., and palm tissue. Economic uses for Urticaceae species include edible greens and fibres for rope or twine. Moraceae species include many different edible fruits (jack fruit, white mulberry, figs, etc.) and can also be used for fiber (tapa) and wood. Palms have many uses from edible palm nuts and palm pith (sago) to food containers to leaves used to create mats for floor or shelter. *Macaranga* species are colonizers in secondary forests, and have limited medicinal uses and can be used for fibre. The abundance of starch as well as leaf phytoliths suggests a combination of both edible and fibre/tool use.

**Section 10.1(2000) (Area A, Block B): Monoliths 4-1M and 4-2M**

These monoliths come from one of the small remnants of Lithofacies 4 in Area A, Block B, which was largely removed during the early excavations of the cave (Volume 1: Fig. 3.25). A radiocarbon date of 19,650 ± 90 bp or 23086–23859 cal. BP (OxA-11550) was obtained from adjacent to the bottom of Monolith 4-2M and a further date of 8630 ± 45 bp or 9350–9688 cal. BP (OxA-11549) was obtained close to the top of Monolith 4-1M (Figs S8.13 and S8.8). The monoliths thus provide a (probably episodic) record from the LGM to the Early Holocene.

The assemblages from the lower part of Lithofacies 4 in Monolith 4-2M (RS-5) are dominated by disturbance taxa, principally *Callicarpa.* A range of herbaceous taxa are present in the lower part of the zone. Dryland and upland species are also prominent. There is then an interval with no pollen preservation and very abundant thermally mature material (RS-6). The upper part of the sequence (RS-7, RS-8) in Monoliths 4-2M and 4-1M is characterized by poorly preserved assemblages heavily dominated by Pteropsida, with *Polypodium* and a variety of lowland forest taxa.

The virtual disappearance of lowland taxa in RS-5 (of those species present *Palaquium*, *Santiria*, *Elaeocarpus* and *Euonymus* are all tolerant of relatively high altitudes: Fig. 8.1) and the high numbers of upland taxa and altitudinally restricted species such as *Acer, Albizzia, Alnus* and *Prunus* suggest depressed temperatures relative to today, perhaps *c.* 21°C or lower. Relatively high counts for dryland species such as *Casuarina, Myrica* and Ericaceae point to relatively low effective precipitation. Some open-ground taxa and very high counts for *Callicarpa* point to climatically disrupted and unstable vegetation but there is little evidence for fully open vegetation at this time.

Almost certainly there is then a stratigraphic break during RS-6. The generally poor state of preservation and very high counts for fern spores in RS-7 and RS-8 suggest that these assemblages may be somewhat biased. Some open-ground taxa and regeneration taxa

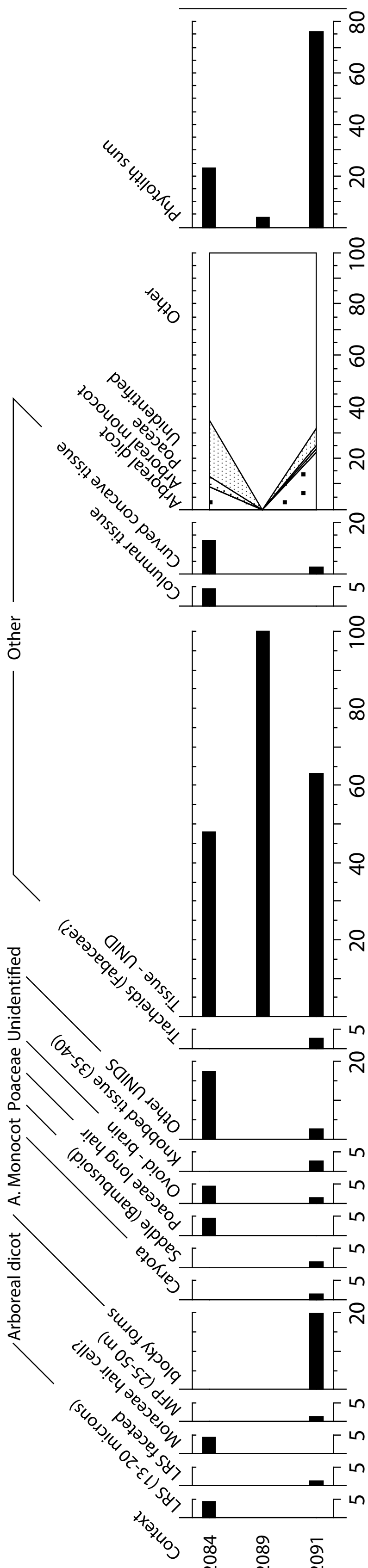



**Figure S8.12**. *Phytolith diagram from Section 2.1 in Area B. (After Hunt* et al. 2012.)

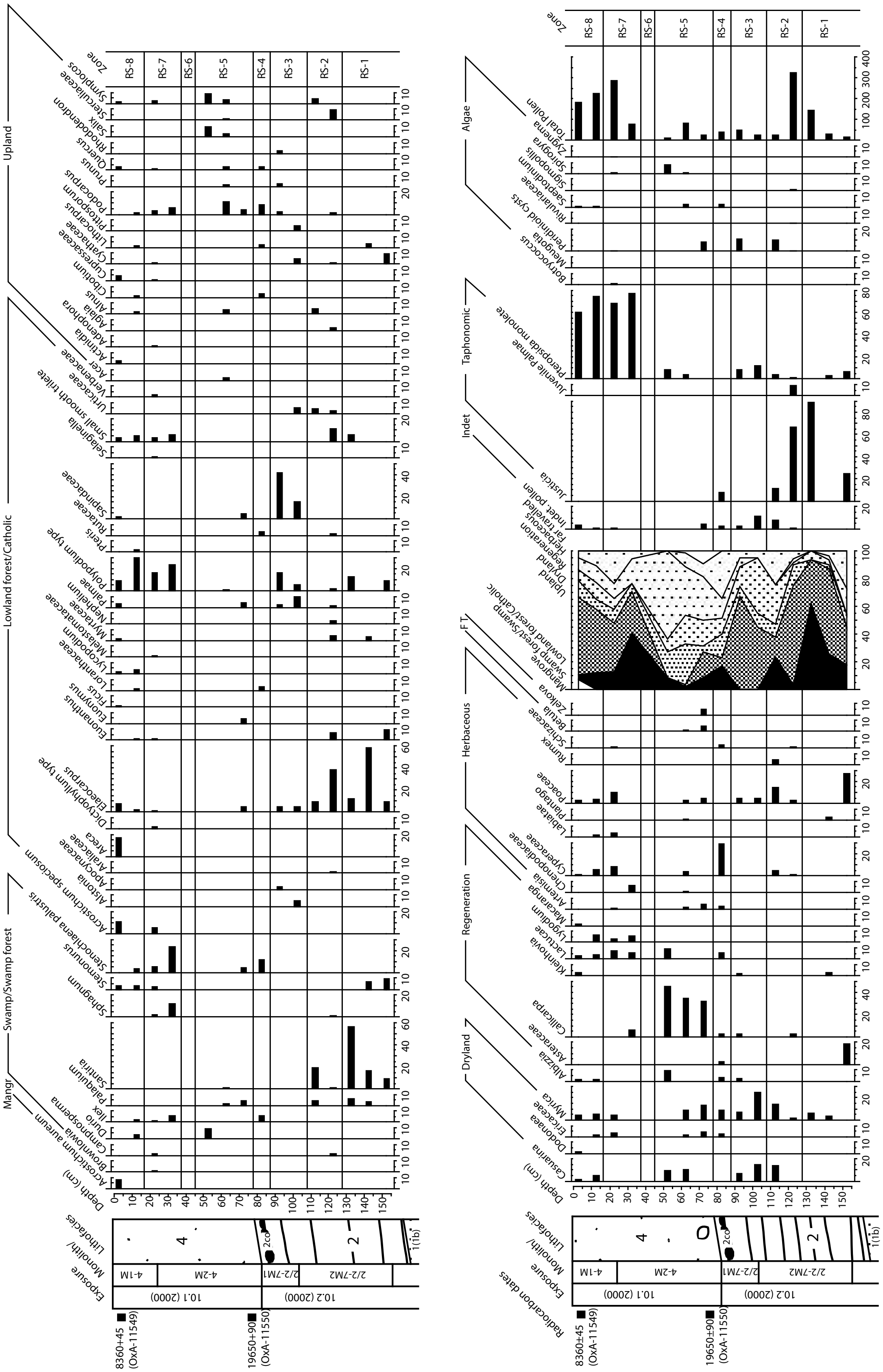



**Figure S8.13**. *Pollen diagram from Monoliths 4-1M and 4-2M in Area A, Section 10.1. (After Hunt* et al. *2012.)*

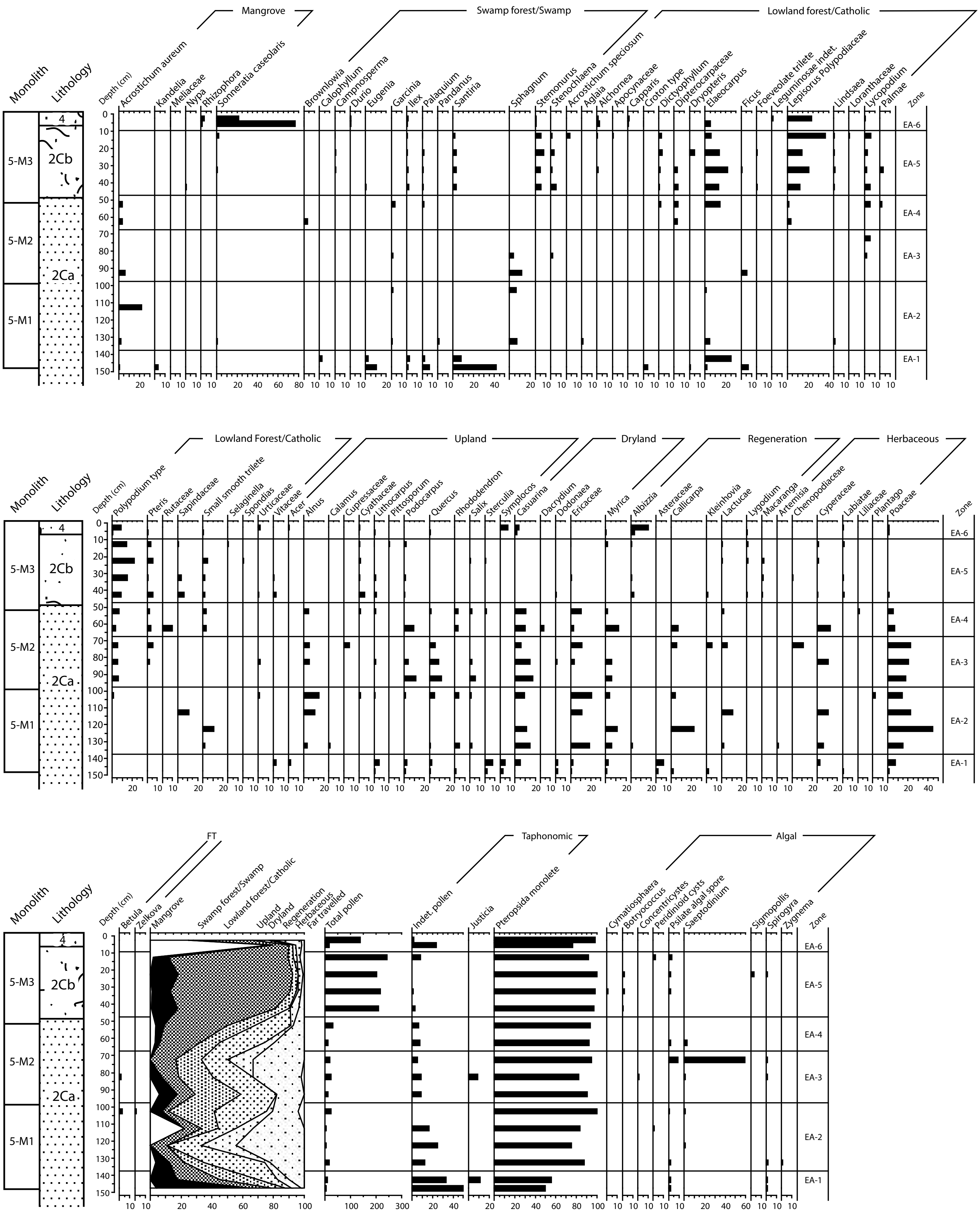



**Figure S8.14**. *Pollen diagram from Monoliths 5-M1 to 5-M3 in Section 5M/Z10. (After Hunt* et al. *2012.)*

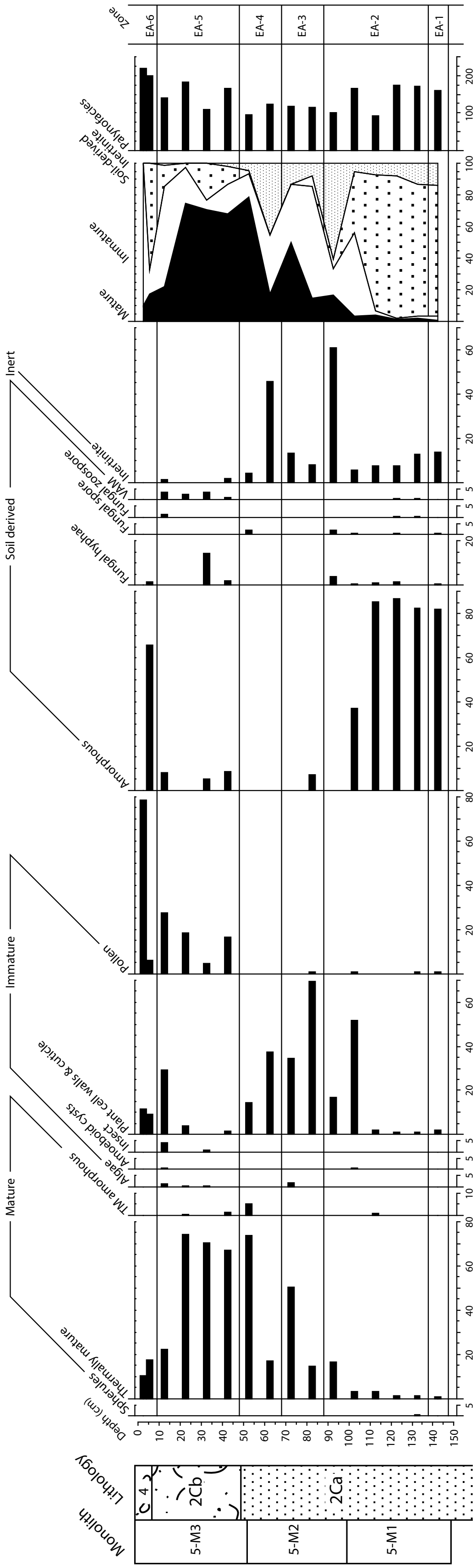



**Figure S8.15**. *Palynofacies diagram from Monoliths 5-M1 to 5-M3 in Section 5M/Z10. (After Hunt* et al. *2012.)*

and the rise in diversity of lowland forest and swamp forest taxa may reflect the re-establishment of forest in the Early Holocene. Deposition seems to have ended before the local encroachment of mangroves.

**Section 5M/Z10 (edge of Area A): Monoliths 5-M1 to 5-M3**

These monoliths (Figs S8.14, S8.15) come from the northwestern edge of the excavated area, from Lithofacies 2Ca, 2Cb and 4. There are no radiocarbon dates in the sampled sequence, but its top runs close to the pre-1950s surface of the cave sediments. The basal pollen assemblages (zone EA-1) in this sequence are comparable with assemblages RS-1 and RS-2 from Monolith 2/2-7M2 (Fig. S8.7), which are in sediments attributed to Lithofacies 2 and stratigraphically below a radiocarbon date of 19,650 ± 90 bp or 23,086–23,859 cal. BP (OxA-11550). If this correlation can be upheld, it is tentatively suggested that a non-sequence (hiatus) separates the sediments containing Zone EA-1, at the base of the section, from the layers above this containing pollen zones EA-2 to EA-6.

The basal zone EA-1 is characterized by high percentages of *Santiria* and other swamp forest species, and of *Elaeocarpus* and other lowland forest taxa. In Zone EA-2, Poaceae are very high, the dryland taxa *Casuarina, Myrica* and Ericaceae are also important, and disturbance taxa, including *Callicarpa,* sometimes also prominent. Poaceae remain high in EA-3, with abundant and diverse dryland and montane taxa. In EA-4, Poaceae decline, the dryland taxa remain prominent, but lowland species rise. Dryland and open-ground taxa decline further, but lowland forest taxa remain high during EA-5 and EA-6. Swamp forest taxa appear in EA-5 and the mangroves *Sonneratia* and *Rhizophora* become important in EA-6.

The high incidence of swamp and lowland forest taxa in Zone EA-1 and the low incidence of dryland taxa are consistent with sediments of this zone being laid down in a warm humid climate. A sharp decrease in swamp and lowland forest taxa and rise in upland, dryland, regeneration and herbaceous taxa in EA-2 suggest cooling, desiccation and the disruption and opening of vegetation. High Poaceae and some Cyperaceae point to open areas. It is possible that the short peak in *Callicarpa* in this zone is stratigraphically equivalent to the peak of this species at the LGM in RS-5. EA-3 is characterized by a peak in *Quercus,* a continued dominance of herbaceous, dryland and upland taxa and a continued absence of lowland and swamp forest species. *Quercus* is most prevalent in modern vegetation and pollen rain between 1000 and 1600 m (Flenley 1973; Kitayama 1992), thus suggesting climatic cooling to *c.* 19–22°C. Dryland taxa remain significant in EA-4, but the appearance of lowland taxa such as the Dipterocarpaceae suggests that temperatures had risen considerably, while precipitation was still relatively low. Swamp forest taxa appear and lowland forest taxa rise in EA-5, which is generally comparable with assemblages in RS-8 and thus likely to be of Early Holocene age. Mangroves become very common in EA-6, most probably reflecting the Mid-Holocene marine incursion reported by Hunt and Rushworth (2005b).