Portuguese margin. Pollen analysis of the MIS 7 sequence of I-284 will enable us to characterise the pattern and nature of the vegetation response to the specific combinations of global climatic parameters (atmospheric carbon dioxide, insolation, ice volume) in each of the MIS 7 substages, and clarify the relative vegetational and climatic status of each one.

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Rates, causes and mechanisms governing long-term patterns in plant species richness: evidence from the 320,000 year pollen record of Pula Maar, Hungary

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For too long there has been a major gulf between models used to identify and understand the processes and mechanisms governing spatial patterns of plant species richness and those governing temporal patterns. In many spatial models, the temporal scale is at worst ignored, at best the assumption is made that the data is too coarse in scale to provide any meaningful ecological results. In temporal models, there are far too many examples where modelling of the long-term fossil records have focused entirely upon their use in climatic reconstruction with little or no attention paid the overall patterns in species richness observable through time.

In this paper, new modelling of the long-term palaeecological data from Pula maar, a 3 million-year-old crater lake in northeastern Hungary (WILLIS *et al* 1999a; 1999b), will be presented. The sediments in this crater are exceptional in that yearly accumulation is recognisable in the structure and provide a 320,000 year fossil record deposited between 3-2.67 Ma with an 'in-built' timescale of annual resolution. This dataset therefore represents multiple temporal changes in taxonomic richness through time.

Using models developed to primarily understand the spatial relationship of species richness to energy and water, we have compared variations in taxonomic richness in the 320,000 year fossil sequence to calculated orbital insolation (as a proxy for energy), and paleo-proxies for water. Results from this study indicate that such an approach can provide important information on the relative roles of water and energy in accounting for species richness through time. Interestingly, however, results also indicate that it is not only the amount of energy/precipitation that affects richness but also the amplitude of the variation.

These results have important implications for understanding both the relationship of present day species richness to climatic variables and also for predicting future trends with increasing variability of climate.

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TAPHONOMY AND ARCHAEOLOGICAL PALYNOLOGY

Secrets of the Bilge: Piecing together the Microbotanical Remains of a 3,300-year-old Shipwreck

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The Uluburun shipwreck was found off the Mediterranean coast of Turkey, near the modern town of Kas. Excavations conducted from 1984 to 1994 uncovered a wealth of artifacts that provide extensive insight into the sea-borne trade of the Late Bronze Age. Among the various artifacts comprising the cargo were 354 rectangular-shaped, 'oxhide' ingots of pure copper, which were all recovered. Over the course of the ten-year excavation campaign, more than 100 microbotanical sediment samples were collected from the wreck site by the excavators for later palynological analysis, using the techniques outlined by Weinstein (1996) and Gorham and Bryant (2001). Of these, thirty were associated with copper oxhide ingots. These thirty sediment samples represent material found mainly sandwiched between the ingots, including dunnage, or plant material used for packaging and cushioning the ingots and other artifacts. The oxhide ingots also served as ballast for the ship, so the sediment samples are thought to have been in direct contact with water and detritus found in the ship's bilge. Due to the anoxic environment created by the presence of copper in such large quantities, unusual organic remains such as murex opercula were found among the ingots (Pulak, 2001:32). Preliminary analysis has confirmed that the sediment samples from the oxhide ingots also contain well-preserved botanical materials, including pollen. Once all the ingot samples have been analyzed, pollen types and concentrations will be plotted across the wreck site to determine if any correlations with other artifacts may be generated. Since the ingot samples come from a contamination-compromised environment which is also anoxic, a complete analysis of this group of samples should provide a substantial background portrait of pollen taxa to which the spectrum of taxa from more securely-contained samples could be compared. Such a comparison also will allow issues of contamination or low preservation in certain cargo containers to be more accurately addressed.

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Archaeological plant resins in the Mediterranean: Pollen extraction and analysis

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Shipwreck sites are known to be a wealth of information, nevertheless, more avenues are available for closer examination. Found on some shipwrecks are amphora filled with various types of resins used for trade, used as a sealant lining the inside the amphora, or resins used as an additive to flavour some foods, such as wine. Resins are plant based and due to their composition are highly preservable. Pollen trapped in resins can identify the type and origin of the resin sample. However, recovering fossil pollen from resins have presented a myriad of problems. Resins are distinguished from tar and pitch by the purity of the sample and the plant source from which

they originate, nevertheless, the use of the term may be a misnomer because many plant exudates consist of resins, gums, mucilages, oils (fats), waxes, and latex. Some of these conglomerates may be separated and identified through the use of mass spectrometry, yet, solvents that reduce resins to liquids are not always conducive for the recovery of fossil pollen and spores. Eleven resin samples identified as "resins" were recovered from the shipwreck site of Tektas Burnu and were then examined for fossil pollen. Several methodologies were attempted, yet one method has proven to be more effective than any of the others, regardless of composition of the resin sample analyzed. Although the size in these samples is small, pollen was recovered suggesting that the recovery technique is valid and that the examination of larger size samples should reveal significantly more information about each sample.

Record of poaceous phytoliths from an archaeological site of west Bengal, India

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Rich and diverse phytoliths (opaline silica bodies of plant origin) of poaceous affinity are recovered from soil samples of an archaeological site of Pakhanna (23° 25' N, 87° 23' E), District Bankura, West Bengal, India. The sediments have been dated as 2110 ± 340 years B.P and correlable with the Pre- metal Early village Farming community culture. The recovered phytoliths are grouped under Chloridoid, Panicoid and a type combining characteristics of both Panicoid and Festucoid classes (as observed in Bambuseae). Panicoid and Chloridoid types are recovered from all the six soil samples of different depths of the studied trench but the former occurs in higher frequency (71.3%-94.95%) than the latter (6.01%-19.4%). The third type (Bambuseae) was infrequent(6.5%) and recovered from only one sample.

Two types of panicoid phytoliths viz., cross shaped and dumbbell shaped, have been observed among which cross shaped ones types are more frequent than dumbbell shaped ones. A high percentage of variant.1 cross and low percentage of variant .6 cross (among the 8 variants of cross shaped phytoliths described by Piperno,1984) suggesting affinity towards cultivated panicoid species *Zea mays* occurred at the upper depths. High percentage of variant .6 cross and low percentage of variant.1 cross, characteristic of wild panicoid grasses, occurred at the lower depths of the excavated trench.

In addition to the phytoliths, the presently studied samples recovered rice grain, pulses and oil seeds. The present data on phytolith study suggests that maize was another major cereal crop cultivated by the people of Pre-metal Early village Farming community of this part of Eastern India about 2110 ± 340 years B.P.

Pandanus back-swamps to Taro fields-pollen-based chronologies and the taphonomy of agricultural soils in the Pacific: an example from Rapa Island, French Polynesia

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Confusion has reigned ever since palynological techniques were employed in attempts at defining human influence on Pacific Islands. Much of this confusion has been fuelled by some contentious assumptions as to how human activity may be represented in palaeoenvironmental records. The palynological understanding of how humans have influenced vegetation change has to a greater degree rested on the identification of anthropogenic marker taxa. Such taxa may be represented as a direct result of people such as introduced cultigens, or represent a more indirect response to human activity such as an increased contribution of 'weeds'. The concentration on more conventional pollen depositional sites (e.g. crater lakes or large 'unmodified' peat systems) on the Pacific Islands with their inherent taphonomic integrity and potential to retain continuous climatic records, has resulted in the identification of few if any marker taxa. Instead, identifying changes in fire frequency and

sedimentation rates beyond a 'natural' regime has become tantamount with the onset of human activity on islands. In order to connect these claims for anthropogenic burning with the palynological record 'pyrophytic' taxa such as the ferns *Histiopteris incisa* (Pacific-wide) and *Pteridium esculentum* (in New Zealand) but also Poaceae have been utilised. Recently there have been moves away from these conventional sites in order to more adequately support attempts to understand the nature of human settlement on the Pacific Islands.

Rapa Island (lat. 27 °37'S and lon. 144 °20'W) in the Austral Archipelago, French Polynesia, provided an opportunity to explore some alternative sites for palaeoenvironmental investigation. The island was colonised by Austronesian speaking people by ~720 yrs BP (archaeological charcoal). The island represents a highly eroded tertiary (5.1 Ma K-Ar age) volcanic caldera drowned on the southeast side forming a protected harbour. A series of six sedimentary cores were obtained from a back-swamp deposit at the interface between the lower valley fill and lagoon at the harbour head. The modern swamp surface represents a remnant of a formerly extensive taro (*Colocasia esculenta* introduced by Pacific Islanders) pondfield agricultural system abandoned since the early 1900s. Each core was placed 20m apart running along a 120m transect perpendicular to the lagoon shore. Each core has been dated revealing pre-human sedimentary bases for each, with all cores sampled for pollen. Such a high spatial resolution approach was attempted in an effort to resolve the potential taphonomic problems inherent in such active depositional sites.

Colocasia esculenta pollen, rare in Pacific Island records, was identified from four of the cores in what is thought to be an agricultural soil immediately beneath the modern swamp surface. Underlying this soil is a peaty sequence dominated by up to 95% *Pandanus* pollen with associated macroremains. Significantly, a palm species (closely aligned with *Howeia forsteriana*, endemic to Lord Howe Is), absent from historic records, falls out of the record with the advent of *Colocasia* and is now extinct on island. The amorphous nature of the soil pollen record and a lack of plant macroremains meant that attempts at AMS C14 dating were reduced by taphonomic constraints. To resolve such constraints AMS dates on pollen-fractions were attempted on samples across a range of the cores including:

Soil samples with no pollen of 'modern' character e.g. historically introduced plants.

Pandanus dominant pollen-fractions from samples at the soil/peat interface.

The dates obtained produced a palynological-based timeframe for human activity that broadly fits within the chronology suggested by the island's archaeological record. They also provide a chronology that far exceeds the resolution achieved by other Pacific Island palaeoenvironmental studies based primarily on bulk sediment dates. This chronology has allowed for a greater level of interpretation of the palynological data and has extended the depth of its application to the archaeological record.

Anthropogenic environmental change and initial settlement in New Zealand

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Over the past twenty years, there has been vigorous debate, concerning the timing of first human settlement in New Zealand. Three chronologies have emerged: 1) first human settlement occurred no longer than 600 years ago; 2) it occurred about 1000 years ago; 3) it occurred at least 1400 years ago. The shorter chronologies have relied mainly on radiocarbon dating of archaeological material. Such dates are minimum ages because the site of first settlement may have been missed. Visible or identifiable archaeological evidence most likely represents a period of established settlement (when a population is of sufficient size to be viable long-term); therefore, palynological data has played a major role in establishing an initial date of settlement. Palynological evidence of anthropogenic environmental change has traditionally focused on two aspects of agricultural activities: clearance of indigenous plants and cultivation of domesticated plants. In the pollen record, these activities are signalled by the decline of indigenous plants, the presence of abundant microscopic charcoal particles, the presence of cultigens, and the presence of weeds associated with agriculture. It is well documented by early European explorers in New Zealand that prehistoric Polynesians (the indigenous population) cleared huge tracts of forest through burning, to provide space for settlement building and to grow crops. The palynological signature of these events may be detected in sedimentary deposits, without the exact site of disturbance needing to be discovered. However, controversy has arisen surrounding the recognition of the palynological signal of human impact on the environment in New Zealand because of the lack of pollen and spores of prehistoric cultigens and weeds associated with agriculture.

It is now generally accepted that a rapid loss of forest and coincident rapid rise and sustained abundance in the pioneer plants of *Pteridium esculentum* and wild grass, from about 800 to 600 yr ago, results from anthropogenic burning. This has been interpreted as the palynological signal of initial human impact on the environment of New Zealand. Recently, Flenley & Todd (2001) have argued that this may not be the palynological signal of initial human impact, but rather the establishment of the use of the *Pteridium* rhizome as a staple food, which allowed people to settle areas previously uninhabitable because of lack of a suitable crop. They proposed that small and sometimes intermittent occurrences of *Pteridium* prior to the rapid increase might reflect small temporary clearings in the forest, used to grow crops for a few years and then abandoned. In this situation, *Pteridium* is a weed in the abandoned gardens, and may disappear as forest regenerates. They proposed that colonization was a two-stage process. In the initial stage, colonization was limited to coastal areas, and the north, because of the need to grow tropical crops. The second stage occurred after the development of the technology to produce the *Pteridium* rhizome as a crop and food resource.

As part of multidisciplinary research, sedimentological and palynological study of lake sediments from a small coastal catchment, in a region where early settlement may be expected to have occurred, was undertaken to reconstruct erosion, vegetation, and fire histories. Tephrochronology and AMS dating of pollen and spore concentrates were used to construct a chronology. Between *c.* 1600 BC and AD 1200 a conifer/broadleaved forest surrounded the lake. At *c.* AD 1200, forest was rapidly replaced by fire-induced scrub. The unprecedented magnitude and rapidity of this deforestation clearly signals anthropogenic agency, and marks the beginning of established settlement. At *c.* AD 1400, a short erosion event coincides with local fire and is probably a consequence of anthropogenic burning. After European settlement in AD 1850, European-introduced plants appear in the pollen record and extensive pasture was established. Following the Flenley & Todd (2001) scenario, small sporadic occurrences of *Pteridium* spores prior to 1200 AD may be indicative of small coastal settlements, perhaps during initial colonization before the *Pteridium* rhizome was cultivated. However, similar occurrences of *Pteridium* are known from deposits even beyond the time of possible discovery journeys to New Zealand. Local erosion events during this period are not accompanied by deposition of charcoal, so probably result from landslides caused by severe storms or tectonics. Low abundance of small charcoal particles probably results from distant infrequent fires, induced either naturally or anthropogenically.

FLENLEY, J.R. & TODD, A. 2001. A Genome or a Memome: the cause of the rise of bracken fern at around 700 BP in New Zealand. In: M. JONES & P. SHEPPARD (eds.), Australasian Connections and New Directions. **Proceedings of the 7th Australasian Archaeometry Conference 2001**, pp. 141-154.

Quantitative relations between archaeological and palynological data at multiple sites in Denmark

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Traditionally, pollen records from periods influenced by agriculture have been interpreted qualitatively using changes in indicator pollen types. Mostly, increases in palynological "anthropogenic indicators" have been takes as evidence of intensification of land-use. One potential approach of validating such interpretations is a comparison with independent lines of evidence for human activity. Ideally, such evidence would relate directly to agricultural practices such as ploughs, spades, fossil field systems or remains of domesticated animals. Such direct evidence of agriculture does exist but usually not in quantities that will allow numerical comparison with pollen data. Instead, we have used crude numbers of all types of archaeological finds stored in the national database of cultural history in Copenhagen as independent evidence of the cultural impact at landscape level. Most archaeological finds in this database relate to graves or stray finds of stone tools but we hypothesised that the geographical distribution of such finds would reflect the degree of agricultural disturbance at the landscape level. Pollen data from 14 lakes of roughly similar size were collected and divided stratigraphically into 11 archaeological periods covering the last 6000 years. Archaeological data from within 10 km around each site were retrieved from the database and compared to the pollen records of the same periods. To mimic the "pollen view of the landscape" archaeological data were down-weighted according to distance using a variety of weighting

functions. In this way higher weights were given to finds closer to the lakes than further away. Canonical ordinations with associated permutation tests for significance indicated highly significant relationships between the crude number of archaeological finds and major gradients in pollen data. This was especially true for periods with many grave finds and for classical palynological indicators of agriculture such as *Plantago lanceolata, Chenopodiaceae, Artemisia* and *Cichorioideae*. Some patterns were obscured by soils differences but were made evident after variance due to soils clay content was partialled out. The results suggest that at this geographical scale and when many sites are compared together biases in palynological and archaeological methods may not severely disturb the main signal of intensity of agricultural activity in either sets of data.

Palynology and Taphonomy of the Great Cave at Niah, Sarawak, Malaysian Borneo

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This contribution briefly describes the calibration taphonomic studies and then in more detail the palynology of the Late Pleistocene deposits at the Great Cave at Niah, Sarawak, Malaysian Borneo. The Great Cave came to fame 40 years ago as containing the oldest Human remains in island SE Asia. This was later questioned but recent re-evaluations, of which this research is a part, confirm that people were indeed using the cave before 40 ka BP.

The taphonomic studies show that the predominant pathways by which pollen enters the cave are biogenic, with important vectors including bats (both insectivorous and vegetarian), cave swiftlets and burrowing wasps. Airfall pollen is only significant in a zone c.20 m wide at the cave mouth, but it is in this zone that much of the significant archaeological finds are located, including the famous 42 ka old 'Deep Skull'.

The palynological study, of over 10 m of section, shows that the vegetation around the cave changed dramatically during the late Pleistocene. Drought-stressed, sometimes scrubby lower montane forest was present during much of the Late Pleistocene. Mangroves were intermittently within reach of the vectors from the cave and at one point, very close to the 'Deep Skull' location, *Avicennia*-dominated vegetation was close to the cave and the sediments are full of estuarine datoms.

There is strong evidence for repeated fires in the forest outside the cave from before 40 ka BP. It is possible that these reflect human activity, possibly a foraging strategy which favoured regenerating forest. The vegetational picture from this research contrasts with current models suggesting that the north of Borneo was a rain-forest refugium during the late Pleistocene.

Palynological studies in the Cave sediments from the Moravian, Javoříčko and Hranice Karsts–Czech Republic

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The sediments of the karstic formations from the Moravian part of the Czech Republic (Moravian, Javoříčko and Hranice Karsts) were investigated. They are of Holocene, Pleistocene and Miocene ages. Palynological investigations were made in the collaboration with further geological and archeological disciplines.

The main problem of the palynological studies in the caves is that the sediments – especially of the Quaternary ages - do not contain the plant rests in their original positions. This fact causes problems complicating the ages determinations. The mixing of the different ages components - especially Quaternary and redeposited Tertiary ones - is common. Their preservation states may be different or similar. Sometimes it is very difficult to distinguish the age of palynomorphs known from both Quaternary and Tertiary (f.e. *Pinus, Ulmus, Alnus, Quercus, Corylus, Betula*).