Late Holocene paleoenvironmental history of two estuaries in Dhofar (Sultanate of Oman)

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The coastal wetlands in Dhofar (Sultanate of Oman) provide a record of Late Holocene paleoenvironmental history. The age of the surface sediments at some selected sites in the estuaries, locally known as *khawrs* and *qurms*, ranges from 750-390 calendar years (cal y) BC to Present. Geomorphological data suggest that prior to 270-420 cal y BC these estuaries were open to the sea and received a high input of fresh water from the mountains. At least from 270-420 cal y BC onwards, the physiography of the estuaries changed as a consequence of dwindling fresh water input from the mountains. As a result, the open estuaries changed into barrier dominated estuaries with periodical input of saline and fresh water. Palynological data indicate that the estuaries are mainly filled with (i) pollen and spores from the surrounding vegetation; (ii) a regional input of pollen and spores through surface and subsurface runoff from mountains, coastal plain and, *wadis*; (iii) pollen and spores from East Africa and the Indian subcontinent brought in by the monsoon. Between 750-390 cal y BC and 270-420 cal y BC the local input of *khawr* taxa prevailed whereas from 270-420 cal y BC to Present coastal plain and *wadi* taxa prevail. Both geomorphological and palynological data suggest the ancient centers of trade such as Samhuram at Khawr Rawri (ca. 100 BC to 400 AD) and Zafar at Khawr Al Balid (12th to 15th centuries AD) were affected by important hydrological changes related to desertification of the region as a consequence of a weakening SW (summer) monsoon.

Vegetational changes and human presence in the low and subalpine zone in Val Febbraro, upper Spluga Valley (Central Alps), northern Italy, from the Neolithic to 1 AD

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An interdisciplinary palaeoecological study in Val Febbraro, the upper Spluga Valley (I), between 1830m and 2304m asl, suggests temporary presence of early Neolithic man at around 6,000 BP. Local forest clearance and charcoal dust are found. Stages of forest and treeline disturbances, and increased human presence are seen from around 5,500 BP, 5,100 BP, and 4,000 BP. A marked increase of disturbances, mainly pasturing, is dated to the beginning of the Bronze Age. The last major stage of human made impact on the vegetation corresponds with the beginning of Iron Age, with a small temporary reduction seen during the Roman Period. Local archaeological sites, finds and 14C dates coincide with the vegetational and noticeable phases.

Poster session h7

NON-POLLEN PALYNOMORPHS FROM FRESH-WATER SEDIMENTS, PEAT DEPOSITS AND ARCHAEOLOGICAL SITES

Alpine extrafossils in palynological preparations from Austria – A contribution to the new Innsbruck-Extrafossil-Database ttp://botany.uibk.ac.at/downloads/extrafossils.pdf

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Extrafossils or non-pollen palynomorphs are often completely overlooked in palynological studies. Here we present some detailed microscopical studies on all kind of reproductive and vegetative remains of algae and fungi, as well as on zoological remains (e.g. arthropoda, turbellaria), which show that extrafossils may be as abundant as pollen in Quaternary studies.

Palynological analyses performed on peat stratigraphies from the Ziller Valley in Tyrol, Austria (Schwarzensteinmoor and Schwarzensteinalpe within the interdisciplinary research project 'HOLA – Evidence and Analysis of Holocene Avalanche Events', http://fbva.forvie.ac.at/800/hola.html) allow to assess the importance of extrafossils for the interpretation of high Alpine long-term environmental change.

Extrafossils such as *Botryococcus*, *Chloromonas*, *Chlamydomonas*, *Ustulina deusta*, *Gaeumannomyces* or Mycorrhiza spores (e.g. *Glomus*) indirectly add to the reconstruction of soil conditions, hydrological change, timberline fluctuations and of Alpine forest density, whereas spores of coprophilous fungi (eg. *Podospora*, *Sporormiella*, *Cercophora* and Sordariaceae) may account for the 6500 year old history of human and grazing impact in Austria.

Digital photographs of all determined and undetermined extrafossils allow now to set up a new Internet-Database in order to firm as a forum for palynologists working on extrafossils in mountainous regions worldwide, and to allow determination and discussion in this field of rising interest to environmental scientists, archaeologists, geographers and geologists.

The abundance of snow algae (Chloromonas and Chlamydomonas) in Holocene bog sediments linked to shifts in Alpine Timberline and snow-avalanche frequency in Tyrol, Austria

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The Quaternary history of snow algae is completely unknown today. Blooms of the Chlorophyceaen unicellular algae *Chlamydomonas nivalis* and *Chloromonas nivalis* frequently cause „Red Snow" in artic and alpine snowfields at summertime due to the massive accumulation of secondary carotenoids. Many of these snow algae survive a snowmelt and other unfavourable conditions by building cyst-like resting stages. These cysts have a well developed, long-lasting cell wall with species-specific ornamentation and can be recognized in palynological studies.

Here we present the first comparative study on *Chlamydomonas* and *Chloromonas* cysts found in Holocene sediments from two bogs in the Austrian Alps (Schwarzensteinmoor & Schwarzensteinalpe in Zillertal, see also our project homepage HOLA – Evidence and Analysis of Holocene Avalanche Events',

http://fbva.forvie.ac.at/800/hola.html) which show that the amount of snow algae varied dramatically for the last 9500 years. For Schwarzensteinmoor (2150 m a.s.l.), the amount of cysts seems thereby directly correlated to the landscape openness and to the amount of snow transported to the coring site by snow avalanches in late winter and early spring.

Major avalanches starting at 2700 m a.s.l. had a pronounced negative effect on the long-term stability and stand structure of the *Pinus-cembra*-timberline below 2300 m a.s.l., and produced rising snow algae values by the focussed deposition of huge snow amounts at lower altitudes. An increase in the grazing pressure and human impact on the *Pinus cembra* forests since the Neolithic period more than 6000 years ago may have even accentuated this effect. The frequency of snow algae cysts in Holocene sediments may therefore directly account for the long-term avalanche frequency in mountainous regions worldwide.

Are fern spore key indicators of recovery ecology in wet tropical lowland rainforest communities? Vegetation reconstruction from coastal peats

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The coastal peat swamp in the lowland wet tropics at Garu, West New Britain, has developed in a area with a dynamic environmental history. The region has been defined by periodic disastrous plinian volcanic episodes and allows us to examine the resilience of tropical rainforest communities to major environmental change. Four metre profiles, with very clearly bedded tephra and peat layers, have permitted fine-scale resolution palynology, dating from around 3000 yrs BP.

The spore and pollen analysis which allowed us to examine in detail the natural regeneration of the rainforest also provided the possibility to identify key indicators of the processes of recovery. The fossil plant assemblages at this peat swamp indicate clear changes in vegetation communities occurring between volcanic eruptions, and once recovery commences, the forests generally re-established themselves quite rapidly, reaching relative maturity within a century or less.

It appears possible that ferns have played a significant role in the recovery ecology of the rainforest communities following the major tephra events. However, before we can confirm this, we need to determine if the abundance of ferns is a palynological artefact (COLINVEAUX 1999) or a genuine expression of the ecological process (cf. Maunten Paia). It is notable that the peat rates of 1cm/5-8 years may be best explained by a significant imput of organic matter from a dominant fern community. The rapid peat rates are reflected by fast recovery of the rainforest communities.

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LENTFER, C. & BOYD, B. 2001. **Maunten Paia: Volcanoes, people and environment: The 1994 Rabaul volcanic eruptions.** Southern Cross University Press, Lismore.

Non-pollen palynomorphs as sources of palaeoecological information: case-studies from Mediterranean Spain

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Several examples from Mediterranean Spain are used to show that records of non-pollen palynomorphs (algal and fungal spores and cysts, charophytes and other microfossils of unknown biological origin) are worthwhile in addition to pollen analysis for studies of palaeoecological reconstruction. In the lacustrine sequence

of Cañada de la Cruz, the stratigraphy of palaeolimnological indicators is compatible with climatic control of vegetation stages at the response scales of decades to centuries. The sequence of Navarrés provides evidence of millennial-scale change in the trophic conditions of a peat-forming basin, which parallels local and vegetation changes since the last glacial to the Holocene under the influence of fire events, climate change and human activity. The sequence of Villaverde shows out-of-phase relationships of vegetational and limnological developments, probably in connection with alterations in local drainage patterns caused by karst dynamics and groundwater input. The correlation between sedimentological, and local microfossil and macrofossil stratigraphies is nevertheless notable. The sequence of San Rafael offers an example of synchronous variation of xerophytic pollen and microfossils indicative of temporary marsh desiccation, in concordance with regional evidence of aridification since the mid-Holocene. The sequences of Siles and Gádor show how extrafossil abundances can be used to establish the tempo of pastoral pressure, climatic change, and fire incidence. Non-pollen palynomorphs can also help address crucial taphonomical issues with coprolite, middens, and other fossil materials.

Fresh-Water Algae, indicators of monsoon fluctuations over West Africa during the last glacial-interglacial transition

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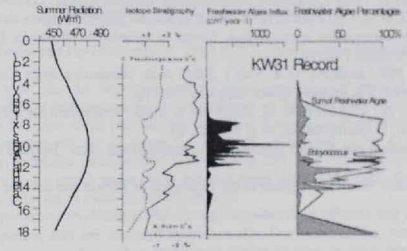
The study of aquatic and mangrove pollen grains and algae from fresh water environments from core KW31 recovered off the mouth of the Niger River (3°31'1N - 05°34"1E; 1181 m water depth) documents large-scale changes in river discharge linked to variations in Atlantic Monsoon rainfall during the last glacial-interglacial transition and the Holocene.

The algal assemblages are composed of 70 morphotypes corresponding to 26 determined taxa. Two main taxa are dominant: *Pediastrum* which records the strongest river input from 14 500 to 7500 cal years B.P. and *Botryococcus* which indicates surficial runoff in more arid periods, particularly at the onset of the deglaciation and during the Younger Dryas. Several dry events punctuated the first and more intense phase of the so-called "African Humid Period" (14 500 cal years B.P. – 8 200 cal years B.P.) : during the Younger Dryas (13 400-12 100 cal years B.P.), then around 11 400-11 200 cal years B.P. and 9600-9400 cal years B.P., testifying for important climate instability. The fluvial phase ended after 7500 cal years B.P., while dry conditions definitively took place after 5500 cal years B.P. KW31 shows that the increase in fresh-water input to the ocean and correlative rainfall over Tropical West Africa was gradual in response to insolation forcing at the transition from glacial to interglacial situations ; the record of the end of the Holocene fluvial period is on the contrary abrupt, contrasting with land data which indicate that humid conditions persisted during the late Holocene, allowing for a lacustrine phase centred around 3500 years B.P.



The late glacial maximum hydrological conditions of the Venetian Po Plain (north-eastern Italy). Some evidence from non-pollen palynomorphs

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Sedimentary sequences from the venetian alluvial plain (north-eastern Italy) have been widely studied in recent years (detailed references in Miola *et al.*, 2003). Many Authors reported the presence of peat layers at different depths from the ground level. According to radiocarbon dating, the ages of peat layers range from 22,500 to 18,000 yr BP. These layers could be used as a biostratigraphic tool for the correlation of sequences, when litho-stratigraphic data are not useful. In fact the sedimentation has been greatly affected by the evolution of the principal fluvial systems (Adige, Brenta, Piave and Tagliamento) and by the sea-level fluctuations (Castiglioni & Pellegrini, 2001; Bondesan *et al.*, 2002). On the other hand, the microfossil content of sediments such as sands, silts and clays, is quite poor. Pollen analysis of peats, on the contrary, offers useful results. In particular it has been argued that the entire area was covered by an upland plant community, mostly consisting of Poaceae, *Artemisia*, Chenopodiaceae, Caryophyllaceae, Asteraceae Asteroideae and Apiaceae, and arboreal plants as *Pinus* and *Betula*. These data do not report pollen records from local plant communities of peat bogs, with the exception of Cyperaceae and a few aquatic *taxa*.

Our research aims to identify the local plant communities in LGM peat-bogs, in order to contribute to the definition of past local hydrological conditions. Samples of radiodated peat sediments from sequences cored in the north Adriatic sea coastal area, have been analysed. We have studied pollen, non-pollen palynomorphs and macrofossil remains (*sensu* Birks & Birks, 1980), and compared pollen and non-pollen palynomorphs data with semi-quantitative macrofossil remains data.

We identified some herbaceous pollen types and many types of Fungi, Algae and Mosses and non-pollen palynomorphs of unknown origins. Pollen of Cyperaceae and spores of Mosses were the dominant *taxa*. Among the macrofossil remains, *Carex* cf. *fusca* rootlets and remains of the brown moss *Scorpidium scorpioides* were the most abundant. So we argued that mosses spores were possibly produced by *Scorpidium scorpioides*, now living in artic and boreal regions, in eutrophic bogs with low content of mineral salts (Polunin & Walters, 1985).

In order to decide whether there is an equal distribution of pollen and spore associations among sites, pollen and spores records have been compared by means of a new statistical method of data analysis, namely the NonParametric Combination of Dependent Permutation (NPC) Tests (Pesarin, 2001). This new method has been adopted because the data configuration is characterized by a relatively high number of variables, i.e. pollen and spore *taxa*, compared to the number of statistical units, i.e. peat samples. In this situation a standard multivariate approach, as Principal Component Analysis, is not appropriate and applicable and in general it does not permit any kind of decision on the problem of determining whether there is an equal distribution of pollen associations among the sites.

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Holocene non-pollen palynomorphs from Lake Zempoala, Mexico

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A 520 cm long core from Lake Zempoala (2800 m alt.), located 65 km SW of Mexico City comprises the last ca 6350 calendar years. Apart from pollen, a number of other microfossil types were recorded and documented. Among these are the spores of various coprophilous ascomycete taxa (*Podospora*-type, *Cercophora*-type and *Sporormiella*-type). We also recorded chlamydospores of the soil fungus *Glomus* (erosion indicator) and hyphopodia of *Gaeumannomyces* (parasitic on Cyperaceae). In addition we found heterocysts of *Rivularia*-type (cyanobacteria; probably indicating phosphate eutrophication of the lake), charred epidermal fragments of Poaceae (human impact) and leaf-spines of *Ceratophyllum* (the pollen of which does not fossilize). The first fossil record of *Sporormiella* was by Owen Davis and he used these characteristic fungal cells to document changing grazing pressure in N-American sites during the late Pleistocene herbivore extinctions and late Holocene introduction of domesticated herbivores by Europeans. The records of non-pollen palynomorphs in the Lake Zempoala deposits form a valuable addition to the pollen record. The paleo-environmental indicator value of the non-pollen palynomorphs is evident. Many of the non-pollen palynomorphs appear to be cosmopolitan, but not ubiquitous.

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Lake deposits, natural archives of past land use and atmospheric pollution

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Traces of the past play an important role in the appreciation of present-day landscapes. Natural archives, such as lakes, peat bogs and ponds are important records of the past. They contain information about past environments and climate but also about past human activities. These natural archives are not only part of our cultural heritage, but they also tell us of events in the past which may serve as a lesson for the future. Unfortunately present-day landscape development (a.o. housing and road construction) and maintenance work (a.o. dredging) and lowering of ground water levels threaten these natural archives. Results of sediment studies may provide convincing arguments to value and preserve them.

Our history is preserved in archives. For the last decades, most climate and environmental parameters (e.g. temperature, water quality, etc) are recorded instrumentally. For climate data, we can even rely on written records from the past 200 years. However, when going back further in time, or when reconstructing non-measured records, we need to rely on the natural archives. In The Netherlands, lakes, peat bogs and ponds, if undisturbed, are most valuable natural archives. Lake deposits incorporate particles consisting of (a mix of) minerals, organic and inorganic chemical components, the remains of living organisms (pollen, macrofossils), etc. Studying these

sediment layers (read: natural archive) with geobiological, geophysical and geochemical methods, reveal information about past climates, environments and human activities.

Pollen analysis of the sediment reflect the shift in agriculture in the second halve of the 20th century from cereal growing (rye, wheat) to corn (*Zea mais*) production. Corn became an important crop in the last decades of the previous century, as the cornfields tolerate great quantities of manure produced by the increasing bio industry (pig farming) in the area. The corn in turn is used to feed cattle. Coeval to this shift the pollen records indicate increasing nutrient levels of the meadows by lower values of grassland weeds as ribwort plantain (*Plantago lanceolata*). The increase of arboreal pollen in the record of Fort Vechten shows the reforestation of the fortress since the Second World War, when the area was completely deforested for military purposes

In 2003, two small antropgenic lakes near Utrecht, viz. Lake Vechten and Lake Fort bij Vechten were sampled and analysed. From each lake several sediment cores were taken. Based on the ^{137}Cs data it was clear that the lake sediments were undisturbed and record the period from 1940-2003. The chemical composition and concentration of spheroidal carbonaceous fly-ash particles was determined using 1-cm thick slices. Lead was extracted following GRANEY et.al. , 1995. The method used to extract SCP was an adaptation of the method developed by ROSE, 1990. The SCP curve - the first in The Netherlands - can serve as a reliable dating method for last century deposits in The Netherlands (ROSE, 1999).

Results show that he atmospheric lead and SCP deposition increase from 1940 towards the 1970's and than sharply decrease. The increase in the lead content is caused by the increase of the combustion of leaded gasoline. From 1923 tetraethyl (TEL) lead was added to gasoline for its anti-knock properties. However, soon after the introduction of TEL, scientific research revealed that gasoline lead poses a serious threat to human health. It lasted until 1970 before legislative measures were taken to curtail lead in gasoline inducing a strong decline in the atmospheric deposition of lead after the 1970's.

GRANEY, J.R., A.N. HALLIDAY, G.J. KEELER, J.O. NRIAGU, J.A. ROBBINS & S.A. NORTON. Isotopic record of laed pollution in lake sediments from the northeastern United States. **Geochim. Cosmochim. Acta**, 59. pp. 1715-1728.

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Linking current environments and processes to fungal spore assemblages

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While the basic premise of palaeoecological research is that the past and present can be linked, qualitatively or quantitatively, this has not been the case with much of the work in fungal spores. This relates partly to the shortage of ecological data, especially in terms of microfungi on plants or in soils. An additional problem is that despite the increasing range of surface-studies of pollen influx and representation in a range of European environments, this approach has rarely been extended to include fungi. To address this problem, modern samples have been analysed from moss polsters, surface litter, shallow soil scrapes and slightly deeper soil samples from a range of different vegetation types. In this paper, we outline the techniques used and make recommendations for further research in this field, regarding sampling spatially and in terms of depth and choice of material. Secondly, we report modern fungal and pollen assemblage data from heathland and woodland sites in the UK and suggest how these can be used to interpret subfossil, Holocene-aged fungal spore assemblages.

Linking pollen transport in rivers to catchment vegetation: implications for sediment source tracing and palaeoenvironmental reconstructions

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Existing work has shown that pollen and spores account for a significant proportion of the particulate organic load transported by rivers and the water-borne pollen assemblage is closely related to that of the surrounding vegetation. This paper represents an investigation of the relationship between fluvial pollen and the vegetation of the surrounding catchment. The catchment of the River Exe Devon, UK, was chosen for the study as it represents a catchment with distinct zones characterised by contrasting vegetation and hydrological response. The River Exe rises on Exmoor and its upper catchment is characterised by moorland and rough pasture with limited suspended sediment production. The central part of the catchment is dominated by coniferous plantations and pasture, whilst the lower part is dominated by areas of arable farming which are typically areas of high suspended sediment production. Samples were collected at a number of sites along the River Exe to identify the sources of the water-borne pollen and to examine both the temporal and spatial variations in its assemblage during storm events. A number of sampling techniques were employed, including point, hydrograph and time-integrated sampling. The results demonstrate that water-borne pollen exhibits similar hydrodynamic behaviour to fine particles, once saturation is complete. The relationship between suspended sediment and pollen/spore concentrations is not a direct relationship, mainly due to the effects of seasonality, production, preservation and source i.e. re-suspended material or fresh input. Temporal and spatial variations in the water-borne pollen characteristics have been identified, these relate to the dominant vegetation type and flowering season as shown by the transport of *Calluna vulgaris*. The results from frequent sampling permit the construction of a model to demonstrate the input and outputs of the system and the production of a steady state pollen diagram, which are compared to pollen diagrams with a fluvial signal.

Poster session h8

POLLEN CALIBRATION AND QUANTITATIVE RECONSTRUCTION OF PAST VEGETATION COVER

Reconstructing biodiversity from pollen data: making the data comparable

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Biodiversity has long been of interest to ecologists and conservation biologists. Several factors have been proposed that may regulate biodiversity of a community or a region, including climate, climatic stability, habitat heterogeneity, competition, predation, disturbance, production and energy availability. However, the mechanism and importance of these factors are still unknown. A biodiversity history may reveal the possible relationship between biodiversity and the environment, and provide clues as to how this relationship may change in the future. Preserved fossil artifacts of animals or plants may be a useful source of biodiversity history. However, the fossil record is often not complete or continuous. Fossil pollen from pre-dated sediments may be a more accessible source for this purpose.

So far, there have been at least four categories of methods available for biodiversity reconstruction using pollen data: 1) direct comparison of the number of pollen types (palynological richness) encountered in pollen spectra; 2) comparison of diversity indices based on down-core pollen spectra, such as the Shannon-Weaver index, Simpson's index, Berger-Parker index etc.; 3) comparison of palynological richness using rarefaction