Late Quaternary environmental history of the Central Peruvian Andes

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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 Runtaccocha (near Andahuaylas) and Qewllaccocha 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 Torrepata 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 periods, 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

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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

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Pollen records from permafrost sequences complemented by ^{14}C, IRSL and ^{230}Th/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 sever 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 cryoxerophitic taxa characterize pollen records dated >55-50 ^{14}C 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 ^{14}C 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 Karginski (Middle Weichselian) interstadial.

In the pollen spectra dated ca. 31-28 ^{14}C 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 dryer 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 ^{14}C dated to between 12 and 11 ka BP (Allerød). Decrease of

pollen concentration, disappearance of shrub pollen is noticeable for Younger Dryas spectra and records a climate deterioration.

The early Holocene deposits is characterized by dominance of *Alnus fruticosa, Betula*, and Ericales pollen and *Equisetum* spores. The highest pollen concentration and high shrub pollen content in the deposits, dated from 9 to 7.5 ^{14}C ka BP, reflects warm and wet climate during that interval. Decrease of amounts of shrub pollen reflects the deterioration of climate after 7.5 ka BP. Climate and vegetation of the Laptev coast area became similar to modern since that time.

Paleoclimatic changes during the last ca. 750 kyr recorded in the Kathmandu Valley, central Himalaya

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We carried out palynological and sedimentological studies of the drilled core obtained from the Kathmandu Valley, in order to reconstruct paleoclimatic changes in the central Himalaya and to clarify changes of the past Indian monsoon during the Middle to Late Pleistocene. The continuous record of Indian monsoon in the Himalaya has not been clarified yet, although many scientists have carried out intensive studies of deep-sea sediments in the Indian Ocean and loess-paleosol sediments in China. The Kathmandu Valley, which is located on the southern slope of the central Himalaya and is directly influenced by Indian monsoon, is one of the best targets for the paleoclimatic study. After the pollen analysis of 218-m-long core taken from the basin-fill sediments, we could have outlined the paleoclimatic changes in the Kathmandu Valley during the last ca. 750 kyr and clarified millennial-scale climatic changes from 12kyr to 45 kyr.

The basin-fill sediments of the Kathmandu Valley are mainly composed of Pleistocene thick lacustrine-fluvial sediments. The 218-m-long core was obtained at Rabibhawan in the western central part of the Kathmandu Valley. The core is lithologically divided into three parts:1) 15 m thick gravelly mud at the basal part, 2) 187 m thick clayey and muddy sediments in the middle, 3) 9 m thick sand bed at the top. The samples used for pollen analysis were firstly collected at one-meter intervals from the core in order to reveal the outline of the paleoclimatic changes in the valley. Next, the samples at 10 cm intervals were collected in order to clarify millennial-scale climatic changes in the valley. The ages of the core were estimated to be ca. 12 kyr to ca. 750 kyr from magnetostratigraphic study and AMS ^{14}C dating.

The pollen diagram of the core was characterized by predominance of *Quercus*, which attains 30-80% of the arboreal pollen. *Pinus, Castanopsis, Alnus, Betula* and *Carpinus* were next dominant arboreal pollen in the diagram. Predominant nonarboreal pollen were Gramineae, *Artemisia* and Chenopodiaceae. On the basis of pollen assemblages and fluctuation of ratio of arboreal and nonarboreal pollen, the pollen diagrams were divided into 19 pollen zones. We inferred paleoclimatic changes on the basis of interrelationship between present distribution of vegetation and vertical climatic zonation in the Kathmandu Valley and surrounded mountains. For the purpose of inference of paleoclimate, we used the following genera as climatic indexes: *Pinus, Tsuga, Picea and Abies* for cold climate, *Quercus* and *Castanopsis* for warm climate, *Alnus, Betula, Carpinus* for wet climate and Gramineae, *Artemisia* and Chenopodiaceae for dry climate. The fluctuation curve of arboreal pollen corresponded to curve of δ18O obtained from deep-sea sediments in the Indian Ocean (BASSINOT et al. 1994). Our results are as follows:

1.- We obtained the paleoclimatic curve ranges in age from MIS 2 to MIS 19.
2.- The paleoclimatic changes in the valley were mainly divided into two parts at the boundary between pollen zone 10 and pollen zone 11, due to drastic change of numbers of pollen concentration: three to four times larger in the lower part. It corresponded to a boundary between MIS 8 and MIS 9. The lower part was characterized by fluctuation of longer cycle, and predominance of warm-and-wet climate. On the other hand, fluctuation cycle was much shorter in the upper part, and climate was cooler or cold-and-drier, except an interglacial period of MIS 5. It was inferred that activity of Indian monsoon became weak since MIS 8, and dry climate seems to have prevailed in the central Himalaya.
3.- Interglasial periods of MIS 11 and MIS 13 were warmer-and-wetter climate, in comparison with interglacial periods from MIS 2 to MIS 19. The percentage of arboreal pollen was 70 %, and value of pollen concentration was very high. *Castanopsis, Mallotus* and *Alnus* had very high percentages. Therefore, activity of Indian monsoon seems to have become very intensive during MIS 11 and MIS 13 in the central Himalaya.

4.- The climate has changed to be cooler in the central Himalaya from MIS 4 to MIS 2, and cool-and-wet climate and cold-and-dry climate repeated alternately.

BASSINOT, F. C., LABEYRIE, L. D., VINCENT, E., QUIDELLEUR, X., SHACKLETON, N. J., LANCELOT, Y. 1994. The astronomical theory of climate and the age of the Brunhes-Matuyama magnetic reversal. **Earth Planet. Sci. Lett.** 126: 91-108.

Long continental pollen records of Ukrainian Quaternary

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Continuous Quaternary sequences are studied in the sections of depressions: section Gat' (the Trans-Carpathian Lowland, western Ukraine), section Muzychy (the Polissya Lowland, northern Ukraine) and section Novorayske (the Donets river basin, eastern Ukraine). The deposits are represented by an alternation of hydromorphic paleosols and gleyed non-soil loams (or lake sediments). The stratigraphic subdivision of the sections is made according to the Ukrainian stratigraphic framework of the Quaternary (Veklitch et al., 1993) (field stratification of the Gat' section by B.Vozgrin). Six interglacial units, corresponding to paleosols (or pedocomplexes), have been palynologically investigated between the Brunhes-Matuyama boundary and Eemian Interglacial.

The first interglacial after the paleomagnetic reversal, the 'Upper Martonosha' one, is characterized by predominance of Pinus, and small admixture of diverse Neogene relics (Carya, Pterocarya, Juglans, Myrica, Ilex). Carpinus has appeared rather early, and the succession Quercetum mixtum - Carpinus is not clearly expressed. The late phase of the interglacial is well pronounced and marked by spread of Picea (to the less extent of Abies).

The second and third interglacials correspond to the two pedocomplexes of Lubny soil unit, and are separated by thin loess bed, formed under steppe vegetation. In the Early Lubny interglacial, vegetational succession Picea – Pinus - Quercus+Ulmus+Tilia – Carpinus - Picea is typical, and the drop of AP occurred at its end. During the Late Lubny interglacial, the early appearance of Carpinus (also Fagus in the Trans-Carpathians), Picea and Abies is characteristic. In the western Ukraine, the extensive distribution of Abies, as well as of Alnus, makes the clear distinction of the third interglacial from two preceding ones. Few pollen of Pterocarya and Juglans occur.

The Zavadivka unit that has been previously correlated with Likvin (Mindel-Riss) interglacial (Veklitch et al., 1993), includes pedocomplexes of two interglacials. The first one, the 'Lower Zavadivka', has well pronounced Quercetum mixtum and Carpinus phases, separated by a drop in broad-leaved taxa and increase of Pinus. In the 'Lower Zavadivka' interglacial, Carpinus reached its maximum distribution during the Middle Pleistocene times. Picea occurred since the beginning of Carpinus phase, and few Pterocarya appeared at the end (only in the Western Ukraine). The vegetational succession, and the last appearance of Pterocarya, enables the correlation of the 'Lower Zavadivka' with Holsteinian Interglacial. The next 'Upper Zavadivka' interglacial has the early appearance of Carpinus and Picea (in the Trans-Carpathians also Fagus), though Quercus peak of the mesocratic stage is also expressed. Abies extensively distributed at the end of the interglacial in the Trans-Carpathians.

The last Middle Pleistocene interglacial corresponds to the Potyagaylivka soil unit which is overlain by the till of Dnieper (Saalian) glaciation in the northern Ukraine. This interglacial differs from the preceding ones by the absence of distinct vegetational successions, lower participation of broad-leaved trees and absence of Abies (very small amount in the Trans-Carpathians). Forest-steppe and steppe vegetation existed in the eastern Ukraine.

The regional differences in vegetation distribution in Ukraine are shown for the Midde Pleistocene interglacials, as well as for the Eemian interglacial in the described sections. Two interstadials are defined above the succession of the Last Interglacial within the Pryluky-Kaydaky pedocomplex.

Pollen content of gleyed loams that separate the interglacial and interstadial deposits indicate stadial environments: predominance of steppe (meadow-steppe in the west of Ukraine and xeric steppe in the east), disappearance (or drop) of broad-leaved trees, and, in the northern Ukraine, the distribution of arcto-boreal elements of vegetation.

VEKLITCH, M.F., SIRENKO, N.A., MATVIISHINA, ZH.N., TURLO S.I. et al. 1997. Stratigraphic Framework of the Quaternary of Ukraine. M.F.VEKLITCH (ed.). 40 pp. State Committee for Geology of Ukraine, Kyiv.

Last Glacial decadal-to-centennial multi-proxy record of climate variability from Colombian Lake Fuquene: presentation of a 'next-generation' project

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Lake basins in tropical mountains have the potential to archive past climate change with high precision as migration of vegetation belts occurred altitudinally. In the Colombian Andes maximum vertical displacement of the upper forest line (UFL) over a glacial-interglacial cycle is some 1500 m, representing a temperature change of some 8° to 9°C.

Pollen analysis of long sediment cores, collected in the intramontane basins of Bogotá and Fuquene (c. 4°N, 2550 m elevation, c. 80 km apart), have shown the potential to reconstruct past climate change from vegetation dynamics. Two aspects cause that we may expect unprecedented accuracy: (a) the basins are located halfway the maximum (3300 m) and minimum (1800 m) altitudinal position of the UFL during a glacial-interglacial cycle, rendering these sediments a very sensitive archive, and (b) the geological setting has led to very thick accumulations of lacustrine sediments (some 600 m in the Bogotá basin and some 60 m in the Fuquene basin). Resolution of current records varies from 1500 yr (in a 3,000,000-yr long record) to some 200 yr (in a record covering the last 160,000-yr). Chronological control is insufficient and based on few absolute datings and curve matching with marine $?^{18}O$ records.

The newly designed composite Fuquene Project is funded by ALW (the last 70 ka) and WOTRO (70 to 130 ka). In November 2002 two parallel cores of 60-m were collected in increments of 100-cm from a floating raft. Intercore correlation was based on several proxies and by using the sediments of both cores; hiatuses from core barrel breaks were avoided and we reached at a continuous sediment record (the 'green line' sediment sequence).

Element analysis (XRF Cortex scanner, NIOZ), *grain size analysis* (VU), *loss-on-ignition* analysis and *pollen analysis* (IBED) will be carried out with a sample distance of 1-cm (c. 25 yr temporal resolution). In addition, sediment column *photography* and downcore *geo-electric resistance analysis* (NITG), *lithological description* (Univ. Bogotá) and high-resolution ^{14}C *dating* (some 80 datings are scheduled; CIO) will become available. This multiproxy approach offers a unique opportunity to place vegetational and climatic change in its dynamic abiotic environment. Additional proxies (*diatoms, stable isotope analysis*) are scheduled to have a later start. Curve matching and correlation of multiproxy-based records of climate variability from Lake Fuquene with *ice-core* $?^{18}O$ *records* (P. Grootes, Kiel), *marine* $?^{18}O$ *records* (N. Shackleton, Cambridge), and analysis of *orbital frequencies* (M.F. Loutre, Louvain la Neuve) are scheduled for the later part of this project. Inter-site correlation with high-precision $?^{18}O$-based climate records from *Cariaco Trench* (Venezuela) and *Santa Barbara Basin* (California) are also foreseen.

Main objectives are (a) to generate a high-resolution multiproxy record of the last 140,000-yr from the tropics, (b) to better understand causes of climate change and mechanisms at work by comparing records of climate change from northern hemisphere, equatorial, and southern hemisphere sites, and from terrestrial, marine and ice sheet environments.

HOOGHIEMSTRA, H. 1984. Vegetational and climatic history of the high plain of Bogotá. **Dissertationes Botanicae** 79: 1-368. J. Cramer, Vaduz.

MOMMERSTEEG, H. 1998. Vegetation development and cyclic and abrupt climatic change during the late Quaternary. **PhD thesis**, Univ. Amsterdam: 191 pp.

Paleovegetation and paleoclimate in the Kathmandu Valley and Lake Baikal during the Late Quaternary

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The Lake Baikal sediment is one of the best archives which records the Late Quaternary paleoclimatic changes at high-latitude in inland of Asian continent. On the other hand, the basin-fill sediment of the Kathmandu Valley is ideal for studying the history of Indian monsoon activities. We tried to reconstruct paleovegetation and paleoclimate changes in both regions during the Late Quaternary based on palynological studies.

Samples and pollen record of Lake Baikal

We carried out pollen analysis on the BDP99 core, which is 300 m-long and taken from Posolskaya Bank in Lake Baikal by the Baikal Drilling Project. The upper part of the core consists of diatomaceous silty clay, and lower part is mainly silty clay (Williams et al, 2001). We took samples at 40 cm interval from 0 to 120 m in depth. The pollen assemblage is characterized by dominance of *Pinus*, *Artemisia* and Gramineae. The percentage of forest-tree taxa, such as *Pinus*, *Alnus* and *Betula* shows high value during a period when the total amount of pollen grains are large. The percentages of grassland taxa such as *Artemisia*, Chenopodiaceae shows high value during a period when the total amount of pollen grains are small.

The amount of pollen grains are noticeably large between 14-21 m, 34-42 m, 50.5-52 m, and below 61 m. These intervals are interpreted to indicate dense vegetation during warm period, and they are correlated to marine oxygen isotope stage (MIS) 5, MIS 7, MIS 9 and MIS 11, respectively.

Samples and pollen record of Kathumandu Valley

A continuous 218-m-long core (RB core) was obtained in the western part of the Kathumandu Valley by Paleo-Kathmandu Lake Project in 2000. The RB core is lithologically divided into three parts: basal sand and gravel dominant beds of 38 m, 170 m-thick muddy lacustrine beds and overlying fluvial sandy beds. We took samples at 1 m interval from 218 to 30 m, and at 10 cm interval from 30 to 0 m in depth. Based on the paleomagnetic study, the RB core covers in age from ca. 750 to 10 kyr.

The pollen assemblage of the RB core is characterized by dominance of *Quercus* and *Pinus*. *Picea* and *Castanopsis* occasionally increase during short periods. *Alnus* and Gramineae show cyclic repetition of increase and decrease.

We recognized nine cycles of warm - wet and cold – dry period during ca. 750 kyr based on the following changes of relative abundance of five genera : *Quercus*, *Castanopsis* as warm climate, *Pinus* as cold climate, *Alnus* as wet climate, and Gramineae as dry climate. The fluctuation of percentage of total arboreal pollen indicates cyclic climatic changes which correspond to MIS 5-19.

On the basis of two climatic records in Lake Baikal and Kathmandu Vally, we discuss on the regional differences of vegetational responses to glacial / interglacial climate changes in representative areas in Asia. Furthermore, we refer to environmental changes during the mid-Pleistocene transition.

Palynomorphs demonstrate the link between continental aridification, sea surfaceproductivity and the global climate

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Pollen records from a number of ODP sites in the western North Pacific Ocean allowed us to reconstruct Pliocene to Recent vegetation and climatic conditions, and to correlate these with loess deposits in central east Asia. Our data record increasing continental aridification through the late Neogene, although glacial-interglacial fluctuations are also evident. The associated increase in eolian flux potentially impacts the global climate directly by decreasing the incident solar radiation absorbed on the Earth's surface. Our analysis of terrestrial and marine palynomorphs in mid-latitude deep-sea environments off Asia demonstrates a significant indirect impact, as limiting nutrients are transported to oceanic environments. Climatic deterioration results from the increase in productivity and sedimentation rates which sequesters large amounts of carbon, reducing the efficacy of the greenhouse effect.

Peak dinoflagellate cyst concentrations recording phytoplankton blooms correlate with peak pollen concentrations, of which a high proportion is herb pollen recording cool, arid conditions. The higher particle flux (comprised of terrigenous dust and authigenic plankton) resulted in rapid sedimentation in the abyssal western

North Pacific Ocean over short intervals ~5, 3.5, 3, 2.5, 1.6, 0.8, 0.4 Ma. These rapid sedimentation events, recorded by the excellent preservation of oxidation-susceptible "round-brown" protoperidiniacean dinoflagellate cysts as well as highly soluble calcareous planktonic foraminifera, coincide with documented times of climatic deterioration in the late Cenozoic. We attribute the global cooling to a decrease in atmospheric greenhouse gas concentrations, as CO_2 was sequestered (as organic and inorganic carbon) in abyssal sediments over a large area of the Pacific Ocean.

A long continuous record in Mediterranean for the last 130,000 yrs high resolution analyses of the ODP Site 976

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High resolution multiproxy analyses (isotopes, pollen, clay minerals) of the ODP Site 976 (36°12N, 4°18W, Alboran Sea) have been done for the last 130,000yr. Pollen assemblages have been combined to clay minerals analyses and oxygen isotope stratigraphy to reconstruct the western Mediterranean paleoenvironments and climate changes during last climatic cycle. Chronology of the core is based on AMS ^{14}C dating and oxygen isotopes record.

Pollen and oxygen isotope curves record the classic continental and marine paleoenvironmental changes and the general climatic trends from the Eemian to Holocene. Moreover pollen curves shows successive and rapid environmental changes all-over the last climatic cycle in the Mediterranean region that mimic the high latitudes climatic changes recorded in the Greenland and in the North Atlantic. Repetitive developments in temperate forest (mainly *Quercus*) expressed warm and humid climate and are closely correlated to the Dansgaard/Oeschger interstadials (Johnsen et al, 1992; Grootes et al, 1993; Dahl-Jensen et al., in prep.). Semi desert expands, which marked cold dry climate and recurrent aridity events on the continent, are related to the cold events evidenced in sea surface waters by abundance peaks Neogloboquadrina pachyderma (sinistral coiling) in the North Atlantic (Bond et al, 1993; McManus et al, 1994). Clay mineral contents performed on the same samples fit to pollen results showing, in particular, enhanced southern wind input from Sahara during the cold dry events.

Such pollen curves provide climatic records, with resolution similar to classic oxygen isotope records, and could be used as reference curves for a chronological approach of other marine and continental pollen files.

Calcareous nannofossils and palinomorphs from Neogene sediments of a well in the Macuspana Basin, Tabasco, Mexico

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The calcareous nannofossils and palinomorphs assemblages contained in cutting samples from a well located in the Macuspana Basin allow for dating of the drilled section.

The section analysed is comprised of about 3000 m of clastic sedimentary rocks. The age of these sediments is from Early Pliocene to Late Miocene.

In the Early Pliocene (125 to 1410m) floristic association from calcareous nannofossils is constituted by *Sphenolithus abies, Reticulofenestra pseudoumbilica, Discoaster tamalis, Amaurolithus delicatus and Ceratolithus acutus* among others. These assemblages are characterized by the NN15, NN14-NN13 and NN12 biozones. The Late Miocene (1425 to 2975m) nannofossils are represented by *Discoaster quinqueramus, D. berggreni, D. shafferi, D. neoerectus, D. neohamatus, D. calcaris; Discoaster quinqueramus* and *Discoaster calcaris* biozones (NN11 and NN10).

Pollen, spores and dinoflagellate represent the palinomorphs assemblages in this well. The Pliocene interval contains the pollen *Psilatricolporites crassus* and *Bombacacidites baculatus*, as well as the dinoflagellate *Operculoidinium crassum*. The Miocene is determined by the presence of the dinoflagellate *Selenopemphix brevispinosa*.

A diversity and abundance of calcareous nannofossils and dinoflagellates are prominant in the Early Pliocene (NN15 and NN12) and the Late Miocene (NN11). Pollen and spores are abundant in all the section indicating that these sediments were deposited in an environment of shallow water.

Climate and vegetation changes around Lake Baikal during the past 350,000 years

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To understand the relationship between vegetation and climate change in the future (i.e. global warming), it is necessary to know the relationships between paleoclimate and paleovegetation of the past. To do this we carried out the reconstruction of climate and vegetation changes around Lake Baikal over the past 350 kyr years, by using sediment cores extracted from Lake Baikal (BDP96-2 and BDP99-1).

BDP96-2 core was drilled at Academician Ridge, in the center of Lake Baikal, and BDP99-1 core at Posolskaya Bank, in the south of Lake Baikal. Pollen analysis and grain size analysis were done by using 0-15m samples of the BDP96-2 core and 0-100m samples of the BDP99-1 core. The ages of BDP96-2 core is already determined from whole core magnetic susceptibility records (Sakai et al., 2000). Although the ages of BDP99-1 core isn't completely clear, it is about 780 kyr B.P. at 234m (Sakai, personal communication). According to those, BDP96-2 core is about 350 kyr B.P. at 15m, and at 100m of BDP99-1.

The median grain size of both cores ranged from 3 to 9 fai, and were smaller in the glacial periods and larger in the interglacial periods. In the sediments of Lake Baikal, it is well known that the variation of grain size is corresponded with concentrations of diatom, and also corresponded with the marine oxygen isotopic curve (Kashiwaya et al., 1999). As a result, both samples were correlated with the oxygen isotope stages.

Pollen concentrations of both cores ranged from 0 to 10^5 grains per $1cm^3$ of the sediment samples. Also the pollen concentrations of both cores were smaller in the glacial periods and larger in the interglacial periods. They rapidly increased at the end of the glacial periods, and then gradually decreased during the interglacial periods. From the results of pollen analysis, the major pollen taxa during the interglacial periods of both cores were *Pinus*, *Picea* and *Abies*; all of which, are thought to have originated from the main components of the Taiga forest. However, one of the major pollen taxa of BDP96-2 during oxygen isotope stage 7, which was a slightly cooler interglacial period, included *Larix* which also component of the Taiga forest. While the major pollen taxa of BDP99-1 during the glacial periods were the herbs *Artemisia* and Chenopodiaceae. However, during the glacial periods, the pollen taxa of BDP96-2 was nothing because of the sparse amount of pollen.

From the results of the analyses, we believe that during the glacial periods the montane subarctic desert and/or the montane tundra were spread on the center basin of Lake Baikal, and the steppe was spread on the south basin of Lake Baikal. Furthermore during the interglacial periods we believe the Taiga forest covered the Baikal basin as it does presently. However, the fir forests were more to the south and the larch forests were more to the north of the Lake Baikal basin.

A long record from New Caledonia for comparison with the key site of Lynch's Crater, northeastern Australia

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For several decades one of Australia's key palaeoenvironmental sites has been the long record from Lynch's Crater in the tropical northeast (see KERSHAW 1976; KERSHAW 1986; KERSHAW et al. 2002). One of the most compelling aspects of this record is a dramatic rise in charcoal that corresponds with a rise in sclerophyllous vegetation and a decline in *Araucaria* during the late Pleistocene. Over the years research at the site and from locations nearby have attempted to unravel the possible contributions made by people and climate change to this dramatic shift in fire regime and vegetation composition (MOSS & KERSHAW 2000; KERSHAW et al. 2003). However, it has been difficult to assess the regionality of the changes as comparable sites have not been found in the southwest Pacific.

New Caledonia is an ideal place to independently assess vegetation changes seen in the late Quaternary pollen records of northeastern Australia for two reasons. Firstly, New Caledonia as a remnant of Gondwana is floristically related to Australia, in particular they have in common the tropical *Araucaria* genus. Secondly, New Caledonia was not inhabited by people until around 3ka, and thus provides a test of the hypothesis that aboriginal burning of the landscape was a major factor in the loss of *Araucaria* forest from northeastern Australia in the late Pleistocene.

We present a long Pleistocene record from Lake Xere Wapo in the Plaine des Lacs region in the southeast of New Caledonia. The record demonstrates how fire has a very long history in this landscape. But of greatest interest is that the decline in *Araucaria* that occurred at Lynch's Crater around 38 ka is matched by a similar decline in the Plaines des Lacs region of New Caledonian. However, there is one very important difference. At Lake Xere Wapo this decline occurs in the absence of fire, suggesting that climate change drove the *Araucaria* decline more than people or fire.

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The Pliocene-Pleistocene transition andQuaternary ice ages in the tropical Andes: a record of 2100 pollen samples from a lacustrine 586-m core from the Bogotá basin in Colombia

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Lacustrine sediments accumulated since late Pliocene time in the intramontane basin of Bogotá contain one of the longest pollen-based climate records in the world. The high plain of Bogotá located at 4°N latitude and

2550 meters altitude in the northern Andes was an ancient lake filled during the late Pliocene and Pleistocene times. Tectonic subsidence of the basin coinciding with continuous sediment supply from the surrounding mountains allowed the accumulation of nearly 600-m of sediments. We collected Funza-2 from the basin of Bogotá: at 586-m below the surface of the high plain we reached to bedrock. We analysed samples at 20 cm distance along the core. Fission track dates of intercalated volcanic horizons, and curve matching with long marine $\delta^{18}O$ records (V19-30, ODP 677 and ODP 846) provide the time control of the record.

For the first time we present the full pollen record that shows with great detail vegetation change, the evolution of primitive late Pliocene biomes into the modern ones, direct evidence of northern hemisphere trees migrating into Colombia after the closure of the Panamanian Isthmus, the significant climate cooling between 3 and 2.5 Ma (the Pliocene-Pleistocene transition from 470-402 m core depth), the long series of Pleistocene ice ages from a near-equator perspective (from 402-6 m core depth representing MIS 100 to MIS 3), the asymmetric character of most ice age cycles, and climate variability within ice age cycles with a temporal resolution of some 1500 yr.

In the evolution of north Andean mountain biomes three major phases can be recognised:

(1) proto-Andean forest of late Pliocene time (586-470 m core depth) was mainly composed by *Hedyosmum, Podocarpus, Weinmannia, Ilex, Eugenia* and *Myrsine*. High arboreal pollen representation reflect a very high altitudinal position of the upper forest line (UFL) evidencing warm climatic conditions during late Pliocene time.

(2) between 470-410 m core depth at higher elevations warm-to-cool montane forest made place for cool-to-cold treeless grasslands (paramo). From 470 m upwards a gradually lowering UFL reflects that cool climatic oscillations became progressively colder. The terrestrial equivalent of the Pliocene-Pleistocene boundary at 2.6 Ma is clearly recorded by an increase of cold subparamo (*Hypericum*) and grassparamo vegetation. We inferred a cooling of 5°C between 3.0 Ma and 2.6 Ma. Coldest conditions were reached at 402 m core depth probably reflecting MIS 100.

(3) In the uppermost 402 m of core sediments Pleistocene ice ages are reflected with increasing amplitude. Alnus started its record at 257 m core depth (1 Ma); Quercus migrated slower across the Panamanian Isthmus and started its record at 475 ka (92 m core depth). It took 200 kyr before oak forest became common as zonal forest in the upper montane forest belt. The modern oak forest community is not older than last interglacial time (MIS 5e).

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Palaeoenvironmental research in "Las Tablas de Daimiel" National Park (South-central Iberian Peninsula, Spain)

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The "Tablas de Daimiel" core (TD) was obtained in the central area of "Las Tablas de Daimiel" National Park (South-central Iberian Peninsula, Spain) and it is 38.5 m deep. We present the results of a multidisciplinary research on the TD core upper section which corresponds to, at least, the last 40.000 years (VALDEOLMILLOS *et al.*, 2003). The research comprised pollen analyses, mineralogical analyses by X-ray

diffraction methods, conventional petrography of thin sections by petrographic microscope, scanning electron microscopy (SEM with EDAX) and isotopic analyses ($\delta^{13}C$ and $\delta^{18}O$).

This multidisciplinary research has permitted to establish the history of the fluvial-palustrine environment, to identify palaeoenvironmental changes on the aquatic ecosystem from the fossil assemblages as well as from the mineralogical microstructure and composition of the sediments, and to identify palaeoclimatic events and their relationship with the environmental evolution from the vegetation changes.

In the same way, the obtained results in this research show the importance of the multidisciplinary studies in the reconstruction of palaeoenvironments of Quaternary age.

VALDEOLMILLOS, A., DORADO VALIÑO, M., RUIZ ZAPATA, M.B., BARDAJÍ, T., & BUSTAMANTE, I. 2003. Paleoclimatic record of the Last Glacial Cycle at Las Tablas de Daimiel National Park (Southern Iberian Meseta, Spain). In: M.B. RUIZ ZAPATA, M. DORADO VALIÑO, A. VALDEOLMILLOS, M.J. GIL GARCÍA , T. BARDAJÍ, I. DE BUSTAMANTE & I. MARTÍNEZ MENDIZÁBAL (eds.). **Quaternary climatic changes and environmental crises in the Mediterranean Region.**. pp. 221-228. Ministerio de Ciencia y Tecnología-Universidad Alcalá-INQUA. Alcalá de Henares.

Climate variability from Colombian Lake Fuquene: an analysis of period MIS 6-MIS 3 by 25-yr steps and the integration of biotic and abiotic proxies

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We present the initial results of the composite 60-m core from Lake Fuquene, located at 2550 m elevation in the Colombian Andes.

After three decades of palynological research in this area, and being aware of the huge potential of the sediments in this basin, we aim to generate a climate record from 4° latitude for the purpose of examining decadal-to-centennial scale climate variability. We sampled at contiguous 1-cm intervals along the sediment core, producing a resolution that is an order of magnitude higher than that obtained before. Based on ^{14}C dates, stratigraphies obtained in previous studies, and an assumed linear accumulation rate, the age of the core top is c. 27 kyr BP and the bottom sediments extend into MIS 6 (up to c. 140 ka). For the first time in the region vegetation dynamics and inferred climate change will be compared with the evolution of abiotic characteristics in the basin. So in addition to the analyses of biotic proxies (pollen, diatoms, organic matter content), measurements of abiotic indices, such as grain size, stable isotopes, and elements (XRF-Cortex scanner) will be conducted.

Altitudinal vegetation belts have been shifting continuously in the past, and have a sensitive response to climate change. The fossil pollen record indicates a long sequence of stadial-interstadial cycles during the entirety of the period MIS 3 to MIS 6. In an earlier pilot study these c. 2 to 3.5 kyr cycles seemed to approximate the Dansgaard-Oeschger (D/O)-cycles recorded in Greenland ice cores. Initial studies in Colombian long pollen records showed significant D/O-cycles were also present during the last interglacial (MIS 5e) and superimposed on the well known climate shifts of entire MIS 5. The montane forests of the last interglacial were dominated by arboreal taxa including *Hedyosmum, Podocarpus, Weinmannia* and *Quercus*. During cooler stadials and the full glacial period, 'cold' Poaceae-dominated paramo vegetation and 'cool' shrub-dominated subparamo vegetation (*Hypericum*, Asteraceae, Ericaceae) dominated the region. Low lake levels are indicated by a low ratio of shallow water : deep water aquatics (i.e. *Myriophyllum, Ludwigia, Hydrocotyle*, Cyperaceae : *Isoetes*). Element analysis showed increased Fe content in the numerous volcanic ash horizons. Abundance of Al, Si and K may be related to strong weathering. Variations in element abundance (Al, Si, and Ca) may also be suggestive of changes in precipitation. Evidence from clay mineralogy, such as changing smectite : kaolinite ratios also may support climate change.

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Poster session h6

TAPHONOMY AND ARCHAEOLOGICAL PALYNOLOGY

The Upper Palaeolithic site Bolshaya Akkarzha: palynological records and palaeoenvironmental reconstruction

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The Late Palaeolithic site Bolishaya Akkarzha is situated in the western steppe zone of Eastern Europe (Northern Black Sea coastal area, Ukraine). The archaeological, lithological, palynological and palaeontological studies were carried out. Stratigraphic subdivision was based on the chronostratigraphic classification of the loess-soil formation of Ukraine (Veklich, 1968). The loess horizon of 0.95 m in thikness included a cultural layer at the depth 0.9-1.0 m between the Holocene black soil (Chernozem) and red subfossil soil. The latter was formed during the Wurmian interstadial (W_2-W_3, df). According to Veklich, the loess is an Early Prichernomorskii subhorizon (W_3, $p\xi_1$) formed during the maximum of the last Pleistocene glaciation. The cultural layer was formed in the middle of the Late Palaeolithic time (16.0-22.5 ka BP).

Traces of four light surface houses with fireplaces and a great number of silicic artifacts were found. The artifacts consist largely of microinventory, which suggests that this site was a seasonal dwelling used by hunters in spring and summer. Also, numerous *Bison priscus* bones were discovered. Analysis of these remains in cultural layer provided a possibility to deduce the annual schedule of domestic activities of population in that region, hunting in particular, which depended on animal migrations and was distinctly seasonal.

Palynological studies were carried out in two lithologically identical sections exposed at distance of some 10 m from each other. A total 40 samples were collected from the loesses and the overlying and underlying horizons. Chemical treatment was executed by Gritchik & Zaklinskaya (1962). Additional ultrasonic treatment of samples was also applied.

The highest concentration of pollen and spores in good conservation was observed in the samples from the Holocene horizon and subfossil soil. Pollen and spores concentration appeared to be lowest in loess horizon included the cultural interval. Such low frequency of pollen and spores in loesses was probably due to the subaerial genesis of loesses, scarcity of vegetation in the harsh glacial climate, and abrupt changes in temperature and humidity, which were highly unfavorable for subfossil pollen and spores, conservation, etc.

The pollen and spores from the underlying horizon of subfossil soil indicate on forest-steppe spreading in the region. In pine-birch forest (predominance of *Betula* and *Pinus*), some temperate species of *Carpinus, Alnus, Ulmus, Tilia, Quercus, Acer, Salix* grew. In steppes both xerophylous(Chenopodiaceae), and mesophylous (Asteraceae, Poaceae, Polygonaceae, Cichoriaceae, and others) species were present. Xerophylous species of *Artemisia* were relatively rare.

Special attention was given to samples from loess horizon and cultural layer in order to reconstruct vegetation and palaeoenvironment that existed during the Wurmian glaciation maximum (18.0-19.0 ka BP), and