

comparison with other long palynological sequences of central Italy, suggests for the bottom of the Stracciaccappa pollen record an age of approx. 60,000 years.

Five radiocarbon dates, all of the last glacial period, ranging from around 36,000 and 19,000 years BP help in defining the age of some minor arboreal spreads interrupting the succession of steppe and grassland formations dominated by *Artemisia*, other Asteroideae, Gramineae and Chenopodiaceae. Stracciaccappa turned out one of the most sensitive sites of the Lazio region to the pleniglacial climatic changes. In fact the pollen sequence shows a number of slight expansions of angiosperm trees, corresponding to the middle pleniglacial interstadials recognized in other long pollen records of Europe. Compared to central and northern Europe, the record of Stracciaccappa shows a significant vegetational complexity and a wealth of minor oscillations, as many other Italian sites (FOLLIERI *et al.* 1998). In these weak expansions the pollen of angiosperm trees has similar floristic and vegetational features and is constituted mainly by deciduous oaks (*Quercus robur* type) and *Corylus*, accompanied in very low percentages by *Betula*, *Alnus*, *Tilia*, *Ulmus*, *Fagus* and *Zelkova*. The pollen diagram records the last presence of *Zelkova* before the radiocarbon date 36,330 ± 1630 years BP, whose extinction was found in central Italy sometime before 30,000 years BP. In these forest expansions *Picea* is always present, and reaches in some cases values of 5-7%, indicating a local presence for this conifer tree, whose diffusion area is nowadays restricted to the Alps and to only few relic stations in northern Apennines.

A preliminary palynological work carried out in 1993 by GIARDINI on the sedimentary record pointed out that the Holocene vegetation history had anomalies; a careful microscopic observation of the sediment led to establish that a reworking of sediments had happened during the industrial coring in well defined Postglacial levels. Several hand-operated piston corers were used in the following years obtaining again unreliable pollen and radiocarbon results, caused by a particular slippery level which provoked a reworking of the sediment during the coring. In the last years an artificial dig was excavated in the centre of the crater and the sampling carried out on the outcrop of the trench, obtaining a new, finally reliable, sediment record.

The pollen diagram shows that the Holocene reforestation is mainly due to *Quercus robur* type accompanied by *Corylus*, *Tilia* and *Betula*, and later by *Q. ilex* and *Q. cerris* type and *Ulmus*. The record ends few centimetres after the AMS radiocarbon date of 7495 ± 80 years BP. The Holocene sediments from Stracciaccappa do not contain therefore the last thousands years of vegetation history.

FOLLIERI, M., GIARDINI, M., MAGRI, D. & SADORI, L. 1998. Palynostratigraphy of the last glacial period in the volcanic region of central Italy. *Quat. International*, 47-48: 3-20.

GIARDINI, M. 1993. Late Pleistocene and Holocene history of vegetation at Stracciaccappa, Monti Sabatini volcanic district (central Italy). Abstracts INQUA SEQS Symposium "Quaternary stratigraphy in volcanic areas". Rome, September 20-22, 1993, p. 34.

The biogeographical role of *Pinus* forests in the central Spanish meseta

Franco-Múgica, F.¹; García-Antón, M.²; Maldonado-Ruiz, J.³; Morla-Juaristi, C.³ & Sainz-Ollero, H.²

¹ Dpto Ecología, Facultad de Ciencias, Universidad Autónoma de Madrid, 28049 Madrid.

² Dpto Biología (Botánica), Facultad de Ciencias, Universidad Autónoma de Madrid, 28049 Madrid.

³ Unidad de Botánica, Dpto. Silvopascicultura, ETSI de Montes, Univ. Politécnica de Madrid, 28040 Madrid.

The study of several well-dated holocene pollen sites in the inner of the Spanish northern meseta allows us to understand the landscape changes in an area intensely disturbed by humans during the last thousand years. Traditionally, a potential vegetation dominated by evergreen and semideciduous oaks, mainly *Quercus ilex* subsp. *ballota*, *Quercus faginea* and *Quercus pyrenaica*, has been assumed for this territory. However, the *Pinus* species that nowadays live with them (*Pinus pinaster*, *P. nigra* and *P. pinea*) have been interpreted as having a secondary role in the forest succession. Nevertheless, the derived pollen results call this widely accepted model into question. The continuous dominance of pinewoods in all the studied sites throughout the Holocene provides a very different interpretation. The characteristic Holocene substitution of conifers by broadleaf-species visible in other parts of the Iberian peninsula, never takes place in these sites where a continental climate prevails. Moreover, special substrata such as sands, have favoured the persistence of stable landscapes since the Lateglacial. Merely, the recent intense anthropogenic activity could have broken out the process, so relevant for the classic interpretation of the vegetation of the area, where conifers were outcompeted by a deciduous-species expansion. Local differences have been observed in recent times due to the diverse human land use. Pinewoods persist in those sandy areas of

the Tierra de Pinares Region till today. This fact is mainly due to the soils not being suitable for agriculture whereas in more favourable sites, a major deforestation along the last millennium took place.

Poster session h4

TROPICAL PALEOECOLOGY: SENSITIVE ARCHIVES OF ENVIRONMENTAL CHANGE

The Big Bang! Again and again and again. How wet tropical rainforest copes with repeated volcanic destruction

Jago, L. C. F. & Boyd, W. E.

Centre for Geoarchaeology and Palaeoenvironmental Research, Southern Cross University, Lismore, NSW 2480, Australia.

The Holocene of West New Britain, Papua New Guinea, is characterised by periodic catastrophic volcanism. The region is mantled in dense wet tropical rainforest, and has been occupied by people since the Pleistocene. The region is an excellent laboratory to examine the resilience of tropical rainforest to major environmental change. This poster will describe the results of pollen analysis of layered peats and tephra deposited in a coastal swamp on the north coast of West New Britain. The analyses provide us with a macro-level landscape account of the periodic destruction and recovery of the coastal forests during seven periods of volcanic activity in the latter part (last 3000 years) of the Holocene. Based on c.4 m sediment sequences, the stratigraphy comprises peat dating from around 2850 - 1850 BP, c.1700 - c.1450 BP, c.1450 - c.1300 BP, c.1300 - c.800 BP, c.700 - c.550 BP, and c.500 BP - recent (two layers of peat).

The pollen analysis allows a fine-scale of resolution, permitting us to examine in detail the recovery ecology of the forest. This allows us, in turn, to identify key indicators of the processes of recovery, which will enhance, for example, further interpretation of phytolith analyses currently being undertaken at other localities in the study area. At present, the pollen analysis lets us recognise different ecological recovery pathways, much as expected by examination of modern analogues (LENTFER & BOYD 2001; THORNTON 1996). Once recovery commences, the forests generally re-established themselves quite rapidly, reaching relative maturity within a century or less.

Of interest here, is the role of ground ferns in the initial recolonisation of the barren tephra land surfaces following several of the volcanic eruptions. Of note, palynologically, we find that the fern spore flora is particularly rich and useful for ecological interpretation. In this floristically-rich tropical rainforest, for example, we find the pollen flora to be relatively depauperate. In particular, many of the upper canopy flowering trees tend to be underrepresented within the pollen spectra, and it is largely the presence of epiphytic ferns that confirms for us the local presence of a forest canopy at times when we may have little pollen evidence for this.

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THORNTON, I. 1996. *Krakatau: The destruction and reassembly of an island ecosystem*. Harvard University Press, Cambridge, Massachusetts.

Middle Wisconsin paleoenvironments from a sediment sequence at NW Sierra Madre Occidental, Sonora, Mexico

López Higuera, A.¹; Peñaalba Garmendia, M. C.^{1,2}; Paz Moreno, F. A.¹ & Van Devender, T. R.³

¹ Departamento de Geología, Universidad de Sonora, 83000 Hermosillo, Sonora, México.

² Instituto de Ecología, UNAM, ERNO, 83250 Hermosillo, Sonora, México.

³ Arizona-Sonora Desert Museum, 85743 Tucson, Arizona, USA.

A multidisciplinary study with a geological-ecological approach was made in a Late Quaternary small basin called "El Aguaje del Caballito Blanco", located in the northwestern Sierra Madre Occidental (28° 24' 14" N, 108° 36' 00" W), state of Sonora, Mexico, with the intention of determining the geological and biological paleoenvironments associated to its formation. It is a close basin fixed within tertiary volcanic rocks of Oligocene age. The work is based on the application of different analyses (pollen, particle size distribution, organic content [LOI] and moisture, and X-ray diffraction) to a 1m-depth sediment core. The upper part recorded a radiocarbon age of 34,500 ± 700 BP (Beta-170379). This is the first continental reference of the Middle Wisconsin in Sonora and in the Sierra Madre Occidental.

Four phases which show variations in the sedimentary contribution and in the basin's vegetation, and which reflect different climate environments were identified. The basin was covered by a stable column of water, but with oscillations within the water level. The sediment shows variations in the grain's size (sands and silts) and its classification (very poorly sorted and poorly sorted) tending to lower energy to the most recent levels, where the organic accumulation is maximum as well as the water level.

A pine (*Pinus*) forest with spruce (*Picea*) surrounded the basin now covered by oak (*Quercus*) and pine, therefore it is estimated that such vegetation expanded in heights of at least 400 m lower than the present limit, which was possible within a moister and colder climate than the present in all the sequence and particularly in the first and third phases. The second phase was relatively warmer and drier than the other phases, which originated a slight rise in the altitudinal limits of distribution of the oak (though always below the present limit) and the occurrence of forest fires registered through charcoal and rocks fragments. The most recent phase at around 34 ka BP, is the moistest and mild-cold, where the basin achieves higher stability.

The neolithisation in the Gunung Sewu (Java, Indonesia)

Chacornac-Rault, M. & Sémah A. M.

Department of Prehistory, Institute of Human Palaeontology (National Museum of Natural History), Paris (France). UR055, Research Institute for the Development, Bondy (France).

This study is located in the Gunung Sewu area (Eastern Java), near the boundary between the western part of the island which receives abundant aseasonal precipitations and the eastern part where the dry season is clearly differentiated.

In this area, numerous caves are filled by archaeological deposits including Holocene ones.

To get more palaeoenvironmental data about this period corresponding with the emergence of agriculture and the beginning of the neolithisation for this region, we carried out cores in three swamps near the currently Song Terus excavated cave.

For these three sites, Guyang Warak, Tritis and Bugel, the +/- five meters long cores are corresponding to upper Holocene and Holocene ages.

Our study is principally based on pollen analyse and completed with charcoal and phytoliths analyses. Every marker brings complementary information:

- Pollen analyse allow to reconstruct the fossil vegetal landscape and its history.
- Charcoal study on palynological slides gives evidence for some fire phases. These fires can be natural in dry climatic period or can show agricultural practice like slash-and-burn agriculture.
- Phytoliths analyse gives information about Poaceae ecology and can show important economic plants indeterminate with pollen (rice, bananas...). Phytoliths give also some information for low pollen zones.

The evolution of the vegetation can be assigned to climatic variations or anthropic actions.

For the anthropic action in the diagrams we observe:

- at first, the utilisation by man of plants which are present in the vegetation,
- subsequently, man helps development of these plants (Arecaceae, *Arenga*, *Pandanus*, *Gnetum*...),
- at last, Poaceae are cultivated after slash-and-burn.

At Bugel swamp the first cultivation is underlined by rice phytoliths (*Oryza*). In the three swamps there is cultivation of Poaceae. These Poaceae, after morphometric and M.E.B studies, seem to be maize (*Zea mays*) while maize is supposed to be introduced by Portuguese at 16th century.

Mid-and Late Holocene vegetation and climate history of the NW Sierra Madre Occidental, Mexico, based on pollen analysis of tree Cienegas from Sonora and Chihuahua

Ortega-Rosas, C. I.^{1,2}; Peñaalba-Garmendia, M. C.^{2,3} & Guióti, J.¹

¹ Centre Européen de Recherche et d'Enseignement en Géosciences de l'Environnement, Université d'Aix Marseille III, 13545 Aix en Provence, France.

² Instituto de Ecología, Universidad Nacional Autónoma de México, 83250, Hermosillo, Sonora, México.

³ Departamento de Geología, Universidad de Sonora - 83000, Hermosillo, Sonora, México.

This work is a paleoecological study developed in the northwestern Sierra Madre Occidental, Sonora, Mexico. The main study site is a *Sphagnum palustre* peatbog called "Ciénega de Camilo" (28°25'39" N, 108°34'03" W, altitude 1,550 msnm). We include the site stratigraphic study, the fossil pollen analysis from the CAM 3 core of 3,60 m-depth and a radiocarbon date of 8,610 yr B.P. and the analysis of modern pollen rain from an altitudinal transect between 600 and 1900 m elevation. Additionally, we introduce preliminary palynological results from two other Holocene close sites in the states of Sonora (Ciénega de las Taunás, 1700 msnm) and Chihuahua (Ciénega de Yepéché, 1810 msnm).

The stratigraphic profiles analysis in the Ciénega de Camilo let us to identify five sedimentation units, composed of inorganic light plastic clays in the bottom older than 8,600 yr B.P. and one evolution to less plastic and organic clays for the last 6,000 years. We conclude that the sedimentation in the peatbog is of detritic type, beginning with the plastic clays deposit in the bottom that favored the water and sediment accumulation. The origin of the Ciénega de Camilo could be dated to 11,000 radiocarbon years.

On the other hand, modern pollen rain could identify the different communities based on their pollen representation. The pine forest, oak-pine and epithermal oaks-pines communities of temperate and wet climates were easy to distinguish from the tropical deciduous forest and thornscrub communities of arid climates, while the latter two communities were difficult to differentiate based on the pollen content. Nevertheless, we identified high frequencies of *Bursera* as being characteristic of the tropical deciduous forest.

From the fossil pollen analysis of the CAM 3 core, we identified changes in the altitudinal distribution limits of Holocene communities that were reflected in expansions and contractions of the distribution areas in response to the climatic change. Between 8,600 and 6,000 yr B.P., a mixed-conifer forest with *Pinus* and *Abies* covered the region. *Quercus* was less common than today. *Abies* is not present today at the study zone, and the closest modern analogue for this paleovegetation is located in two canyons on the edge of Mesa del Campanero at 2,000 m elevation, where populations of *Abies durangensis* with *Pinus strobiformis* grow in a cold climate. We conclude that the distribution ranges of mixed-conifer forest vegetation was 400 m lower than today. From 6,000 to 4,000 years ago an oak-pine forest was installed and the mixed-conifer forest migrated to higher elevations. At 4,000 yr B.P. we detected the maximal distribution of *Quercus* around the site, which shows the warmest and/or most arid period for the Holocene in the area. The forest at Camilo in the last 4,000 years has been relatively modern with a oak dominance. The last 2,000 years indicate the progressive diminution of pine extension in the region and oak increasing. The vegetation may have become progressively more open in the last 600 years, this suggested by the declines in the fern spores, increases in oak and juniper-cypress pollen.

The palynological preliminary results from the two other sites "Ciénega de Las Taunás" and "Ciénega de Yepéché" present similar conditions in the vegetation for about the last 2,000 years. Both paleorecords show a pollen dominance of *Pinus*, Cyperaceae, *Quercus*, Poaceae and Asteraceae that reflects a more open landscape than in the Ciénega de Camilo's forest, vegetation similar to the present. Nevertheless, the general tendency to the

diminution of pines and increasing of oak and juniper-cypress in all paleorecords may suggest a drought increase in the last centuries, having a regional effect on vegetation dynamics, although human action is not excluded.

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Vegetational and environmental history of the Colombian Caribbean during the Holocene

Urrego, L. E.¹; González, C.¹; Polanía, J.²; Castaño, A. R.¹ & Correa, J. A.¹

¹Departamento de Ciencias Forestales, Universidad Nacional de Colombia, sede Medellín A.A. 568 Medellín (Colombia).

²Universidad Nacional de Colombia, sede San Andrés.

In the past, mangrove ecosystems have undergone changes in extension and floristic composition in response to local and regional environmental shifts and human alteration processes, as well as to global sea level rise. It is unclear if the mangroves of the Colombian Caribbean have persisted during the Holocene, how have they responded to environmental and anthropogenic changes, and how would they react to the current sea-level rise phenomenon.

Successional sequences were reconstructed in three different mangrove-dominated sites of the Colombian Caribbean, by means of the characterization of present vegetation communities and palynological analysis. Pollen records comprise two different time scales related to regional and local vegetation and environmental changes:

1. A long time scale pollen assemblage that records middle Holocene sea level stabilization around 6000 yr BP, which gave place to delta and lake formation in La Guajira (northernmost part of Colombia), evidenced by high representation of open vegetation taxa sand-dominated sediments, and subsequent mangroves establishment. Maximum expansion of mangroves is reached around 2700 yr BP and palynological evidence, characterized by a peak of *Rhizophora*, occurs simultaneously in this core and in the San Andres Island core, showing a good correspondence with other regional evidences (river flooding, geomorphologic records) of maximum sea level for the Holocene in the Colombian Caribbean.

2. Short time scale pollen assemblages span the last 350 years and record continuous anthropogenic impact, evidenced by the presence of *Zea mays* pollen grains. Main environmental changes are related to fluvial dynamics (higher sedimentation rates, river-bed changes, flooding level increase), hurricanes, precipitation changes and sea-level rise, which have caused the inland displacement of the coastal line. A high precipitation period around 200 yr BP could be inferred from higher sedimentation rates, and increments of mangrove, tropical and Andean forests taxa. Mangrove curves and stratigraphy show sea-level increase since 100 yr BP.

Palynological record in sediment recent from estuary of the Caravelas river and of the coral reefs of Abrolhos Parcel, state of Bahia, Brasil

Oliveira, P. P.¹; Santos, F. A. R.¹; Kikuchi, R. K. P.² & de Oliveira, P. E.³

¹Laboratório de Micromorfologia Vegetal, Departamento de Ciências Biológicas, Universidade Estadual de Feira de Santana, km 03, BR 116 norte, 44.031-460, Feira de Santana, Bahia.

²Instituto de Geociências, Universidade Federal da Bahia, Campus de Ondina 40.170-115, Salvador, Bahia.

³Laboratório de Geociências, Universidade Guarulhos, praça Tereza Cristina, 01 - Centro, 07023-070, Guarulhos, São Paulo, Brasil.

Palynology of Brazilian mangroves is scarce, especially of its sediments. The aim of this work was to investigate the palynological signs in sediments from estuary of the Caravelas river and from coral reefs of Abrolhos Parcel. The site of study is located in extreme south of the state of Bahia (17°43'S and 39°16'W), and

presents a vegetation dominated by Atlantic forest. The samples of sediments were obtained with PVC tube and they were subsampled every two centimeters. Each subsample was treated with fluoridic acid to remove inorganic material and the organic content was acetolyzed. Palynological analyses were carried out counting at least a hundred of pollen grains, using spores of *Lycopodium clavatum* L. as marker. All palynomorphs were described and photographed in light microscope and a pollen diagram was constructed using TILIA & TILIA GRAPH programs. The sedimentation ratio was not obtained, since it was not possible to detect the decline of Pb²¹⁰ in the sample, probably due to its sediment remobilization. The sedimentology indicated mineral particles with different sizes, which may related to the pattern depositional in the site. Fine particles are associated to the low energy which is favorable to palynomorph depositions, while coarse particles may associated to depositional site with high energy which make the deposition of the fine particles difficult, included palynomorphs. The palynomorph absence in sediment from coral reef is probably related to the distance of the site from coast (ca. 70km), and the water turbulence that becomes difficult the deposition of palynomorphs. In the sediments from estuary Caravelas river, there were found 140 pollen types (103 identified and 37 undetermined). Even so, three pollen zones were identified by similarity analyses. The palynological analyses indicated that pollen signs of the estuary are constituted mainly by allochthonous palynomorphs due to the presence of pollen types of "restinga" elements and of the rainforest. Autochthonous taxa were represented by the families Rhizophoraceae (*Rhizophora mangle*) and Avicenniaceae (*Avicennia*). *Rhizophora mangle* is the most representative autochthonous element because of its large production of pollen, and its wind-pollination. *Avicennia* presents low pollen productivity and entomophyllous pollination, so it is little represented in samples of mangrove sediments. On the other hand, the pollen assemblage in the estuary sediment evidenced the presence of pollen types of species associated to degraded areas (e.g. *Cecropia*, *Alchornea* and *Didymopanax*). It was observed many damaged palynomorphs (folded and/or broken) pointed to their distant origin, and their transport by river, as well as the *de novo* suspension processes and redistribution of the sediments in the depositional site. This is the first study of pollen grains (and spores) presented to mangrove sediments of Bahia State. (Supported by CNPq)

Wetland biotic response to human-induced and natural hydrological changes in South Florida: implications for paleoecological reconstructions

Donders, T. H.¹; Wagner, F.¹ & Visscher, H.¹

¹Botanical Palaeoecology, Laboratory of Palaeobotany and Palynology, Utrecht University, Budapestlaan 4, 3584 CD Utrecht, The Netherlands.

An accurately dated peat profile from a mixed cypress swamp in Fakahatchee Strand (Florida, U.S.A.) has been examined for pollen and spores. The near-annual resolved pollen record shows a gradual shift from a wet to a relatively dry assemblage during the past 100 years. Timing of drainage activities in the area closely match the onset and duration of vegetation change in the swamp, which thus is an accurate indicator for local water level changes. The local hydrology directly depends on the regional sheet flow intensity due to the generally low topography of the Florida wetlands (WATTS & HANSEN 1994). Therefore, the local vegetation record reflects regional hydrologic conditions by responding to changes in hydroperiod and water level. From this study, the human impact (drainage activities and lumbering) on Florida wetlands becomes apparent. In addition, the documented response allows for recognition of natural changes in hydrology by analysis of older deposits, analogous to WILLARD ET AL. (2001)

High-frequency variation in the record suggests a positive correlation between winter-precipitation and pollen productivity of the major tree taxa, in accordance with results from GREEN ET AL. (1988). Flood-resistant *Taxodium* are dominating the record and might be used as a direct indicator to reconstruct short peaks of precipitation. Further vegetation reconstruction on high temporal resolution will elucidate periods of high and low precipitation.

A strong link between local precipitation and the El Niño Southern Oscillation (SUN & FURBISH 1997) makes this area highly relevant for climate variability studies. High-resolution pollen records from the Fakahatchee may provide valuable clues about past variability, magnitude and persistence of the ENSO climate system.

The recent vegetation record allows better understanding of human-induced and naturally occurring changes in hydrology, both on centennial and annual timescales. South Florida wetlands appear to be an important source of palaeoclimatic and -ecologic information and will be subject to further studies

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Late Holocene drought cycles based on pollen records from the Lacandon rain forest, Mexico

Domínguez-Vázquez, G. & Islebe, G. A.

El Colegio de la Frontera Sur Unidad Chetumal, Herbario, AP 424, Chetumal, México.

Naja Lake is located in the Lacandon region, which belongs to the Maya lowlands area in southeastern Mexico. The mean annual temperature is above 22 °C and the annual precipitation reaches 2500 mm, falling most of the rain during May to October. The physical setting of the lake makes it an ideal location to study precipitation changes during the late Holocene. Present day vegetation types are a mix of lower montane rain forest in the valleys, and pine-oak forest in the mountains surrounding the lake.

For this study two cores of 3.4 m depth were obtained from Naja Lake, NAJA-2 and NAJA-3. The bottom of the cores were dated through AMS and gave a date of 2000 years BP for NAJA-2 and 2360 for NAJA-3. Evidence of high climatic variability was observed throughout the late Holocene. Dry periods recurred several times, but the most severe and long lasting drought, resulted in conspicuous vegetation change (pollen zone 4, NAJA-2.) and the proportion of *Pinus* dominated the pollen spectrum. Throughout the late Holocene *Pinus* expanded its area of occupation during the arid intervals, due to its capacity to resist dry conditions. During the dry phases, elements from the lower montane rain forest, retreated to areas that conserved a certain amount of humidity; and these areas were colonized by *Pinus* as can be observed today in montane rain forest and oak forest.

Conspicuous is the absence of *Zea mays* pollen grains, however, there are evidences of fallow periods in the pollen diagrams, which could signify that at least some kinds of human disturbance occurred during the late Holocene.

The late Holocene in the Lacandon region is characterized by oscillation of environmental conditions, mainly as a result of changes in the precipitation pattern, which occasioned several events of drought. These dry periods occasioned the reduction of the lower montane rain forest, and an expansion of elements from pine forest vegetation. The most severe of these arid events occurred at 1200 BP.

Palynology of cuenca alta del Río Lerma, central Mexico

Ludlow-Wiechers, B.¹; Almeida-Leñero, L.¹ & Islebe, G.²

¹ Department of Ecología y Recursos Naturales, Facultad de Ciencias, Universidad Nacional Autónoma de México.

² Herbario ECOSUR, Colegio de la Frontera Sur, Chetumal, Quintana Roo, México.

A palynological analysis of sediments from Lake Chignahuapan, allowed the reconstruction of vegetation and climate. Six sediment cores were obtained. The samples were treated with acids, acetolised. The data were analysed with TILIA and CONISS.

The palynomorphs show the presence of large extensions of temperate forests. Among these were found *Quercus*, *Pinus*, *Abies* and moist forests. The components of the moist forest were: *Alnus*, *Carya*, *Fraxinus*, *Celtis*, Cupressaceae/Taxodiaceae, *Juglans*, *Liquidambar*, *Myrica*, *Populus*, *Prunus*, Rosaceae, *Salix*, *Heliocarpos* and another Tiliaceae genus. In the shore of the lake developed large weed lands of Asteraceae, Poaceae and Chenop.

The Almoloya ciénega has suffered changes in its extension since the Holocene. This is reflected by the plants for the flooding prairie such as *Arenaria* and Malvaceae, subaquatics represented by Ranunculaceae, *Polygonum*, *Eriocaulon*, *Luzula* and many *Cyperus* and Juncaceae species. The strictly aquatics present are *Berula*, *Hydrocotyle*, *Ludwigia*, *Datura*, *Sagittaria*, *Potamogeton*, *Typha*, *Myriophyllum*, *Utricularia*, *Nymphoides*, and many *Nymphaea*, *Schoenoplectus* and *Heteranthera* species. Another plants present are *Equisetum* and *Selaginella*. Among the algae *Pediastrum* and many Chlorococcales such as *Botryococcus*.

Noteworthy, species as *Batis maritima*, *Nuphar* and *Eriocaulon* were found, where they have not been collected in modern times in the Lerma's River High Basin. The presence of *Eriocaulon* starts during the Holocene, it is scarce and intermittent and its last register is from 3,000 year BP, while the *Nuphar* scarcely appears 2,000 years BP.

Pollen diagrams were made and analyzed, where it was found 5 different zones:

Early Holocene. Zone I, from 11,741 to 8,247 years cal BP.

The *Abies* forest is present at the beginning of the zone. The *Pinus* and moist forests present marked oscillations, both forests alternate, indicating a period of climatic variability. The strict aquatics dominate. It corresponds to a semicold climate with transitions to temperate subhumid, to moist semiwarm, to temperate subhumid.

Zone II. Middle inferior Holocene from 8,247 to 7,357 years cal BP.

It presents a dominance of the *Pinus* forest and of the strict aquatics represented for the algae. It corresponds to a temperate very moist.

Middle superior Holocene. Zone III, from 7,357 to 3,218 years cal BP.

It presents an augment in the *Quercus* forest. In the middle of the zone it can be observed a gradual increase of the grassland. The strict aquatics dominate. It corresponds to moist semiwarm with dry oscillation at the end of the zone.

Late Holocene. Zone IV, from 3,218 to 1,074 years BP.

It presents an increase in the *Pinus* forest, and the grassland augments. The plants of the flooding prairie dominate. Corresponds to a dry temperate climate. The presence of the humans in this zone is indicated by the increase of the Chenop-Am, Asteraceae, Poaceae and the presence of Cucurbitaceae and *Zea mays*.

Recent Holocene. Zone V, from 1,074 to 550 years cal BP.

It presents an increase of grasslands, and there is also an increase of the *Pinus* forest and the strict aquatic species. It corresponds to a moist temperate climate, being this inference tentative because of the human influence.

Five zones were recognized which show climatic and vegetational fluctuations of the last 10,000 years. Fluctuations

Are mainly changes in available humidity. Presence of *Zeamays*, Cucurbitaceae and Chenop. AMS during the last 3000 years is related with agricultural practices. The result confirm other data for the Central Mexican region.

Holocene climatic and environmental change from pollen records of Mexican lakes Zempoala and Quila

Almeida-Lenero, L.¹; Hooghiemstra, H.²; Cleef, A. M.² & van Geel, B.²

¹ Departamento de Ecología y Recursos Naturales, Facultad de Ciencias, Universidad Nacional Autónoma de México, C.P. 04510, México D.F. México.

² Institute for Biodiversity and Ecosystem Dynamics (IBED), Dept. of Palynology and Paleo/Actuo-ecology, University of Amsterdam, Kruislaan 318, 1098 SM Amsterdam, The Netherlands.

Pollen records of a 520-cm long core of lake Zempoala (2800 m alt) and a 884-cm long composite core of lake Quila (3010 m alt), both located 65 km SW of Mexico City, show changes in vegetation and climate. Record Zempoala comprises the last c. 6320 cal yr BP, (based on 6 bulk ¹⁴C ages ranging from 4580 ± 120 to 580 ± 70 ¹⁴C yr BP), record Quila shows the last c. 11,613 cal yr BP (based 4 bulk ¹⁴C ages ranging from 9713 ± 45 to 4650 ± 60 ¹⁴C yr BP). These lakes with submerged aquatics and hydroseral shore vegetation lie today in the *Abies religiosa* dominated forest belt.

From c. 6320 to 2530 cal yr BP site Zempoala shows a mixed forest with taxa from a mesophyllous forest, indicating warmer and more humid conditions than at present. From c. 2530-160 cal yr BP *Abies* forest and *Pinus hartwegii* forest dominate, indicating a temperate climate. For the interval c. 2530 to 1150 cal yr BP abundant *Pinus* forest indicate a more arid climate; this period of increasing climatic aridity coincides with the

collapse of the Maya civilization. During the last c. 310 cal yr BP *Abies* dominated forest with a floral composition resembling the modern one, indicates temperate and humid climatic conditions. In the last c. 180 ¹⁴C years presence of *Zea mays* and *Plantago* are clear indicators of human impact.

From c. 11,610 to 10,650 cal yr BP *Alnus* and *Pinus* dominated forest near the Quila site reflect humid climatic conditions. From 10,650 to 5003 cal yr BP *Pinus* and *Arceuthobium* are indicative of a *Pinus hartwegii* forest, suggesting slightly lower temperatures than at present. A 25-cm thick volcanic ash horizon was found at 380-355 cm core depth. This layer belongs to the well-known "yellow ash" marker with a known age of c. 4200-4800 ¹⁴C yr BP. This age is supported by our bracketing dates of 5620 ± 38 and 4650 ± 60 ¹⁴C yr BP. From 4630-1000 cal yr BP mixed forest, including *Pinus*, *Quercus*, *Carpinus*, *Hedyosmum*, *Juglans* and *Artemisia* indicate mesophytic conditions. From 4630 to 1006 cal yr BP *Abies* forest was abundant, reflecting colder and more humid conditions. From c. 1006-16 yr BP *Pinus* forest was very abundant suggesting, as in site Zempoala, dry conditions.

The pollen record of Quila represents the last 10,000 ¹⁴C yr BP and documents four different types of forest: *Pinus/Alnus* forest (possibly *Alnus jorullensis* in zone QUI-I), *Pinus* forest (most likely *Pinus hartwegii* forest in zone QUI-II), mixed forest in zone QUI-III), and *Abies* forest (*Abies religiosa* forest in zone QUI-IV). Both cores support climatic aridity as a possible factor for the decline of the Maya civilization. The last c. 1000 years shows a decline of mixed forest and increasing *Abies* forest, reflecting cooler and more humid conditions. Also site Quila shows during most recent time human impact by crop cultivation (*Zea mays*) and vegetation disturbance (*Plantago*) leading to erosion. Non-pollen palynomorphs, among which coprophilous fungi, were recorded and illustrated.

Fire Histories from the Wet Tropics

Haberle, S. G.¹, Rowe, C.², Rule, S.², Blumbach, P. B.³, Heijnis, H.⁴ & Forbes, Z.⁴

¹ Research School of Pacific and Asian Studies, Australian National University, Canberra ACT 0200 (Australia).

² School of Geography and Environmental Science, Monash University, Victoria 3800 (Australia).

³ Department of Geography, Oxford University, Oxford (United Kingdom).

⁴ Australian Nuclear Science and Technology Organisation, Lucas Heights, Sydney, NSW (Australia).

The extensive destruction of rain forest by fires across Southeast Asia and northern South America during the severe 1997-98 El Niño clearly demonstrated the susceptibility of large areas of rain forest to fire under conditions of extreme drought and proximity to ever increasing human population densities. Records of ancient microscopic charcoal show fires have repeatedly occurred even in tropical forests since at least the late Pleistocene, resulting in disturbance of forest ecosystems that periodically lead to long-term depletion of rain forest communities. What are the primary drivers for forest fires in the wet tropics and what are the implications of fire histories for the persistence of tropical plant diversity?

This study presents an examination of charcoal records across a range of spatial (continent to catchment) and temporal (millennial to decadal) scales. On the continental and millennial scale, records derived from the three main equatorial landmasses of the world (10°N-10°S) are reviewed. This shows the strong links between global climate change and fire in the tropics, despite the presence of humans, and implies a link between changing disturbance frequencies within the tropics and the persistence of diversity through time. At the catchment and decadal scale, data from four sites in tropical north Australia and Papua New Guinea are presented. The records show that there are clear regional trends in burning histories at the millennial time scale that are likely linked to regional climate phenomena (ENSO and Monsoon influence). On shorter time scales the impact of local biomass change and human activity become more important drivers of the fire regime.

This study highlights the potential of adopting a multi-scaling approach in order to understand the role of fire in ecosystem dynamics and the maintenance of diversity under a variable fire driven disturbance regime.

Last glacial – interglacial cycle in central Baja California, NW Mexico: paleoenvironmental reconstruction through pollen and macrofossils analysis

Peñalba, M. C.^{1,2}; Betancourt, J. L.²; Van Devender, T. R.⁴ & Rylander, K. A.³

¹ Instituto de Ecología, Universidad Nacional Autónoma de México, EIRNO, Hermosillo 83250, Sonora (México).

² Departamento de Geología, Universidad de Sonora, Hermosillo 83000, Sonora (México).

³ U.S. Geological Survey, Tucson, Arizona 85745 (U.S.A.).

⁴ Arizona-Sonora Desert Museum, Tucson, Arizona 85743 (U.S.A.).

Quaternary climatic changes resulted in a shifting of biogeographic regions at a global scale. In areas such as the Baja California peninsula, vegetation changes related to migrations, refuges, and endemism were also linked to geographical isolation. But there is little evidence of the past extension of communities within the peninsula, which could explain their present patterns of distribution, and associated climatic change. In order to remedy this gap, pollen and macrofossils analysis were undertaken on a series of 29 packrat middens collected at the Cataviña granite boulder field, central Baja California (29°48'N, 114°46'W, 640-680m). The fossil record covers the last 40,000 years. Present vegetation at the site belongs to the Sonoran Desert, Vizcaino region subdivision. However, plant macrofossils and pollen records show the dominance of woodland and chaparral taxa during the mid- and late Wisconsin up to 10,000 radiocarbon years BP, with *Pinus juarezensis*, *Juniperus*, *Quercus*, *Garrya*, *Arctostaphylos*, *Ceanothus*, *Ribes*, etc., while desert plants such as *Cactaceae*, *Fouquieria*, *Prosopis*, and *Larrea*, remain present at low abundances all along the fossil record. The desert – chaparral ecotone must have been close to the study site; it is suggested that woodland and chaparral probably extended down to at least 500 m, where they were replaced by desert plant communities of limited extent. The onset of the Holocene was marked by the departure of *Cupressaceae*, *Quercus* and *Pinus*, and the rapid and almost synchronous expansion of desert shrubs. Several chaparral taxa persisted at the site until 8000 BP, paralleling the lingering of oaks and junipers in the southwestern U.S. deserts. After this date, the Holocene vegetation experienced few floristic changes. Minor variations in the representation of some taxa (particularly around 6000 and 4000 BP) probably correspond to climatic perturbations identified from other sites in northwestern Mexico.

Holocene biomes and climate reconstruction of a site in the Sierra Madre Occidental, NW Mexico, from two pollen records

Ortiz-Acosta, M.E.^{1,2}; Guiot, J.¹; Peñalba, M.C.^{2,3} & Ortega-Rosas, C.I.²

¹ CEREGE BP80 13545 Aix-en-Provence cedex 4 – France.

² Instituto de Ecología UNAM Apartado Postal 1354, Hermosillo, Sonora CP 83000 México.

³ Departamento de Geología, Universidad de Sonora, Hermosillo, Sonora CP 83000 México.

Northwestern Mexico is located at the confluence of subtropical and temperate biogeographical regions, and thus constitutes an interesting place for the study of past vegetation and climate changes. An elevation transect from the sea shore to the highest mountains goes successively through desertscrub, thornscrub, tropical deciduous forest, oak woodland, oak-pine forest, and mixed coniferous forest. Surface pollen samples were collected within these vegetation types, and the data were studied and assembled together with modern pollen data from the regional literature (Anderson and Van Devender, 1995; Orvis, 1998). A biomisation method was applied to these pollen data, in order to obtain a set of reconstructed biomes, to be compared to the present vegetation at the different sites. The method consists of assigning to each pollen taxon one or more plant functional types (PFT's), which are based on their basic biology and bioclimatic ranges. Then biomes are defined by a combination of plant functional types (Prentice et al., 1996). In our study we recognized 11 PFT's and the following biomes: desert, semidesert, tropical deciduous forest, warm mixed woodland, and cool mixed woodland. The percentages of coincidence between reconstructed and observed biomes was as follows: 100% for the desert sites, 53% for semidesert, 48% for the tropical deciduous forest, 66 for warm mixed woodland, and 100% for cool mixed woodland. However, most of the errors encountered for the semidesert, tropical deciduous forest and warm mixed woodland correspond to sites located in human disturbed zones. We then excluded disturbed sites, and obtained these results: 80% of success for the semidesert, 100% for the tropical deciduous forest, and 100% for the warm mixed woodland.

The same method of PFT's was used to reconstruct the modern and past climate over two cores from a site in the Sierra Madre Occidental: Ciénega de Camilo. The procedure included a transfer function from PFT's to climatic variables, through an artificial neural network technique for non linear relationships. The correlation coefficients for the calibration of the 124 modern data samples were the following: moisture index 0.934 ± 0.045 , summer precipitation 0.852 ± 0.065 , and temperature of the coldest month 0.806 ± 0.100 . Present reconstructed summer precipitation at this site was 157 mm, while temperature of the coldest month is 9.775°C , and moisture index 0.425 (warm mixed woodland biome).

The first core, CAM1, was dated to 1150 radiocarbon years BP at half its length. The pollen diagram is dominated by *Quercus* with *Pinus*. The variations of the reconstructed temperature of the coldest month and summer precipitation through time were not significant: less than 0.3°C and less than 10 mm respectively. However, moisture index was the highest (0.44).

The second core covers the period from 8610 radiocarbon years BP to the present. Pollen spectra are dominated by *Pinus* at the oldest levels, and *Quercus* with *Pinus* after 6000 BP. Reconstructed temperature of the coldest month at 8610 BP was 1.5°C below the modern value, summer precipitation 30 mm over, and moisture index also over: 0.550, which corresponds to a cool mixed woodland. By 6000 BP, the reconstructed temperature of the coldest month had increased and was 0.5° below the modern value, summer precipitation was 20 mm over, and moisture index was 0.480, which already corresponded to a warm mixed woodland. From 6000 BP to 2000 BP, the temperature anomalies were most often lower than $\pm 0.5^\circ\text{C}$, and there was no significant change in the summer precipitation and moisture index for most of the period; however, several increases in the temperature of the coldest month (0.5°C) were recorded at 3500, 3200 and 3000±. Moisture index did not evidence any change at this time: only changes of temperature of more than 1°C were related to changes in the moisture index. Finally, the most recent levels are characterized by decreasing summer precipitation, including values below the present one.

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Is the 'lost world' really lost? a paleoecological perspective on the biogeography of the Guayana highlands

Rull, V.

Dep. de Biología Animal, Vegetal i Ecología, Univ. Autònoma de Barcelona, CI-215. 08193 Bellaterra, Barcelona (Spain).

Sir Arthur Conan Doyle coined the expression 'Lost World' (DOYLE, 1912) to refer to the remote and high plateaux in the middle of the tropical jungle of the Amazon and Orinoco basins, in northern South America. The uniqueness of the flora from the table mountains (tepui) flat summits has been explained either as the result of a long history of evolution in isolation (Lost World hypothesis or LW) or by alternating upward and downward displacements during the glacial/interglacial Quaternary cycles (Vertical Displacement hypothesis or VD). So far, the problem has been addressed solely on the basis of present-day floristic observations. This paper faces the problem from a Quaternary paleoecology perspective using recent palynological findings in the area, comparisons with paleoecological records from Neotropical mountains and lowlands of similar latitude, isotopic glacial/interglacial records from marine and ice cores, and different points of view about the response of organisms to Quaternary climatic changes, with emphasis on the LGM and the debate on the existence or not of Neotropical refugia.

Recent palynological records from a tepui summit (RULL, 2004) have shown past vertical shifts of vegetation in response to climate, thus supporting the VD hypothesis. However, a physiographical analysis shows that around the half of the tableaux summits are too high for their flora to have reached the lowlands during the

last glaciation, suggesting that a degree of isolation is unavoidable. Thus, part of the flora must have evolved in isolation, whereas the other part must have experienced interchange, as is reflected in the endemism patterns. Therefore, the biogeographical patterns of these summits are the result of a complex evolutionary process in which both LW and VD hypotheses are complementary rather than contradictory. Not all the 'Lost World' seems to be lost.

However, climate forcing alone is not enough to account for the biogeographical patterns in the Guayana highlands. Internal ecological features of the ecosystems are also needed to explain the present-day specialization and endemism of the flora from the tableaux summits. The case of a highly endemic genus (*Chimantaea*, Compositae) is analysed as an example, to illustrate the usefulness and limitations of the different arguments to account for its geographical arrangement. Besides both evolution in isolation and lowland migrations, complex ecological processes leading to differential survival and local extinction patterns are necessary to explain the present-day distribution of this taxon.

Another unsolved debate is the existence or not of the Pantepui (the assemblage of all the tepui summits) refuge during the LGM. Paleocological studies done so far have been unable to find pre-Holocene sediments, and suggested arid climates during the LGM, thus rejecting the idea of the Pantepui refuge. However, the number of localities studied (<10) do not represent at all the vast Pantepui area (ca. 5000 km²) and, consequently, the existence of Pleistocene sediments can not be discarded on this basis. Some ideas are provided for future research, including a more extensive sampling strategy, the evaluation of the individualistic versus the community approach, and the use of island biogeography methods on present-day floristic data.

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Holocene Mangrove Dynamics of the western Ganga-Brahmaputra delta, India

Hait, A. K.¹ & Behling, H.²

¹ Department of Botany, City College, Calcutta - 700009 (India); Present Address - Hanse Wissenschaftskolleg, Lehmkuhlenbusch 4, D 27753 Delmenhorst (Germany) and Center for Tropical Marine Ecology, Bremen (Germany).

² Geowissenschaften, University of Bremen, Postfach 330440, 28334, Bremen (Germany).

The rich and diverse mangrove ecosystems of the Ganga-Brahmaputra delta in India have significant economic and environmental implications for the rapidly growing population in this area. The present day distribution of mangrove is very much influenced by anthropogenic factors in form of land reclamation and decreased river flow influx. Protection of this mangrove forest is essential and urgent. The reconstruction of mangrove ecosystem through time and space is important to understand the development and dynamics of mangrove in this region. This information is necessary for the management of this ecologically unique ecosystem minimizing further degradations.

Palynological studies of several radiocarbon dated long (30 - 50m) and short (2-3m) sediment core located on a north - south transect reveals the existence of a mangrove ecosystem in the western Ganga - Brahmaputra delta since the last 8800 yr BP. The development of this early mangrove was a response to the rising sea -level during early Holocene. However, this early mangrove was restricted in the southern part of the delta and could not stabilize due to subsidence.

Mangrove started to colonize in the stable northern part (which is about 100 - 120 km from the present day coast) since 7000 yr BP. After 6500 yr BP there was a balance between sedimentation and sea level rise. As a result a vast mangrove swamp developed which continued until 4000 yr BP.

Regression of the sea-level started in the area at about 4000 yr BP, which caused the retreatment of the mangrove seawards. The present day mangrove was formed subsequently.

Natural factors such as sea - level changes, neotectonic activity and subsidence contributed significantly to the development of the Holocene mangrove ecosystem of Sundarbans. However, since the early 18th century increasing anthropogenic influence in the form of large scale land reclamation, overexploitation of resources and decreased river flow influx greatly altered the balance and stressed the Sundarban mangrove of the western Ganga - Brahmaputra delta.

Palynological data on a peat deposit from Santo Antônio da Patrulha region, Rio Grande do Sul State, South Brazil

Bauermann, S. G.¹; Behling, H.² & Souza, P. A.³

¹ Laboratório de Palinologia, Universidade Luterana do Brasil, Rua Miguel Tostes, 101, CEP 92.420-280, Canoas, RS, Brazil (soraiah@ulbra.br).

² Center for Tropical Marine Ecology, Fahrenheitstrasse 6, 28359, Bremen, Germany (hbehling@zmt.uni-bremen.de).

³ Departamento de Paleontologia e Estratigrafia, Instituto de Geociências, Universidade Federal do Rio Grande do Sul, Av. Bento Gonçalves, 9500, CEP 91.540-000, Porto Alegre, RS, Brazil (paulo.alves.souza@ufrgs.br).

Palynological studies on the Quaternary sediments carried out in Rio Grande do Sul State have provided important signs about paleovegetational communities and paleoclimates associated. Palynological assemblages have contributed for the comprehension of paleoecological problems, understanding and prediction of possible behavior patterns of the vegetational communities. This study presents unpublished palynological data from Barrocadas peatbog (Bauermann, 2003) which help to the better understand of the Quaternary paleovegetational and paleoenvironmental evolution of the Rio Grande do Sul Coastal Plain, upper portion of the Pelotas Basin.

The study is based on a 4.80 m long core done with Russian sampler, from which 41 palynologically fertile samples were collected. Highly diversified assemblages including pollen grains, spores, algae, phytoclasts and zooclasts having been recognized. Based on the accounts, diagrams of percentage and concentration were made. Additionally, three radiocarbon ages were established by accelerator mass spectrometry at the *Leibniz Labor für Altersbestimmung und Isotopenforschung der Universität Kiel* – Germany (27.775 ± 145 ¹⁴C, 12.948 ± 66 and 3.163 ± 29 ¹⁴C ky). In addition, the present floristic composition of the peatbog was listed through seasonal observations, aiming to compare the pollinic spectrum recorded on the sediments with the present vegetation.

The analysis allowed the establishment of 5 palynological zones, named as bc-i, bc-ii, bc-iii, bc-iv and bc-v, in ascending stratigraphical order. The BC-I Zone (27.775 ± 145 ¹⁴C to 16.000 ky) is characterized by the predominance of herbal pollen grains, mainly Poaceae, Cyperaceae, *Baccharis* type, *Plantago* type and Apiaceae; rare arboreal pollen grains were registered and belong to *Myrsine*, *Arecaceae*, *Alchornea*, *Cecropia*, *Celtis*, *Meliaceae*, *Mimosa*, *Podocarpus* and *Roupala* type. Herbal pollen grains such as Poaceae, Cyperaceae, Apiaceae, *Baccharis* type and *Plantago* dominate the BC-II zone (16.000 to 10.000 ky) also; among the arboreal taxa *Mimosa*, *Myrsine*, *Myrtaceae*, *Cecropia* and *Arecaceae* were recorded. In BC-III Zone (10.000 to 6.000 ky), herbal pollen grains dominate and a small increase in diversity of arboreal ones, including *Mimosa*, *Arecaceae* as well as new taxa occur (*Anacardiaceae*, *Chrysophyllum* and *Matayba*). This dominance is recorded in the BC-IV Zone (6.000 to 1.400 ky) also and new arboreal taxa of tropical habit appear (*Moraceae/Urticaceae*, *Weinmannia* and *Marcgravia Polyantha*). In the BC-V Zone (1.400 ky up today) arboreal taxa are dominant and *Tripodanthus Acutifolius*, *Byrsinima Ligustrifolia* and *Clusia Criuva* appear. From this last zone, *matas de restinga* are established, which are characterized by vegetational communities forming, in the Brazilian Quaternary, an edaphic vegetational complex, pioneer on the beaches, sandy ridges, dunes and associated depressions, plains and plateaus (BDT, 2004).

The presence of algae (*Debaria* and *Concentricystis Rubinus*) indicates a body of freshwater for the BC-I Zone. A light increase relative to the thickness of the waterplate is suggested in the BC-II Zone due to a great frequency of *Zygnema*. Terrestrial conditions predominate from the BC-III Zone. A cold and dry climate is registered since the Last Maximum Glacial up to the beginning of BC-IV Zone (3.000 ky). Progressively hotter and more humid climate conditions are verified from then to the final of the BC-IV Zone (1.400 ky). From the BC-V Zone, climatic conditions are similar to the current one.

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Late Quaternary vegetational and environmental changes in southern Brazil

Neves, P. C. P. das ¹; Bauermann, S. G. ¹ & Behling, H. ²

¹ Laboratório de Palinologia, Universidade Luterana do Brasil, ULBRA, Rua Miguel Tostes, 101, CEP 92.420-280, Canoas, RS, Brazil (soraiah@ulbra.br).

² Center for Environmental Science and Technology, Bremen, Germany (behling@uni-bremen.de).

Several studies on the Quaternary palynology the have been developed in the South Brazil lately (BEHLING 1993; BEHLING et al. 2001).

In Rio Grande do Sul, the southernmost state of Brazil, the vegetation is present in the Recent, like a mosaic resulting from the differences in relief, soil, geology and hydrography, even though there has been a homogeneous pluviometric regime throughout the year. The distribution of the current vegetation formations results from several transformations occurred mainly along the Quaternary.

Palynological records from fields communities tend to point out dry climates, like the ones at the beginning of the Holocene, while the forest formation ones are related to wet climates. Therefore, it is expected that, from the Medium Holocene on there had been paleovegetational changes, in this area, similar to the ones already recorded in the polyenic spectra of other regions of Rio Grande do Sul.

Taking this into account, the region of São Martinho plays an important role once it is located in a transactional zone between forest formations and fields communities.

The collection point (29° 27' 11" S; 53° 41' 52" W) is situated in the occurrence area of Paraná Basin (Serra Geral Formation) where the current vegetation is predominantly constituted by representatives of Decidua Stational Forest intersected by field areas, probably resulting from the action of fire and shepherds (OLIVEIRA, 1991).

The study is based on a 100 cm core, done by the sampler Russian, from which 50 palynological samples were collected and analyzed on an optical microscope (minimum count of 300 grains of pollen per sample), where grains of pollen, pteridophyte spores, briophytes, algae and phytoclast were determined. For palynological analyses, samples of sediment were removed at regular intervals of 2 cm, and were processed according to the usual palynology techniques. Three radiocarbon datings were performed along the profile collected. With the data obtained, three distinct zones were established on the palynological diagrams: SM1 (100-95 cm) – age 3.231 ± years A. P. – ample rule of the field vegetation over the arboreal; SM2 (95-95 cm) – 1.574 ± 56 years A. P. – the fields also rule and aquatic elements appear; ZONE SM3 (25-0,0 cm) – modern age – fields continue to rule; on the base of the zone there is a significant peak of phytoclast and on the top, a more significant presence of some arboreal elements (*Mystaceae*, *Alchornea*, *Boraginaceae*, among others).

Along all the profile there was a predominance of field formation over the other ecosystems of the region. Although there had already been the establishment of forest formations in other regions, the same did not develop fully in the region of São Martinho da Serra, probably due to the edaphic factor. The results in São Martinho da Serra agree with the results from other field areas in Southern Brazil and undoubtedly demonstrate the character of a natural landscape for the fields in Southern Brazil.

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Late Quaternary vegetation dynamics of the Eastern Arc Mountains, Tanzania

Mumbi, C.¹; Marchant, R.²; Wooller, M.³; Hooghiemstra, H.¹ & Mwalyosi, R.⁴

¹IBED, Faculty of Science, University of Amsterdam, Postbus 94062, 1090 GB Amsterdam, The Netherlands.

²Department of Botany, Trinity College Dublin, Dublin 2, Ireland.

³Department of Geography, University of Alaska, Fairbanks, USA.

⁴Institute of Resource Assessment, University of Dar es Salaam, PO Box 35097, Tanzania.

One surprising outcome from the study of Quaternary environments has been the responsive nature of tropical ecosystems to climate change. Preliminary results are presented from a multi-proxy study (pollen, macrofossil and charcoal) applied to sediments abstracted from peat accumulating sedimentary basins at six highland locations along the Eastern Arc Mountains of Tanzania augmented with vegetation surveys and a program of modern pollen trapping. The research program will also apply bioclimatic models to simulate and investigate ecosystem response to environmental change, the presence of stable states and signals of transitions in ecosystem state, to develop understanding of ecosystem response to environmental change. By combining expertise and techniques, working between traditional disciplines, the environmental dynamics that drive Eastern Arc montane rainforest transitions will be fully explored.

Determining more precisely how these montane ecosystems responded to such forcing we aim to determine environmental thresholds and frequency of vegetation response to environmental change. Results from the proposed research in Tanzania will be contextualised in light of current debates regarding the long term ecological functioning of the Eastern Arc flora. In particular, we aim to determine if high biodiversity in this area has been buffered from the climatic changes experienced elsewhere in tropical Africa.

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Holocene climatic and vegetational history of a *Mauritia flexuosa* L.f. (Arecaceae) swamp community from the Eastern llanos of Venezuela

Leal, A.¹; Rull, V.² & Bilbao, B.¹

¹Dep. Environmental Science, Universidad Simón Bolívar, Caracas (Venezuela). bbilbao@usb.ve

²Dep. Biología Animal, Vegetal e Ecología; Univ. Autónoma de Barcelona; 08193 Bellaterra, Barcelona (Spain). valenti.rull@uab.es

This work is aimed to reconstruct the Holocene vegetational and climatic history of a palm swamp dominated by *Mauritia flexuosa* L.f., a vegetation type locally called 'morichal', using sedimentology and pollen analysis.

The study site belongs to the Amana River system, of the Orinoco basin, in the eastern Venezuelan 'Llanos'. A 195-cm sediment core, encompassing the last 9,070 ± 45 ¹⁴C yr BP, was obtained with a vibracore borer.

Based modern analogue studies, five pollen zones were defined and interpreted in terms of vegetation and environmental dynamics.

Between 9,070 and 8,200 ¹⁴C yr BP the *Mauritia* pollen was absent, and Poaceae and Cyperaceae dominated the assemblage. The relatively high percentages of gallery forest elements, like *Schefflera*, *Cecropia*, *Phyllanthus*, Clusiaceae and Burseraceae, together with a high influx of fern and fungi spores, indicate the vicinity of a gallery forest, suggesting warm and wet conditions. The occurrence of local fires is deduced from the high influx of particulate charcoal.

Between about 7,800 and 3,000 ¹⁴C yr BP, a climate drier than the present is interpreted because of the absence of palynomorphs, most probably due to oxidation. The presence of mottled clays similar to the present-

day savanna soils suggest a strong precipitation seasonality, and a dry savanna vegetation. Lateral changes in the river course are unlikely, due to the constant granulometric characteristics of sediments.

The *Mauritia* pollen reached the site at about 3,000 ¹⁴C yr BP, probably representing the beginning of a climate similar to the present. In addition, the strong increase in the influx of charcoal particles indicates a phase of high fire incidence.

Between about 3,000 and 1,300 ¹⁴C yr BP, the percentages of *Mauritia* and tree pollen were relatively low, and the assemblage was dominated by Poaceae and Cyperaceae, a situation found today in the modern pollen assemblages from the open palm swamps.

A strong decline in total pollen influx involving all pollen types characterised the period between 1,300 and 900 ¹⁴C yr BP, suggesting dry climatic conditions again. However, *Mauritia* persisted.

Between 900 ¹⁴C yr BP and the present, a gradual, conspicuous increase of *Mauritia*, as well as gallery forest taxa (*Schefflera*, *Tapirira guianensis*, *Virola surinamensis*, *Phyllanthus*, *Cecropia*), together with the decline of Poaceae, suggest the establishment of a more diverse and structurally complex palm/forest community, under climates similar to present. The early increase in *Cecropia*, is interpreted in terms of human disturbance.

Our findings show a good correlation with those from other Neotropical savanna and 'morichal' areas, suggesting regional, rather than local, vegetation and environmental patterns of change.

Reconstructing Late Quaternary shifts in the rainforest-savanna boundary in SW Amazonia: a novel approach using pollen, molecular ¹³C analysis and grass-cuticle assemblages

Metcalf, P. R.¹; Mayle, F. E.²; Street-Perrott, F. A.¹; Ficken, K. J.¹ & Killeen, T. J.⁴

¹Tropical Palaeoenvironments Research Group, Department of Geography, University of Wales, Swansea, SA2 8PP, UK. Email contact: ggmetcalf@swansea.ac.uk

²Department of Geography, University of Leicester, Leicester, LE1 7RH, UK.

³Institute of Geography, School of Geosciences, Drummond Street, University of Edinburgh, Edinburgh, UK.

⁴Museo de Historia Natural Noel Kempff Mercado, Avenida Irala 565, Casilla 2489, Santa Cruz, Bolivia.

Palaeoecological reconstructions based on a single proxy are limited, but by combining grass-cuticle analysis with pollen and stable carbon-isotope analyses, ecosystem structure and function can be better understood. This research assesses how forest-savanna boundaries have shifted in response to past environmental changes, which is crucial to understanding the present-day vegetation mosaic and the origins of Amazon biodiversity as a whole.

Stable carbon isotopes act as a tracer of past changes in carbon cycling. Individual plant leaf-wax compounds can be extracted from lake sediments and their isotopic values measured by compound-specific ¹³C analysis, permitting the evaluation of past changes in the abundance of C₃ and C₄ graminoids, and thereby clarifying ambiguities in the pollen record. Grass-cuticle analyses provide even finer taxonomic resolution, enabling the identification of individual C₄ subtypes (which have distinct environmental tolerances). Under favourable circumstances, identifications can be made to generic or even species level, greatly increasing the scope for making palaeoecological inferences from tropical lake sediments.

In this study, a multiproxy approach, using grass-cuticle assemblages and stable carbon-isotope analyses of total organic carbon (TOC), is being applied to a lake-sediment core from Laguna Chaplin (14°28'S, 61°04'W), situated in Noel Kempff Mercado National Park (which straddles a climatic transition zone between Amazonian moist evergreen forest, semi-deciduous forest, and savanna)^(2,3). The δ¹³C values of TOC ranged from 17‰ at the LGM to 26‰ in the late Holocene, suggesting an increased representation of C₄ graminoids during glacial times. This finding is consistent with the corresponding glacial-age pollen assemblages, which are dominated by grasses and palms (*Mauritia/Mauritiella*) with low levels of rainforest taxa, implying an expansion of seasonally-flooded savannas at the expense of seasonally-flooded forest. Compound-specific ¹³C analyses of leaf-wax n-alkanes and n-alkanoic acids from 17 levels in the Lake Chaplin core will be presented, together with a matching suite of grass-cuticle analyses. The palaeoecological inferences previously made from pollen and bulk carbon-isotope data will be tested using these results, permitting overall conclusions to be drawn at much greater taxonomic resolution.

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Holocene dryness and human occupation in South America: understanding the "Archaic Gap".

Araujo, A. G. M.¹, Neves, W. A.¹ & Pilo, L. B.¹

¹ Laboratório de Estudos Evolutivos Humanos, Instituto de Biociências da Universidade de São Paulo, Rua do Matão, 277 – Cidade Universitária 05508-090 – São Paulo – Brazil.

An overview of the archaeological data produced in the last decades for Brazil and neighbouring countries, coupled with a background of recent studies on paleoenvironments for South America, suggests that during the mid-Holocene vast areas of central Brazil and northeastern Argentina ceased to be occupied by human groups.

Independent data coming from dated human skeletons, rockshelter stratigraphy, and chronology of open-air sites converge to the idea that these areas were depopulated or altogether abandoned. Paleoenvironmental data suggests that dryness events constitute the major cause behind the observed trends. This phenomenon expands the already perceived notion that climatic stresses had a major role in the shaping of human settlement patterns in marginal environments, such as deserts and high-altitude settings.

Late Holocene pollen record of Lago Verde in the tropical lowland of the Mexican Gulf coast

Lozano-García, M. S.¹; Sosa, S.¹ & Caballero, M.²

¹ Institute of Geology, Nacional University of México, 04510, México D.F.

² Institute of Geophysics, Nacional University of México, 04510, México D.F.

Lago Verde is a maar lake (18 36 43N; 95 20 52 W) located on the Gulf Coast of Mexico in "Los Tuxtlas" region. The area was covered by tropical rain forest and according to archaeological studies was the core of the Mesoamerican cultures. A 6 m sediment core was obtained from the central part of the lake in order to document the vegetation history of this area. Lago Verde is a shallow lake (max. 4 m), the natural vegetation has been removed and grasslands with some tropical trees such *Bursera* grows around the lake.

According with the radiocarbon chronology the sequence covers the last 2500 yr BP. At the base of the sequence (2500 yr BP) low abundance of tropical trees is record. Pollen of *Zea mais* was found from ca. 2100 to ca. 1200 yr BP. A sudden change in the pollen stratigraphy occurs at ca. 2000 yr BP, with important presence of Poaceae, *Ambrosia* and *Cheno. Am.* along with *Zea* indicating human activity in the area. At 1200 yr BP, no more *Zea mais* pollen is recovered suggesting the abandonment of the area and a dry phase in the lake based on the diatom content suggests a period of dry conditions in the zone. This pollen signals correlates with dry phases in Yucatan, suggesting that this dry climatic signal probably had effect on an ample area of Mexico. After this dry period a recovery of the tropical forest is documented. The last yr BP is characterized by the reduction in the pollen of tropical forest trees which is related to deforestation, presence of *Zea mais* and an increase of erosion rates.

Late Holocene environmental history of the Mekong Delta, Vietnam

Branch, N. & Maltby, E.

Department of Geography, Royal Holloway University of London, Egham Hill, Egham, Surrey, TW20 0EX, UK.

Recent palaeoenvironmental research in Vietnam has examined the Late Holocene history of wetland forest in the Mekong Delta. The specific objectives of the project were to assess the impact of environmental changes, particularly changes in the height of relative sea level, floodplain development, biomass burning and human activity, on the functioning of the wetland ecosystem. Several radiocarbon-dated pollen-stratigraphic records from the Plain of Reeds study area (centred on 10° 44' 37" N, 105° 37' 70" E), supplemented by sedimentological data, indicate that the present-day *Melaleuca* dominated wetland forest colonised the Mekong Delta approximately 3000 years ago. This important event in the vegetation history of Vietnam coincides with a shift to more 'terrestrial' conditions (peat formation) and a decline in the dominance of mangrove (*Rhizophoraceae*) forest. The timing and nature of the succession from mangrove to *Melaleuca*-dominated freshwater wetland is significant for three reasons: (1) it indicates that *Melaleuca* forest has been present in Vietnam for much longer than previously thought; (2) it casts doubt on previous interpretations of the successional dynamics of wetland forests, and (3) it suggests that the transition coincided with a period of sea-level regression (or stabilisation). In addition, the evidence for biomass burning and overall decline in wetland forest in the uppermost parts of the sequences investigated have been tentatively interpreted as clearance and cultivation by human groups. These new records from the Mekong Delta are thought to be important for our understanding of the environmental history of the region, and SE Asia in general, and have implications for current research into the sustainable management of the wetlands.

History of African monsoon since 18 000 years and its impact on the ecosystems of West Africa: contribution of the study of pollen and algae

Eddor, T.¹; Lézine, A. M.² & Cazet, J. P.²

¹ Faculté des Sciences-Laboratoire de Palynologie, Université de Lomé (Togo).

² LSCE, UMR 1572 CNRS-CEA, Orme des Merisiers, 91191 Gif-sur-Yvette cedex (France).

Pollen analyses on continental and marine sedimentary sequences are used to trace back the history of African monsoon at pluri-centennial to millennial scales. Using pollen data from deep oceanic sedimentary sequences recovered off West Africa as atmospheric indicators (wind speed and direction), previous studies carried out by Hooghiemstra (1989) have depicted the main trends of monsoon versus trade wind fluxes during the last climatic cycle, while those carried out by Dupont and colleagues (1992, 1993) have investigated the links between climate evolution since the Brunhes chron. and the extension/retraction of the main ecosystems in West Africa. Recent work by Cazet (2001) and Lézine et al. (submitted) on a borehole taken at the mouth of the Niger River provides the first detailed chronology of the fresh-water inputs to the ocean linked to the increased activity of the West African monsoon at the last glacial-interglacial transition. This work confirms the time interval of the last "African Humid Period" dated by De Menocal et al. (2000) between 14.5 and 5.5ka cal B.P. from faunal and sedimentary studies carried out off Cap Blanc, Mauritania. It allows to precise the monsoon variability since the last glacial. In particular, it shows that the first phase of monsoon activity, which led to a widespread lacustrine extension in the nearby continent, was progressive and characterized by very irregular flows with phases of massive fresh water contributions to the ocean alternating with phases of notable reduction in fluvial contribution.

It is possible today, thanks to the large amount of pollen data collated by the African Pollen Database (APD) to analyze in detail the response of the littoral and continental ecosystems to the variability of African monsoon during the late Quaternary. These data indicate that the *Rhizophora* mangrove reached its maximum extension around 12.14ka cal B.P. and remained developed during the Holocene to about 3ka cal. B.P. It reached up to 21°N latitude in Mauritania while covering river mouths and bays. Inland, tropical trees extended north using river beds as migration routes to enter the Saharan desert as dense gallery forest formations which allowed the installation of abundant animal populations and brought to the men the conditions of the development of breeding and agriculture.

Late Quaternary environmental history of the Central Peruvian Andes

Silva, B.

Department of Geography, Royal Holloway University of London, Egham Hill, Egham, Surrey TW20 OEX, UK.

New radiocarbon dated sedimentary and fossil pollen records from the Central Peruvian Andes, at elevation above 3500 m.a.s.l., have significantly enhanced our understanding of Late Quaternary environmental changes. Towards the end of the last cold stage (late glacial), pollen assemblages dominated by puna elements, along with some montane forest indicators, from Lago Runtacocha (near Andahuaylas) and Qewillacocha mire (near Cuzco) indicate a cold / dry climate. Tentative evidence for a late glacial cold / wet episode (i.e. Younger Dryas?) is also suggested but not presently confirmed. The transition to the early Holocene is marked by peat initiation, and increases in arboreal and montane forest taxa (the above sites with Torrepatá mire and Chaquicoccha mire). The pollen evidence from all four sites implies increased moisture and higher temperatures from about 11,000 to 7,000 cal yrs BP. The middle Holocene (7,000-3,000 cal yrs BP) is characterised by a decline in montane forest indicators, and increases in Poaceae and Chenopodiaceae-Amaranthaceae, suggesting increased aridity. During the late Holocene (3,000 cal yrs BP -present) sedimentary and pollen evidence (increase in puna taxa) indicate a transition to cold / wet conditions with the onset of Neoglaciation. Following this period, higher temperatures are suggested by an increase in montane and moisture-loving taxa (e.g. *Alnus*). Modifications of the natural environment by human activity during the late Holocene is also evident in the pollen records, with unequivocal evidence for clearance and cultivation.

Holocene environmental development of the intra Andean high plain of Duitama (Boyacá, Colombia) from pollen records of Pantano de Vargas

Berrío, J. C.^{1,2}; Gómez, A.³; Hooghiemstra, H.¹; Becerra, M.⁴ & Marchant, R.⁵

¹ Institute for Biodiversity and Ecosystem Dynamics (IBED), Palynology and Paleo/Actuo-ecology, University of Amsterdam, Kruislaan 318, 1098 SM Amsterdam, The Netherlands.

² Inst. Ciencias Naturales (ICN), Univ. Nac. Colombia, A.A. 7495, Bogotá (Colombia).

³ Pontificia Universidad Javeriana, Bogotá, Colombia.

⁴ Archéologie des Amériques, UMR 8096, France, Chercheurs associés UPTC-ACASTC.

⁵ Department of Botany, Trinity College Dublin.

Holocene environmental change and the pre-Hispanic occupation history of the interAndean high plain Paipa-Duitama in the Eastern Cordillera of Colombia, are presented following pollen and sedimentary analysis of lake and swamp sediments. The pollen record from a 625-cm long core (Vargas-1), dated by seven AMS radiocarbon dates, represents the period from 8800 to 2600 BP. The pollen record from 515-cm long core (Vargas-2), dated by four AMS radiocarbon dates, represents the period from 5400 to 1500 BP. We identified seven distinct periods in the environmental development of this basin.

From 8800-7230 BP the active drainage system changed and organic-rich sediments started to accumulate. *Alnus* and *Myrica* swamp forest grew on wet soils. The surrounding slopes were characterised by Andean forest with much *Hedyosmum*, Melastomataceae and *Quercus*. From 7230-6090 BP open water with aquatics and peat-forming *Plantago* is characteristic as lake levels changed repeatedly. From 6090 to 5220 BP open water and grassy vegetation around the lake became replaced by *Alnus*-dominated swamp forest, suggesting a lowering of the lake level. The lake level continued to lower under increasingly drier conditions. From 5220-4400 BP competition between *Alnus*-dominated swamp forest and open grassy vegetation continued, this reflecting changing water levels. *Hedyosmum*, *Miconia*, *Quercus*, Solanaceae, *Relbunium* and Rubiaceae were common elements in the Andean forest. From about 4400-3500 BP there was a high production of organic material as the cover of *Alnus*-dominated swamp forest with *Myrica* fluctuates within the catchment. Deforestation (reduction of *Quercus*), the lowering of the lake level, and increasing erosion (Amaranthaceae/Chenopodiaceae, *Borreria* and *Dodonaea*) point to the presence of pre-hispanic human influence. In the period from 3500-2500 BP there is first evidence of crop cultivation (*Zea mays*) and increased amounts of charcoal in the sediments as the clearance of montane forest (*Quercus*) and erosion increased. From 2500-1500 BP open grassy vegetation is most

abundant and erosion is significant as the lake changed into a swamp. By this time pre-hispanic humans had used nearly all alder wood within the catchment for construction and firewood. The last 1500 years are not represented as sediments have been oxidised and removed.

Poster session h5

LONG CONTINENTAL RECORDS: THE DEVELOPMENT OF "GROUND TRUTH" FOR THE MARINE OXYGEN ISOTOPE CHRONOLOGY

Environmental changes on the Laptev Sea region during the Middle-Late Quaternary inferred from Bol'shoy Lyakhovsky Island (Arctic Siberia) pollen records

Andreev, A. A.¹; Novenko, E. Y.²; Grosse, G.¹; Schirmer, L.¹ & Tarasov, P. E.¹

¹ Alfred Wegener Institute for Polar and Marine Research, Research Unit Potsdam, Telegrafenberg A43, D-14473 Potsdam, Germany.

² Institute of Geography RAS, Staromonetny 29, 109017 Moscow, Russia.

Pollen records from permafrost sequences complemented by ¹⁴C, IRSL and ²³⁰Th/U dates from Bol'shoy Lyakhovsky Island (73°20'N, 141°30'E) document the environmental history in the Laptev Sea region for at least the past 200 ka. Pollen spectra and insect fauna indicate that relatively wet grass-sedge tundra habitats predominated during an interstadial c. 200-170 ka ago. Summers were rather warm and wet, while stable isotopes reflect severe winter conditions.

The pollen spectra reflect sparser grass-sedge vegetation cover during a late Saalian stadial, c. 170-130 ka ago, with environmental conditions much more severe compared with the previous interstadial. Open Poaceae and *Artemisia* plant associations dominated vegetation at the beginning of the Eemian Interglacial, c. 130 ka ago. Some shrubs (*Alnus fruticosa*, *Salix*, *Betula nana*) grew in more protected and wetter places as well. The climate was relatively warm during this time, resulting in the melting of the Saalian ice wedges. Later, during the interglacial optimum shrub tundra with *Alnus fruticosa* and *Betula nana* s.l. dominated vegetation. Climate was relatively wet and warm. Quantitative pollen-based climate reconstruction suggests that mean July temperatures were 4-5°C higher than the present during the optimum of the Eemian Interglacial, while late Eemian records indicate significant climate deterioration.

Low pollen concentration, large amounts of redeposited palynomorphs and presence of cryoxerophilic taxa characterize pollen records dated >55-50 ¹⁴C ka BP and from 119±22 to >79 IRSL ka. Dry grass and sedge communities with few other herbs occupied the area during this time, corresponding to the Zyryan (Early Weichselian) stadial. Dominance of redeposited pollen reflects scarce vegetation cover and/or low pollen productivity.

Higher pollen concentration, fewer redeposited palynomorphs, and increase of Cyperaceae pollen content are characteristic for records dated ca 47-37 ka by ¹⁴C and IRSL. Sedge and grass tundra-like vegetation with some other herbs (mostly Caryophyllaceae) dominated vegetation. Presence of some warm pollen indicator (*Salix*, *Betula nana*, Ericales) reflects relatively warm and wet climate during this interval, corresponded to the Kargini (Middle Weichselian) interstadial.

In the pollen spectra dated ca. 31-28 ¹⁴C ka BP pollen concentration decreased. Grass-sedge communities with some Caryophyllaceae, Asteraceae, Brassicaceae, and *Valeriana* dominated vegetation during this interval. Large amounts of redeposited pollen reflect scarce vegetation cover and/or low pollen productivity in that time. Climate was much drier and colder than during the previous interval. There are no records from Sartan (Late Weichselian) stadial. This may indicate extremely unfavorable environment during that interval.

An increase of pollen concentration and a presence of *Salix* and *Betula nana* pollen, reflecting an amelioration of climate, is characteristic of sediments ¹⁴C dated to between 12 and 11 ka BP (Allerd). Decrease of