## SESSION NO. 78, 1:30 PM

## Tuesday, July 29, 2003

## T25. Are Soils a Source or Sink for Atmospheric Carbon Dioxide? (Posters) (*INQUA Commission on Carbon, INQUA Paleopedology Commission*)

## Reno Hilton Resort and Conference Center, Pavilion

### 78-1 BTH 97 Smalley, I.J.

LOESS DEPOSITS AS CARBON SINKS: SEQUESTRATION OF CARBON VIA THE CHERNOZEMISATION PROCESS

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Chernozem soils appear to favour loess ground as a preferred medium for development. There seems to be a close link between loess and chernozems. The growth of a chernozem in a fresh loess deposit provides an observable and comprehensible method for observing the sequestration of carbon in a soil system. The chernozem (the classic black earth; subsumed into the USDA Soil Taxonomy Mollisol Soil Order) was believed by its first definers to be essentially climate controlled. We believe that, on the analysis of soil forming factors, parent material is more likely to be the defining factor. Loess first, then chernozem (not the other way round as Pyaskovskii suggested). So, ten thousand years ago a loess deposit forms, in a medium latitude location. It has soil qualities as soon as it is formed and the chernozem development process develops immediately. It is essentially a top-down process; rainfall slightly exceeds evapotranspiration, and carbonaceous material builds up steadily; sequestration begins. Eventually small carbonate is deposited at greater depths but the basic sequestration mechanism is the chernozemisation process; the least well defined of the soil science processes. In fact, although chernozemisation falls within the purview of soil science the key control is geological- the delivery of the loess. Nothing really significant is seen through the soil science window- except the build-up of carbon. The arrival of the loess gives a zero point, carbon content per soil unit is measureable, as is depth of deposit. The transition from geology to soil science can be dated- and we have an ideal measure of sequestration rate, in the perfect soil. At this point we have to divide the incoming rate into all factors- and learn to recogise the atmospheric CO2 contribution.

### 78-2 BTH 98 Krull, Evelyn S.

TRACING RECENT VEGETATION CHANGES IN AUSTRALIA'S GRAZED WOODLANDS BY $\Delta^{13}C$ ANALYSES OF SOIL ORGANIC MATTER

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The process of "woody thickening" describes the invasion or proliferation of trees into grasslands and savannas. Such changes have been documented worldwide and are thought to be encouraged by European-style land management practices such as domestic cattle grazing and fire suppression. The question whether a change from savannas to a "thickened" system may serve as a carbon sink or source is still highly debated, particularly with respect to carbon storage as soil organic matter. While "thickening" can be a naturally-occurring process, e.g. caused by climate change, it is the human-induced "thickening" that is of importance with respect to the Kyoto protocol and carbon accounting. Therefore, it is fundamental to establish first, whether a) these systems have indeed changed from grassland to woodland and b) that this change occurred recently and coincides with modern management practices. Human-induced thickening is believed to be very widespread in the dry, grazed woodlands of eastern Australia. Our aim was to determine at selected sites whether a change from grassy (C4) to woody (C3) vegetation had occurred since the initiation of European agricultural practices (last 50-150 years) and how this change had affected soil carbon levels. At a site where anecdotal evidence suggested invasion of woody vegetation (Acacia sp.), samples were taken along a transect, spanning from grassland to transition zone to thickened woodland. We utilized $\delta^{13}C$ and $^{14}C$ data of bulk and size-separated soil organic matter to establish the time course of vegetation change, the change in soil carbon stocks and the change in carbon allocation. Our results indicate a strong shift from grass (C4)- to wood (C3)-derived carbon in the thickened woodland. Furthermore, most of the "young", C3-derived carbon is allocated in the particulate organic carbon (POC) fraction (2000-53μm). Along with greater above-ground biomass, there is also an apparent increase in soil carbon stocks in the thickened compared with the grassy site; however, this apparent increase in soil carbon lies within the sampling error and more samples are necessary to establish a statistical significance. Our results show that thickening can be confidentially traced using the $\delta^{13}C$ technique and that potential exists for increased soil carbon storage in thickened woodlands.

### 78-3 BTH 99 Monger, H. Curtis

SOIL CARBONATES: SOURCE AND SINK FOR ATMOSPHERIC CO2

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Carbonate in arid and semiarid soils of the southwestern USA and Mexico interacts with atmospheric CO2 in two long-term fashions. It is a unidirectional sink for CO2 in the lower and drier regions, and carbonate is a cyclic CO2 sink (carbonate formation) and CO2 source (carbonate dissolution) in the higher and wetter regions. The unidirectional sink consists of progressively more carbonate accumulating in progressively older soils, a process that continues until a soil and its geomorphic surface are destroyed by erosion. In southern New Mexico, for example, soil carbonate ranges from filaments in soils of Historical age to calcretes in soils of late Pliocene age. The cyclic sink-source pattern consists of soils that are near the Pedocal-Pedalfer boundary. These soils have less carbonate than their more arid counterparts because Pedalfer areas expanded during glaciopluvial periods dissolving carbonate and contracted during arid intervals giving rise to CaCO3 formation.

Biotic forms of pedogenic carbonate are common in the early stages of accumulation. Such forms include calcified root hairs, fungal hyphae, needle-fiber calcite, and micro-peloids. In the advanced stages of carbonate accumulation, such as calcic horizons and calcretes, micritic carbonate is the dominant form.

Carbon storage in soil carbonate occurs as non-pedogenic and pedogenic carbonate. Non-pedogenic carbonate, also termed primary, geogenic, or lithogenic carbonate, exists in soils as detritus, mechanically inherited from limestone and similar parent materials. Pedogenic carbonate, also termed secondary, authigenic, or in situ carbonate, formed in soil at its present location or was transported from preexisting soils. All would contain sequestered atmospheric CO2, though the time that sequestration took place can differ drastically.

### 78-4 BTH 100 Liebens, Johan

REGIONAL SOIL ORGANIC CARBON STOCK ESTIMATES ARE INFLUENCED BY ASSESSMENT METHOD

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National and regional soil organic carbon (SOC) inventories are indispensable to assess direction and magnitude of C fluxes between soils and the atmosphere. For these inventories SOC density [C mass/unit area] is typically determined from spatial databases of soil properties and spatially distributed to soil or soil/land use categories on a map. Conclusions based on these SOC assessments are often weakened by uncertainty given the large (10-50%) errors associated with some of the studies. The purpose of the present study was to evaluate alternative assessment methods for SOC stock, and was carried out in Flanders, one of the three federal regions of Belgium. Previous studies have examined the effect of multiple SOC estimation approaches by comparing results from various soil databases and soil maps for a given region, and have demonstrated that outcomes can significantly differ. We employed one soil database and one digital soil map but evaluated three methods to determine SOC density for soils in the spatial database and three spatial distributing approaches to assign the SOC density to map units.

Results show that calculated SOC density is significantly influenced by density estimation method. The maximum difference in total SOC stock for Flanders resulting from the use of various SOC density estimation methods is 6%. Findings indicate that horizon-specific SOC density estimation procedures are better for SOC stock determination than soil type based procedures. When a soil map alone is used as the geographical reference, little difference (1 %) in total SOC stock results from the application of various spatial distributing methods. When the soil map is combined with a land use map, which is frequently done in this type of study, results for total SOC stock are consistently lower (up to 2%) than when a soil map alone is used. The largest difference in SOC stock estimate between any combination of estimation methods is 7 %. This difference is comparable to the maximum variation in stock estimate resulting from the analysis of various soil databases and spatial aggregation methods for other regions. Results underscore the importance of complete, high-quality spatial soil datasets and standardized methods to determine SOC stocks in order for stock estimates to be useful for efforts examining the role of soils in the C cycle.

### 78-5 BTH 101 Guo, Zhengtang

LAND USE INDUCED CHANGES OF ORGANIC CARBON STORAGE IN SOILS OF CHINA

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In the last two centuries, land use has been a significant source of atmospheric through conversion of natural vegetation to farming. China has $CO_2$ 137.5 million hectares of cropland. The long history of agricultural exploitation and the changes of land use suggest that the terrestrial ecosystem of China would have played an important role in the global carbon cycle

Using the data compiled from China′s second national soil survey, we have estimated the changes of soil organic carbon due to land use, and compared the spatial distribution and storage of soil organic carbon (SOC) in cultivated soils and non-cultivated soils in China. The results reveal that 57% of the cultivated soil subgroups (31% of the total soil surface) have experienced a significant carbon loss, ranging from 40% to 10% relative to their non-cultivated counterparts. The most significant carbon loss is observed for the non-irrigated soils (dry farmland) within a semi-arid/semi-humid belt from northeastern to southwestern China, with the maximum loss occurring in northeast China. On the contrary, SOC has increased in the paddy and irrigated soils in northwest China. No significant change is observed for forest soils in southern China, grassland and desert soils in northwest China, as well as irrigated soils in eastern China.

The SOC storage and density under non-cultivated conditions in China are estimated to 77.4 Pg and 8.8 kg C $m^{-2}$, respectively, compared to a SOC storage of 70.3 Pg and an average SOC density of 8.0 kg C $m^{-2}$ under the present-day conditions. This suggests a loss of 7.1 Pg SOC and a decrease of 0.8 kg C $m^{-2}$ SOC density due to increasing human activities, in which the loss in organic horizons has contributed to 77%. This total loss of SOC in China induced by land use represents 9.5% of the world′s SOC decrease. This amount is equivalent to 3.5 ppmv of the atmospheric $CO_2$ increase.

Since 78% of the currently cultivated soils in China have been degraded to a low/medium productivities and are responsible for most of the SOC loss, an improved land management, such as soil erosion prevention and controlling the conservation tillage, would have a considerable potential in restoring the SOC storage. Assuming a restoration of 50% of the lost SOC during the next 20-50 years, the soils in China would absorb 3.5 Pg of carbon from the atmosphere.

### 78-6 BTH 102 Eshel, G.

ENHANCING INORGANIC CARBON SEQUESTRATION BY IRRIGATION MANAGEMENT

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Inorganic carbon can play an important role in sequestering carbon that would otherwise enter the atmosphere and contribute to global warming. Our initial results show that inorganic carbon, as calcium carbonate, is precipitated under treated effluent irrigation in arid region soils. We found a large accumulation of carbonate in a field irrigated with treated effluent for more than 70-years near Bakersfield CA. Radiocarbon dating of 7030± 120 years, suggests that this carbonate is a mixture of old and new carbonates. We also found that the samples from the effluent-irrigated field contained significantly more clay-size carbonate than samples from the fresh-water irrigated ones. This is additional indirect evidence for the enhancement of carbonate precipitation in the effluent-irrigated field. The depth in which the majority of the carbonate is found in this field (2-4 m) is well below the zone of most active root growth. Less than 1 km away, a similar field irrigated with fresh water, accumulated a much smaller amount of carbonate and that accumulation took place at a shallower depth than in the effluent irrigated field (Table 1). The above observations may indicate that in addition to root respiration (providing $CO_2$ as the source of carbon), other processes have an important role in carbonate precipitation in effluent-irrigated fields. We propose a conceptual model that illustrates the different scenarios, depths and intensities, of the processes that control carbon sequestering in soils of arid and semi-arid regions.

Table 1: Mean carbonate content of similar fields at Bakersfield, CA under fresh water and long-term effluent irrigation

| Type of irrigation water | Carbonate content† | | | |
|---|---|---|---|---|
| | 0–2 m | | 2–4m | |
| | # of profiles | Mg/ha/depth | # of profiles | Mg/ha/depth |
| Effluent | 7 | 92.6 b | 4 | 1172 a |
| Fresh | 6 | 68.2 b | 3 | 8.7 b |

† Values followed by the same letter do not differ significantly (0.05 probability level).

### 78-7 BTH 103 Turetsky, Merritt

TOWARD UNDERSTANDING LONG-TERM TERRESTRIAL CARBON: MECHANISMS, MODERN TOOLS, AND MODELING OF SOIL SYSTEMS

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The primary mechanism for C uptake onto land is photosynthesis, yet long-term terrestrial reservoirs of C reside in soils. Sequestration generally occurs where net primary production exceeds C losses to decomposition, leaching export, and/or combustion. Soil C can be physically protected in cold or wet soil environments, or chemically protected by recalcitrant organic compounds, C stabilization onto mineral surfaces, and/or microaggregate formation. Furthermore, feedbacks and responses occur between soil, plant, and water systems that retard or accelerate the uptake and release of C.

The development of isotopic tracers for atmosphere-geosphere interactions has strengthened our ability to quantify the inputs, turnover, movement, and transformation of soil C. For example, $^{14}C$ analysis can provide insight into multiple soil processes, while beryllium isotopes ($^{10}Be$ and $^{9}Be$) have been useful in investigating soil development, sedimentation, and mineral weathering. Radiocarbon and $^{10}Be$ both have atmospheric inputs, but their differences in terrestrial biogeochemical cycling can discern landscape (erosion, deposition) and site-scale (plant-atmosphere) processes.

Modeling, particularly inversion modeling, can help to constrain rates of soil processes where terms for mathematical models are 'solved' by discreet measurements. For soils in high latitude ecosystems, we have constrained C losses to decomposition and combustion, and have investigated interactions among combustion, decomposition, thermal regimes, and hydrology through data-model iterations. In temperate ecosystems, we have constrained rates of loess deposition and hillslope evolution, and addressed the distribution of eolian and alluvial sediment for a small drainage basin. In these examples, sink/source thresholds exist during transitions between disturbance and adjustment. The timing and magnitude of such thresholds are highly sensitive to feedbacks among decomposition, nutrient cycling, and soil climate. Ultimately, an understanding of current soil processes, as well as the legacy and interrelationships of those mechanisms at local, landscape and regional scales, is needed to accurately assess the fate of soil C reserves under a changing climate.

## SESSION NO. 79, 1:30 PM

## Tuesday, July 29, 2003

## T26. High Resolution Records from Late Quaternary Estuarine and Marine Deposits (Posters)

## Reno Hilton Resort and Conference Center, Pavilion

### 79-1 BTH 104 Starratt, Scott W.

SILICEOUS MICROFOSSILS AS PROXIES FOR LATE HOLOCENE CLIMATE CHANGE: THE RECORD FROM NORTHERN SAN FRANCISCO BAY AND THE SACRAMENTO DELTA, CALIFORNIA, USA

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A qualitative record of late Holocene fresh water flux through the Sacramento delta and northern San Francisco Bay has been reconstructed using diatoms and chrysophyte stomatocysts. Coring sites are located in fluvial, subtidal, and marsh environments located between the normal marine environment of San Francisco Bay and the freshwater environment of the Sacramento and San Joaquin Rivers. Because the rivers that flow through the Sacramento delta and into northern San Francisco Bay drain more than 40 percent of California, variation in their discharge from the watershed is an indication of both the volume and timing of precipitation over a significant part of the state. The modern diatom assemblages in subtidal, freshwater, brackish, and saltwater marshes were used to calibrate the late Holocene salinity record. More than 600 diatom taxa have been identified from the modern sediments of San Francisco Bay, with additional taxa identified in core material. Approximately 150 of these taxa comprise more than two percent of any assemblage. Species diversity is lowest in normal marine environments (>30 psu) and highest in brackish marsh environments (2-30 psu). At the Rush Ranch coring site, located near the middle of the salinity gradient, there is evidence of centennial- to millennial-scale salinity cycles over the past 3,000 years. Human impact on the Sacramento and San Joaquin Rivers over the past 150 years, is indicated by a rapid increase in brackish and marine taxa. Prior to European contact about 150 years ago, there are two intervals dominated by freshwater taxa and two intervals dominated by more marine taxa. The intervals that indicate more saline conditions (3,000 cal yr B.P. to 2,500 cal yr B.P. and 1,750 cal yr B.P. to 750 cal yr B.P.) may correspond to periods of lower precipitation suggested by other California climate records. Smaller-scale variations within the salinity cycles correlate with variations in the lake level record at Mono Lake, as well as shorter precipitation cycles in the Lake Tahoe-Truckee River-Pyramid Lake system. Dendroclimatological records from California generally support the record of the past 400 years, although there are discrepancies between records from the Sacramento and San Joaquin Valleys, which may indicate variations in the source of the runoff.

### 79-2 BTH 105 McGann, Mary

HIGH-RESOLUTION FAUNAL AND ISOTOPIC RECORDS FROM HOLOCENE ESTUARINE DEPOSITS OF SAN FRANCISCO BAY, CALIFORNIA

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A 3.52 m core (DJ6-93SF-6) recovered from the western portion of south San Francisco Bay, CA (37º37.83' N, 122º21.99' W) near the San Francisco International Airport has yielded a high resolution, Holocene climatic history of the region. The faunal and isotopic evidence provided by estuarine benthic foraminifers suggests that three distinct climatic periods (two cool, one warm) have taken place in the bay during the last 3800 years.

A modern, shallow water depth (<10 m), foraminiferal assemblage consisting of abundant, subtidal estuarine taxa (e.g., *Elphidium excavatum, Ammonia beccarii, Elphidium gunteri,* and *Elphidiella hannai*) characterizes the core sediments. Within the faunal assemblage, two distinct associations affected by climate change were observed. In the first association, *Elphidium excavatum* is the dominant taxa, often comprising 70-90% of the fauna. Today, this species typically resides in cold, estuarine waters. Its dominance in the core between 352-150 cm (~1870 B.C. to ~A.D 680; dated by AMS$^{14}$C), and 88-18 cm (~A.D. 1270 to ~A.D. 1990), suggests that during these two periods, this area of the bay has remained relatively cold and shallow (i.e., for ~3300 years out of the last four millennia). An *Ammonia beccarii – Elphidium gunteri* association occurs between 150-88 cm (~A.D. 680 to ~A.D. 1270), and its presence is interpreted as representing a period of warmer climatic conditions. In contrast, in the upper 18 cm of the core (~A.D. 1990 to present), the fauna changes dramatically due not to climate, but to the appearance of an invasive foraminifer from Japan.

Oxygen isotope values were measured in specimens of *Elphidium excavatum* at ~10 cm intervals downcore. From 150-88 cm (~A.D. 680 to ~A.D. 1270), $\delta^{18}O$ values (mean=-3.81 mil) average 0.3 and 0.2 mil lighter than below and above this interval, respectively, corresponding to an increase in water temperature of ~1°C in the bay at a time that correlates well with records of the Medieval Warm Period. At 69 cm, following the culmination of this interval of increased water temperature, the $\delta^{18}O$ value is the heaviest recorded in the core (-2.31 mil). These data, associated with a 2.5 times increase in sedimentation rate from 88 to 58 cm, suggest that the drought had ended and increased river runoff contributed to a heightened sedimentation rate at the core site.

### 79-3 BTH 106 Malamud-Roam, Frances

HOLOCENE SEDIMENT RECORDS FROM SAN FRANCISCO ESTUARY TIDAL MARSHES AND THEIR RELEVANCE TO CALIFORNIA PALEO-CLIMATE VARIABILITY

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As depositional environments, tidal marshes provide excellent opportunities for long-term records of changes in physical conditions and biological responses. Late Holocene sediment records have been analyzed from several of the tidal marshes surrounding the San Francisco Estuary, which drains most of northern California. Changes in physical conditions include local events, such as changes in the relative elevation of the marsh surface, changes in sediment supply, and regional changes in climate affecting the amount of fresh water inflow (from 40% of California) and thus estuarine salinity.

Results from marsh cores collected from Benicia State Park, a small marsh in the Carquinez strait between Suisun bay and San Pablo bay, are highlighted here. The sediment stratigraphy and chronology of the cores indicate dramatic changes in physical conditions experienced on this marsh, with periods of both very high and very low sediment accumulation that appear to be reflecting local changes, e.g., from 1250-1050 cal yr BP sedimentation was over 4 mm/yr, and from 1050-300 cal yr BP, sedimentation was less than 0.5 mm/yr. These periods of anomalous sedimentation are seen at other sites in Suisun bay (see also Starratt, S. Abstract, INQUA XVI 2003, and Chin, J.L., et al. Abstract AGU 2003 meeting).

The biological effects of changes in fresh water inflow to the San Francisco Estuary and its adjacent marshlands were assessed using total organic carbon ?13C, and pollen analysis. Drought events recorded in the watershed are recorded in marshes as periods of increased salt-tolerant plants, e.g., several paleo-records across California indicate severe drought centered ca. A.D. 1300 and in the Estuary marshes this period was marked by increased salt tolerant plants.

More recent changes in the Estuary marsh vegetation may not be related to climate variability, but to human modifications of the watershed hydrology. Increases in the ?13C values of organic carbon and the in pollen from salt tolerant plants seen in the tidal marshes suggest an increase in estuarine salinity occurred within the last 60 years, most likely resulting from dam construction along the major tributaries to the Sacramento and San Joaquin rivers.

### 79-4 BTH 107 Schweikhardt, Peter

TIME SCALES OF VARIATION IN SAN FRANCISCO BAY, NORTHERN CALIFORNIA, AND MEASUREMENT PROXIES

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San Francisco Bay's physical properties vary on a range of time scales from sub-daily to glacial/interglacial. It is well known that the Bay exists as an estuary only during sea level high stands, but details concerning the extent to which the Holocene Bay resembles that which existed during the Last Interglacial are of continuing interest. On short time scales, salinity and temperature at a given Bay site vary on a semi-diurnal basis due to tidal influence, and strong diurnal temperature variation is also typical, particularly for near-surface water. Pronounced seasonal fluctuation in salinity and temperature are driven by systematic variation in runoff and insolation. In addition, previous studies have documented dramatic century-scale variation in bay salinity, suggesting corresponding shifts in regional precipitation regimes.

In order to investigate the estuary's variation on these time scales, we use several methods and proxies. To track century-scale secular change and to compare the Holocene Bay with its predecessor, we have developed oxygen isotope records using fossil foraminiferal tests. Our Holocene data extend the record of century-scale trends and confirm the pattern of significant variation over at least the past 4 ka. Foraminiferal species shifts in two sediment cores also identify changes at this time scale, disclosing dramatic site variability in water depth and salinity due to post-glacial sea level rise or seismic activity. Since the isotopic and elemental compositions of biogenic carbonate formed in the Bay are functions of the salinity and temperature of the waters from which they were precipitated, and since mollusk shells are deposited sequentially during the lifetime of the organism, large shell fragments provide records of water temperature and salinity over a period of about 1-2 years. We are using incremental sampling of these shells, analyzed by isotope ratio mass spectrometry and ICP-AES to investigate the history of the annual salinity cycle of the Bay as an indication of variation in regional hydrology. Finally, elemental analysis of the same shells, sampled at a very fine spatial scale by ion microprobe, will allow us to infer daily and tidal-scale temperature changes.

## 79-5 BTH 108 Long, Antony J

PRE-SEISMIC RELATIVE SEA-LEVEL MOVEMENTS AND GREAT HOLOCENE EARTHQUAKES, ALASKA

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The "earthquake deformation cycle" (EDC) accounts for relative sea-level (RSL) movements associated with large plate boundary earthquakes. On March 27, 1964, an earthquake of magnitude 9.2 occurred along the south coast of Alaska, USA. With observational data from 1964 together with microfossil data collected from contemporary tidal flats, marshes and wetlands, we can calibrate models of environmental change represented by fossil assemblages. We use these models to analyse late Holocene earthquakes in Alaska.

Initial analyses of the 1964 event suggests a four stage EDC model (Shennan et al., 1999; Zong et al., 2003):

1. Co-seismic submergence 2. Post-seismic rapid land uplift / RSL fall 3. Centuries-long more gradual inter-seismic strain accumulation / RSL fall 4. Pre-seismic RSL rise

We evaluate the stratigraphic evidence for the 1964 event, and preceding events, at four sites around the Cook Inlet: Kenai, Girdwood, Kasilof and Ocean View and focus on the evidence for pre-seismic RSL rise as a possible precursor to a large earthquake.

At Kenai, Girdwood and Ocean View there is evidence for a rise in RSL before the 1964 earthquake, dated by 137Cs. At Girdwood, Karlstrom (1964) observed tidal inundation of the marsh commencing in 1953. Comparable changes occur before other late Holocene events at all sites. There are differences in the detail of each pre-seismic RSL change, but mixing of microfossil assemblages from the overlying silt into the peat cannot explain the distinct diatom assemblage found within this phase. Quantitative diatom transfer functions provide estimates of the magnitude of the RSL changes for all events at each site. Estimates of late Holocene co-seismic submergence range from 0.28±0.22 m to 1.97±0.42 m and pre-seismic RSL rise from 0.13±0.13 m to 0.21±0.10 m.

The hypothesis that a pre-seismic RSL rise represents a precursor to a large earthquake remains valid and supports a similar hypothesis proposed by recent work on the Cascadia margin of the Pacific Northwest, USA (Shennan et al., 1998; Long & Shennan 1998).

Long AJ & Shennan I 1998 The Holocene 8, 129-142 Karlstrom TNV 1964 US Geological Survey Professional Paper 443, 1-69 Shennan I et al. 1998 Quaternary Science Reviews 17, 365-393 Shennan I et al. 1999 Quaternary International 60, 55-73 Zong Y et al. 2003 The Holocene, 13, 7-20

## 79-6 BTH 109 Goman, Michelle

A 5000 YR RECORD OF HURRICANE STRIKES FROM A COASTAL LAGOON, OAXACA, MEXICO

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In September 1997 hurricane Pauline hit the Oaxacan coastline of Mexico causing significant damage and loss of life. In this paper we attempt to document the frequency with which intense hurricanes have hit the region. Our study area comprises Laguna Pastoria which is a large coastal lagoon ringed with mangroves and shielded from the Pacific Ocean by a large barrier island beach complex. We will present analyses of aerial photographs, stratigraphic cores, pollen analysis as well as archaeological data in order to understand the frequency and intensity with which hurricanes have impacted the region in the past.

## 79-7 BTH 110 Lembke, Lester

CENTENNIAL-INTERDECADAL CLIMATIC CHANGES IN THE OKHOTSK SEA DURING HOLOCENE: RESULTS FROM POLLEN ANALYSIS AND GEOCHEMICAL PROXY RECORDS

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Our recent work in the Sea of Okhotsk reveals records of millenial to interdecadal cyclic climatic changes in this subarctic NW-Pacific marginal sea and the adjacent Amur river drainage basin. The Amur watershed undergoes exteme seasonal as well as longer term climatic changes. Within this area the humid SE-Asia monsoon regime in summer is contrasted by cold, dry continental climate from NE-Siberia in wintertime. These two patterns show considerable variability in both strength and lateral extent on multifaceted timescales. Thus this region seems crucial for our comprehension of complex changes and shifts of atmospheric and oceanographic systems in the Far East and western North Pacific region. We recovered a suite of gravity cores from water depths between 650 m and 1000 m off the E Sakhalin continental margin. There, biosiliceous primary productivity and considerably high terrigenous sediment supply by the Amur river drainage system are main contributors to a depositional environment that leads to sedimentation rates between 30 and 120 cm/kyr. Our present age models consist of AMS radiocarbon control points from planktic foraminifera and benthic shell fragments as well as correlations of magnetic susceptibility values to existing reference records. Thus, to date, our investigations gain an average temporal resolution of 50-200 years between discrete samples for the Holocene. Based on a multi-proxy approach, we use colour-scan values as well as content and accumulation rates of biogenic opal as a proxy for primary productivity while trace and minor and element distributions in the terrigenous fraction serve as indicator for riverine sediment supply. While these datasets provide high-resolution records, stable isotope data of benthic and planktic foraminifera supplement our results on a coarser temporal scale. Our results show high frequency oscillations in Amur river discharge and biogenic productivity that can be correlated to other regional records and also to oxygen isotope records of the Greenland GISP II ice core record. Beneath major deglaciation incidents like Younger Dryas or Terminations Ib and Ic, we also feel confident to recognize significant short-term events like the onset of the Preboreal, the Holocene climatic optimum and the subsequent Late Holocene Cooling with the Medieval Warm Period or the Little Ice Age.

## 79-8 BTH 111 Yoo, Dong-Geun

EVOLUTION OF LATE QUATERNARY DEPOSITS ON THE INNER SHELF OFF THE SOUTHEASTERN COAST OF KOREA (KOREA STRAIT)

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High-resolution seismic profiles and borehole data from the inner shelf off the Nakdong River in the Korea Strait were analyzed to document the stratigraphy and evolution of inner shelf deposits closely related to the post-glacial sea-level rise. The inner shelf sequence consists of three stratigraphic units: transgressive estuarine deposits (Unit III), thin sand layer (Unit II), and Nakdong subaqueous delta (Unit I), from oldest to youngest. 14C age data suggest that the study area became flooded at about 11,000 yr BP and the sea level nearly reached its present position approximately at 6000 yr BP, respectively. Unit III above the acoustic basement consists of estuarine sandy mud and muddy sand including brackish water species of foraminifers deposited during the middle to late stage of post-glacial sea-level rise (11 ?8 ka), whereas Unit II consists of thin sands, as transgressive lag deposits, produced through shoreface erosion during the transgression (8 ka ?6 ka). Unit I consists of recent muds deposited during the last 6000 yr BP when sea level was close to the present level. Recent muds mainly derived from the Nakdong River prograded over transgressive units, forming a Nakdong subaqueous delta.

## 79-9 BTH 112 Nam, Seung-Il

PALEOENVIRONMENTAL CHANGES IN THE KOREA STRAIT DURING THE POST-GLACIAL MARINE TRANSGRESSION

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A 31m-long sediment core (SSDP-102) was taken from the inner shelf (about 40m water-depth) off the northwestern coast of the Korea Strait. Detailed organic-geochemical analyses and stable oxygen isotope measurements on planktonic and benthic foraminifers were performed to establish a high-resolution stratigraphy in the Korea Strait and to elucidate the paleoenvironmental changes associated with the Post-glacial marine transgression. The high-resolution stratigraphic framework of the core was primarily established using 11 AMS 14C ages. The sedimentary sequences of the core SSDP-102 well record the paleoenvironmental changes in transition interval of sea- level rise during the last 12.1 cal ka BP. According to the high-resolution seismic reflection profiles, lithofacies, organic-geochemical data, and d18O and d13C records, the core SSDP-102 can be divided into three units (III to I in ascending order) above the acoustic basement, which reflect distinct changes of depositional environments in response to the Post-glacial marine transgression. Therefore, it is suggested that three phases of sea-level change have taken place within the inner shelf of the Korea Strait following the Post-glacial marine transgression; (1) brackish-estuarine environments from ca. 12.1 to 6.2 cal ka BP; (2) near-shore environments with a period of decreased rising of sea level between 6.2 and 5.1 cal ka BP; (3) modern marine environments after 5.1 cal ka BP. In particular, the occurrence of palnktonic foraminifers G. rubber and N. dutertrei, and their d18O and d13C records together with d13Corg values imply that the present marine conditions influenced by the warm Tsushima Current may have been gradually established after ca. 4.5 cal ka BP.

## 79-10 BTH 113 Nam, Seung-Il

PALEOENVIRONMENTAL CHANGES IN THE NORTHERN EAST CHINA SEA AND THE YELLOW SEA DURING THE HOLOCENE MARINE TRANSGRESSION

NAM, Seung-Il[1], CHANG, J.-H.[1], KIM, S.-P.[1], YOO, D.-G.[1], CHEONG, T.-J.[1], OH, J.-H.[1], and MACKENSEN, A.[2], (1) Petroleum & Marine Resources Division, Korea Institute for Geoscience & Mineral Rscs, Taejon, 305-350, South Korea, sinam@kis.kigam.re.kr, (2) Alfred-Wegener Institute for Polar- & Marine Rsch, Bremerhaven, 27568, Germany

Cores ECSDP-101 (ca. 3m long) and ECSDP-102 (ca. 3m long) and core YMGR-102 (ca. 2m long) were collected from the northern East China Sea, off the mouth of the Yangtze River and from the southern Yellow Sea, respectively. According to AMS 14C ages the northern East China Sea and the southern Yellow Sea began to have been flooded at about 12.3 cal ka BP. In particularly, the δ18O and δ13C records on the benthic foraminifera Ammonia ketienziensis combined with d13Corg records were used to delineate the paleoceanographic changes from the northern East China Sea to the Yellow Sea during the Holocene marine transgression. The three cores investigated well represent the paleoenvironemtal changes from brackish-estuarine to modern marine conditions associated with rapid global sea level rise during the transition from the Last Glacial Maximum (LGM) the Holocene. In particularly, the establishment of the present marine regimes of the northern East China Sea and the whole Yellow Sea took place at about 6.5 cal ka BP.

However, throughout the Holocene, δ18O values of A. ketienziensis from the northern East China Sea are about 1‰ lighter rather than those recorded in the southern Yellow Sea. Furthermore, similar patterns of the δ18O values for A. ketienziensis, as recorded in the northern East China Sea and southern Yellow Sea, were also observed in core CC-02 collected from the central Yellow Sea (Kim and Kennett, 1998). In the central Yellow Sea, the δ18O values of A. ketienziensis during the Holocene are about 0.3-0.5‰ heavier than those in the southern Yellow Sea. This distinct difference in δ18O values of A. ketienziensis probably reflects regional changes in salinity and/or temperature, probably implying the Holocene oceanographic changes from the northern East China Sea to the whole Yellow Sea.

## 79-11 BTH 114 Watanabe, Naoko

ENHANCED EL NIÑO LIKE CONDITION IN THE NORTHWESTERN PACIFIC OCEAN DURING LATE HOLOCENE; EVIDENCE FROM DRASTIC CHANGE OF THE SURFACE CURRENT, KUROSHIO

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The Kuroshio Current is a main component of subtropical circulation in the northwestern Pacific Ocean and effects climatic changes in the region. The Ryukyu Arc region is a key area for studying past variability of the Kuroshio since it is the area where the current strengthens after diverging from the North Equatorial Current. In this area, Ujiie *et al.* (in press) used 15 piston cores to reconstruct time-space changes in surface water masses based on planktonic foraminiferal assemblages younger than 20 ka. Of the four modern planktonic foraminiferal groups characterizing this region, the *Pulleniatina* group is most characteristic of Kuroshio Water. However, this

species diminished in abundance twice during the LGM and late Holocene, from ca. 4.5 to 3 ka, respectively. During the latter event (the "*Pulleniatina* minimum event" or PME), the effect of the Kuroshio Water was greatly diminished without any cooling signal. The same event has been recognized in the South China Sea and the western equatorial Pacific Ocean. In this study, we propose a new hypothesis for the PME by considering the delicate ecological differences between *Pulleniatina obliquiloculata* and *Neogloboquadrina dutertrei*. Although both species inhabit the thermocline in Kuroshio Waters at present, their relative abundance was reversed during PME. Using 3 cores obtained from the Ryukyu Arc region, we measured $\delta^{18}O$ of *P. obliquiloculata*, *N. dutertrei* and *Globigerinoides sacculifer*. $\delta^{18}O$ curves of *P. obliquiloculata* and *N. dutertrei* represent heavy values during the PME, although *G. sacculifer*'s values do not change. Therefore, the PME indicates an environmental change in sub-surface waters. *P. obliquiloculata* inhabits the thermocline of the entire equatorial Pacific. However, sub-surface water is relatively cooler when the thermocline is shallower, as occurs during El Niño events. Moreover, the velocity and strength of the Kuroshio Current tends to decrease when the North Equatorial Current bifurcates in more northerly latitudes prior to El Niño. Therefore, we suggest that PME indicates the onset of the modern ENSO system around the low-latitude northwestern Pacific Ocean.

### 79-12 BTH 115 Zong, Yongqiang

RECONSTRUCTION OF HOLOCENE MONSOON VARIABILITY FROM THE PEARL RIVER ESTUARY

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The variability of East Asian Monsoon (EAM) is an important manifestation of global climate change, and is a regional system teleconnected to other systems such as North Atlantic Oscillations (NAO). The understanding of the variability of EAM is therefore globally significant. Furthermore, EAM is of tremendous socio-economic importance in East Asia where flood and drought hazards are common. The Pearl River estuary is well placed within the EAM region, and any variation in the intensity of EAM will result in a change in the freshwater flux into the estuary and inner shelf region of the South China Sea. The aim of this presentation is to show the potential of such estuarine environments for climate reconstructions over a Holocene timescale by linking together present day sedimentology, geochemistry and micropalaeontology of the estuarine system to fluctuations in freshwater flux associated with discharge from the Pearl River. The Pearl River is 2214 km in length with a drainage area of 425,000 km2 and an average annual discharge of 302 billion m3. Two small deltaic complexes lie within the drowned basin of the estuary itself. Sea level in this region since 7000 cal. Year BP has been stable with possible fluctuations of less than ±0.5m. We present diatom, foraminifera, carbonate stable isotope and bulk organic stable isotope data from a series of surface sediment samples from the eastern part of the Pearl River estuary and inner shelf that show a clear relationship with proximity to freshwater discharge. The identification of such a relationship makes it possible to examine the estuarine sedimentary archive to identify variations in freshwater discharge linked to changes in monsoon intensity. Preliminary, sedimentary, stable isotope and faunal data from a 10m sediment core from the eastern Pearl River estuary indicate changes in freshwater flux associated with EAM.

### 79-13 BTH 116 Teng, Louis S.

LATE QUATERNARY EUSTATIC AND CLIMATIC RECORDS OF THE TAIPEI ESTUARY, TAIWAN

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Estuaries contain continuous Holocene sediment records that usually provide important repertories of past eustatic and climatic information. During the lowstands, however, estuarine deposits are prone to erosion such that pre-Holocene sediment records are often obliterated and become hard to interpret. Only in rapidly subsiding estuaries like the Taipei Basin of northern Taiwan could early sediment records be preserved and reveal past environmental responses to varying climate and eustacy. The Taipei Basin is a filled estuary that accumulated up to 350-m-thick siliciclastic sediment in the past 200 ky. Near the depocenter in the northwest Taipei Basin, the sediment comprises two unconformity-bounded sequences, each of which consists of an aggradational alluvial fan gravel, a retrogradational fluvio-estuarine sand/mud and a progradational fluvial sand/mud. The aggradational and progradational successions were deposited in cold and warm stages shown by pollen assemblages, and the retrogradational successions during the cold-warm transitions. These successions can be tied to the deep-sea oxygen isotope curve through palynostratigraphy and radiometric datings and correlated with glaciation-modulated eustatic cycles. The result shows that the aggradational, retrogradational, and progradational successions were accumulated during the lowstands, transgressions, and highstands respectively. Outside the depocenter, the sediment becomes thinner, the transgressive systems tracts are less well developed and the highstand systems tracts often absent. The sediment is packed with amalgamated alluvial gravel and sand of the lowstand systems tracts. These sediment records show that the Taipei Basin was subjected to intense erosion during the sea level fall and only began to accumulate alluvial fan gravels during the late lowstand. During the sea level rise, the Basin was inundated as an estuary and filled with retrogradational fluvial and estuarine sediments. As the sea level neared the highstand, fluvial sediment prograded into the Basin and filled it up as a floodplain. In view of the Taipei Basin stratigraphy, pre-Holocene deposits tend to be strewn with hiatuses even in rapidly subsiding estuaries, and the sediment record is inevitably biased toward cold stages and lowstands.

### 79-14 BTH 117 Wehmiller, John F.

THE RECORD OF QUATERNARY SEA-LEVEL CHANGE, NORTH CAROLINA COASTAL PLAIN, MID-ATLANTIC US

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The Albemarle Embayment of northeastern North Carolina contains a thick section (up to 60 m) of Quaternary strata that preserve a complex history of sea-level change and coastal evolution over the past million years. A detailed study of the geologic framework of this segment of the coastal plain is now underway, using a variety of geophysical, geochemical, litho- and bio-stratigraphic tools, under the auspices of a cooperative research program of the U.S. Geological Survey, the North Carolina Geological Survey and several academic institutions. Eight core holes up to 65 m deep were drilled on the northern Outer Banks (75.6W, 35.8N) in 2002; a similar number will be drilled in 2003. Over 7200 km of seismic lines in estuarine, back-barrier, and inner shelf environments, and 500 km of ground-penetrating radar lines along the coastal barriers, combined with stratigraphic and paleoenvironmental analysis of cores, record a history of mid- to late-Pleistocene valley incision and sedimentation during regression/transgression cycles. Seismic and sidescan sonar data combined with ~200 vibracores from the inner shelf, indicate that the distribution of Recent sediment (above the Holocene ravinement surface) on the shoreface and inner continental shelf is patchy and controlled by the underlying geologic framework, which also influences the geomorphology of the overall barrier island system. In many locations, Pleistocene (or older) deposits are exposed on the shelf or shoreface. We derived age estimates (ranging from ~100 ka to ~1,000 ka) for Pleistocene units from molluscan amino acid racemization data, which broadly define aminozones or discrete intervals of deposition. Aminozones recognized in subsurface sections are represented by transported fossil material found on beaches or both in-place and reworked material on the inner shelf. The late Quaternary record includes a valley-fill sequence associated with the paleo-Roanoke River and its tributaries, which is incised into the underlying Pleistocene deposits. This sequence ranges from ~3 m to >30 m in thickness; seismic stratigraphy and radiocarbon ages indicate at least six distinct phases of deposition since the last glacial maximum.

### 79-15 BTH 118 Horton, Benjamin P.

THE APPLICATION OF LOCAL AND REGIONAL TRANSFER FUNCTIONS TO RECONSTRUCT FORMER SEA LEVELS, NORTH NORFOLK, ENGLAND

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Foraminiferal assemblages from Thornham and Brancaster marshes (Norfolk, UK) illustrate that elevation with respect to mean sea level is the most statistically significant controlling variable. We developed local (Thornham and Brancaster marshes) and regional (data from Thornham and Brancaster marshes combined with those from eleven sampling areas around the UK) predictive foraminifera-based transfer functions, and applied them to a sediment sequence from Holkham North Norfolk, UK. The chronological framework was provided by four radiocarbon dates and five infrared stimulated luminescence ages.

Although there is a general similarity between the local and regional transfer functions, there are significant differences associated with the precision of the reconstructions. It is no surprise that the error ranges of local function are more precise than their regional counterparts as the data used to develop the latter transfer function are derived from thirteen sites with a great variety of tidal, sedimentological and floral characteristics. However, the magnitude of this difference is small when compared to the overall magnitude of the error terms associated with each transfer function and so does not represent a significant improvement in performance. The elevation of the relative sea levels also differed somewhat between the two transfer functions, primarily due to the lack of modern analogues in the local transfer function. We suggest that interpretations based on transfer functions derived from local training sets should be treated with caution unless the constancy of environmental conditions at the sample site can be. Intuitively, these conditions will be most satisfactorily met when dealing with 'young' high marsh sediments, but will be subject to increasing conjecture as the age of the sample and its depth relative to the tidal frame increases. The resulting relative sea-level curve from the regional transfer function showed a general trend of rising RSL throughout the Holocene, which is consistent with observations and model predictions from areas close to the limit, and beyond, of the British ice sheet at the Last Glacial Maximum.

## SESSION NO. 80, 1:30 PM

## Tuesday, July 29, 2003

## T34. Cenozoic Eolian Deposits and Global Climate Change (Posters)

## Reno Hilton Resort and Conference Center, Pavilion

### 80-1 BTH 119 Zhou, Liping

RETRIEVING PALEOENVIRONMENTAL INFORMATION FROM LOESS DEPOSITS IN CHINA WITH A MULTIPROXY APPROACH

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Succession of loess deposits is one of the most complete geological archives which contain rich information on terrestrial environmental changes for the last several million years. Reconstruction of the regional paleoenvironment can be achieved by the use of physical, chemical or biological proxies obtained from the loess deposits. However, the retrieval and interpretation of the paleosignals which have clear association with regional environmental changes are not straightforward. The inferred climate variability is sometimes found to display inconsistency depending on the proxies used. This is particularly true when the amplitude of the climate change is considered. Here we present a multiproxy study on loess deposits from different parts of the Loess Plateau in China. Downcore variations of magnetic, sedimentological and mineralogical measurements are compared and implications of the results based on individual proxies are discussed.

### 80-2 BTH 120 Guo, Zhengtang

MAGNETOSTATIGRAPHY OF AN EARLY-MIDDLE MIOCENE LOESS-SOIL SEQUENCE IN THE WESTERN LOESS PLATEAU OF CHINA

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Earlier studies on two parallel sections (QA-I and QA-II) in the Qinan region from the western Loess Plateau demonstrated that loess deposition in northern China started by 22 Ma ago, indicating the onset of Asian desertification and winter monsoon circulation by the early Miocene time. A third section, 218.2 m thick, about 30 km east of the previously studied sections, is geomagnetically dated in this study. The upper portion (0-166.5 m) of this section consists of alternat-

ing typical loess and soil units while the lower part (166.5 m-218.2 m) is water-reworked, but the material was derived from loess deposits.

Thermal demagnetization was performed on 853 samples at an average interval of 25 cm. Samples were demagnetized in a MMTD-600 Thermal Demagnetiser and measured using a 2G three-axis cryogenic magnetometer, both installed in field-free space. Most of the samples yield a stable characteristic remanent magnetization (ChRM) above 350 degree and 91% of the samples gave reliable characteristic remanence directions.

The obtained magnetic polarity zonation is well correlative with the portion from the Chron C6Ar to Chron C5r.3r of the GPTS without any significant hiatus. Extrapolation based on sedimentation rate indicates a time span of the sequence from 21.4 Ma to 11.6 Ma BP. The boundary between the typical loess-soil sequence and water-reworked lower portion is dated for 19.6 Ma.

Lithostratigraphy and magnetic susceptibility of the sequence are consistent with the geomagnetic results. They show high similarity and correlativity with those of the QA-I and QA-II sections. These results firstly confirm our earlier studies that loess deposition started in northern China by the early Miocene, and secondly demonstrates that the stratigraphy of the Miocene loess-soil sequences is spatially correlative, having therefore great potential for the study of regional/global climate changes during the Miocene time. The Miocene loess-soil sequences, combined with the well-known Quaternary loess-soil sequence and the Late Miocene-Pliocene Hipparion Red-Earth formation, provides a unique continuous eolian record of paleoclimates since the early Neogene.

## 80-4 BTH 122 Chen, Mingyang

DUSTSTORM, MONSOON AND UPLIFT OF QINGHAI-XIZANG PLATEAU

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Recently, China has implemented a program of control sandstorms in surrounding areas of Beijing. This program is in order to bid farewell to sandstorms in Beijing by 2010. The sand and dust storms become a hot research topic in China. A North Pacific core (LL44-GPC3) has been used to evaluate changes in influence of strong duststorms. From this core, eolian sedimentation decreased from 70 to 50 Myr ago. Fine eolian grain size and the low accumulation rates in the Eocene and early Oligocene are in agreement with a vigorous trade wind, the evaporite formation in Southeast Asia and the South China was displaced by the tropical rain florist, which was connected with the uplift of the Tibet Plateau by 65-45 Myr ago. During 37-30 Myr ago large increases in grain size was connected with the uplift of eastern Tibet Plateau. A moisture channel from India Ocean to Lanzhou Basin formed. The evaporite formation in Lanzhou Basin disappeared at 32 Myr ago. It seems that the vigorous winter and summer monsoon formed at that time. A relatively arid temperate steppe or forest-grassland environment appeared, where the early strong duststorms happened. So did as significant change of eolian deposition at 25, 15 and after 3 Myr ago. Since 15 Myr ago the northwestern China has been getting worse to worse. It reflected the rainshadow effect by the Tibet Plateau. Eolian accumulation rates sharply increased at 3 and 1.2˜C0.7 Myr ago. From distribution of calcium soil and loess, the steppe or forest-grassland environment shifted from 104ºE to 106ºE, 112ºE and 114ºE respectively at 32, 29-8, 7-3.5, and 1.2-0.7 Myr ago. As the semiarid and arid area expands, and monsoon strengthens by uplift of Tebit Plateau, the frequency of strong duststorms or eolian accumulation rates sharply increase. The yearly expanding acreage of desertified land is from 1,560 square kilometers in the 1950s-1970s to 3,436 square kilometers during the last five years of the 1990s. It shows desertification-control projects do not change a deterioration situation . But the duststorm sharply decreased in the 1970s-1990s. It shows the frequency of strong duststorm is not directly connected with sandstorm and acreage of desertified land, a sky with floating dust in spring could never bid farewell in Beijing, even if the present desertified land situation recovered to 1950s.

## 80-5 BTH 123 Lu, Houyuan

A NEW POLLEN RECORD OF THE LAST 2.8 MA FROM THE CO NGOIN, CENTRAL QINGHAI-XIZANG (TIBETAN) PLATEAU

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A new pollen record from the lake of Co Ngoin in the central Qinghai-Xizang (Tibetan) Plateau provides information on the vegetation and climate changes during the last 2.8 Ma. Seven major significant changes in pollen associations indicate the processes of vegetation change and possible tectonic uplifts. The seven changes in vegetation succession include a temperate montane conifer and broad-leaved mixed forest, cold temperate montane dark conifer forest, alpine shrub-meadow and alpine desert, montane dark coniferous forest and alpine shrub meadow, montane dark coniferous forest and alpine meadow, alpine desert and meadow. The pollen record provides the evidence at least five times tectonic uplifts occurred at about 2.58 Ma, 1.87 Ma , 1.17 Ma , 0.83 Ma, and 0.3 Ma ago, respectively. Before 0.8 Ma, this region maintained the altitude below 4,000 m a. s. l. The larger amplitude of uplift occurring at about 0.8 Ma ago enforced the plateau rising into cryosphere, shaping the basic topographic pattern of modern plateau. The major successions in vegetation of this area were largely controlled by the stepwise uplift of the Tibetan Plateau.

## 80-6 BTH 124 Deng, Chenglong

PALEOCLIMATE IMPLICATIONS OF MAGNETIC PROPERTIES AND MINERALOGY OF THE CHINESE LOESS/PALEOSOL COUPLETS OF THE LAST 1.2 MA

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A multiparameter investigation of 15 loess-paleosol couplets (S0/L1 to S14/L15) from the Jiaodao section sequence in the central loess plateau of China using mineral magnetic approaches was conducted. The magnetic parameters display systematic variations that seem to be closely related to paleoclimate variations and intensity of pedogenesis. High-temperature and high-field magnetic properties exhibit systematic variations that can be directly related to magnetic mineral transformations by pedogenic processes. High-temperature susceptibility curves of paleosols show a generally decreasing trend in reversibility from the base of the Lishi Formation to the Holocene black loam, indicating a decrease in weathering intensity. This may reflect a long-term increase in aridity and/or a general long-term cooling trend of the interior of the Asian continent from 1.2 Ma ago to the present. Some samples display wasp-waisted hysteresis loops. These are most pronounced in moderately enhanced paleosols, less pronounced in the practically unaltered loess, and subdued in the well-developed paleosols, but wasp-waistedness reappears in the most developed paleosols. These magnetic variations in Chinese loess and paleosols are jointly controlled by the changes in composition, concentration and grain-size, but each variable has different effects at different stages of pedogenesis.

## 80-7 BTH 125 Sun, Jimin

PROVENANCE OF LOESS MATERIAL AND TRANSPORTATION OF EOLIAN DUST TO THE LOESS PLATEAU AND THE NORTH PACIFIC

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Results of a multiple, isotopic, chemical and mineralogical analysis of loess from the three northwestern inland basins (including the Junggar Basin, the Tarim Basin and the Qaidam Basin) and the Loess Plateau region of China are summarized. It is argued that the gobi desert in Mongolia and China, rather than the three inland basins, are the dominant source areas of the Loess Plateau. However, although these gobi and sand deserts are regarded as the main source regions, they serve as dust and silt holding areas rather than dominant producers. The mountain processes (e.g., glacial grinding, frost weathering, salt weathering, tectonic processes) in the Gobi Altay Mts., Hangayn Mts. and the Qilian Mts. have played an important role in producing the vast amounts of loess-sized material for forming the Loess Plateau. Dust entrained from different geomorphological units of China has different contributions to the proximal and distal regions. Dust derived from the Junggar and Qaidam basins is transported by near-surface winds, and thus mainly accumulates on the windward slopes of the local mountains (local dust). For the Tarim Basin, dust can be transported not only by the near-surface winds, but also by the westerlies whenever the dust is entrained to an elevation of > 5000 m asl. In the latter case, dust from the Tarim Basin (the Taklimakan Desert) can be transported out of the basin and ultimately to the remote Pacific (long distance dust). In most cases, dust entrained from the gobi desert in Mongolia and China is transported by near-surface winds, serving as medium distance dust, but occasionally (about 10%), it can be transported by the westerlies to the remote Pacific Ocean and even to the United States (long-distance dust).

## 80-8 BTH 126 Lu, Huayu

PERIODICITIES IN LOESS-PALEOSOL SEQUENCE OF CHINA

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Periodicity in Chinese loess-paleosol sequence has long-time been investigated. However, there are many drawbacks in the previous works so that the conclusions are still controversial and the interpretation is equivocal. In this study, two typical loess-paleosol sequences (148 m and 191 m in thickness, respectively) in the Loess Plateau are sampled and total 2872 samples are measured in order to reconstruct the palaeoclimatic changes during the past three million years. On the basis of the new and sensitive proxy indicator of paleoclimate and the newly developed independent (orbitally-untuned) time scale, time series of the dust storm variations, which is highly related to the paleoenvironmental system changes, is obtained. By wavelet transfer and power spectrum analyses, the results show that there are approximately 400, 200, 100, 66, 57, 41, 31, 27 and 22 kyr cycles in the loess record. The orbital cycles are weak and are not completely presented in the new time series; there are also non-orbital cycles. Because the eccentricity frequencies of the solar irradiance of the approximately 400-kyr and 100-kyr are preserved in these sequences, the missing of 41-kyr-obliquity and 22-kyr-precession cycles in part of the time series may be explained by lower time-resolution of the loess-paleosol deposit. The presentation of the non-orbital cycles may be explained by the unstable depositional process of the dust and pedogenic process in the paleosol units, which misrepresents or obliterates imprint of the solar irradiance frequency. This conclusion may imply that it should be cautious when investigate the specific paleoenvironmental changes recorded in the loess, especially in the paleosol units.

## 80-9 BTH 127 Chen, Jun

VARIATION OF ZR/RB RATIOS IN THE CHINESE LOESS SEQUENCES DURING THE LAST 130KYR AND ITS IMPLICATION FOR CHANGES IN WINTER MONSOON STRENGTH

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We have selected seven loess-paleosol sections covering the last 130kyr in the Loess Plateau of China for measuring concentrations of the trace elements Zr and Rb as well as the grain size. Variations of Zr/Rb ratio along the sequence in all of the sections display a generally similar pattern to that of the grain size which have been generally considered as a proxy of the East Asian winter monssn strength. This close relationship has been also verified by a spatial gradient distribution of the two parameters in the seven sections along the N-S transect across the Loess Plateau. Further analyzed data of Zr and Rb concentrations in five separated particle fractions show that the ratio of Zr/Rb increases as the grain size increases. This well explained a positive linear relation of the ratios and values of the mean grain size existed in all of the least weathered loess samples. Acid solution experiments indicated that both Zr and Rb are immobile elements during pedogenic processes. Therefore, the variations of Zr/Rb ratios in the sequences can be regarded as a better index for the winter monsoon strength than the mean grain size. Matching the Zr/Rb record with the mean grain size curve suggests that strength of the winter monsoon during the marine isotopic stage 3 is particular weak. This means the Asian monsoon could be driven by changes of the solar insolation on the precessional time scale.

## 80-10 BTH 128 Gu, Zhaoyan

CARBON ISOTOPE RECORDS FROM THE LOESS-PALEOSOL SEQUENCES FOR C3/C4 PLANT VARIATIONS IN THE LOESS PLATEAU DURING THE LAST 150 KA BP: IMPLICATION OF VEGETATION RESPONSE TO CLIMATIC CHANGES

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It is important to understand which is the major factor to drive ecological changes on a regional scale since our atmospheric CO2 level is increasing because human activities. In this presentation, the analyses of carbon isotope of organic matter, grain size, carbonate, and magnetic susceptibility have been carried out on the samples from the loess-paleosol sequences at different sites in Chinese Loess Plateau for the histories of C3/C4 plant abundance and climate since the last interglacial. The following conclusions emerge from the analytic data. First, the fact that the flora are characterized by a mixture of C3/C4 grasses during relative warm periods except for the last interglacial (equivalent to Eemian in Europe), and by a C3 grass domain during relative cold periods of the last 150 ka BP indicates that temperature is the major factor to induce changes in C3/C4 abundance. This conclusion is also supported by an increasing trend of C4 plant abundance for a given period from the cold northwest to the warmest southeast of the Loess Plateau. Second, the C4 plant abundance during warm periods increase with seasonal intensity of precipi-

tation and/or dryness, implying that the East Asian monsoons play an important role in the plant photosynthetic type when the temperature is high enough to grow C4 plants. Finally, a great contrast in the C3/C4 plant abundance is presented between Holocene and the Eemian, when atmospheric CO2 level was high for both of the periods. The Holocene flora is a mixture of C3/C4 grasses in the plateau. However, the Eemian flora become into a C3 plant domain only in the southeastern plateau. Since the Eamian climate is the warmest in the last 150 ka BP, it can be deduced that forest had fully covered on the southeastern plateau due to reducing of the seasonality of precipitation during that period.

## 80-11 BTH 129 Wang, Haibin

PARTICLE SIZE DISTRIBUTIONS OF THE LAST INTERGLACIAL PALEOSOL S1 PROFILES IN THE CHINESE LOESS PLATEAU: THEIR PEDOGENIC AND CLIMATIC IMPLICATIONS

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The last interglacial paleosol S1 gradually differentiated from the northwest to the southeast. At the Lanzhou and Dingxi sections in the northwestern part of the Loess Plateau, the three paleosols (S1S1, S1S2, S1S3) corresponding to marine isotope sub-stages 5a, 5c and 5e and the two intervening loess units (S1L1, S1L2) corresponding to marine isotope sub-stages 5b and 5d are completely preserved and the post-depositional in situ weathering and the post-weathering translocation of clay and carbonate did occur in the paleosols but only to limited extents. At the Tianshui section in the southern part of the western Loess Plateau, the three paleosols were partially welded, and the post-depositional in situ weathering and the post-weathering translocation within the S1 profile occurred more pronouncedly and the S1 intruded into the underlying older and coarser loess L2 more deeply than in the northwestern part. The three soil-forming events occurred repeatedly just in one single soil profile at the Lantian section in the southeastern part of the Loess Plateau and a major portion of the S1 paleosol developed in the underlying older and coarser loess L2. Undoubtedly, the post-depositional in situ weathering and the post-weathering translocation within the S1 profile at the Lantian section were the predominant processes probably during the entire period of the last interglacial. The Qingyang section is an expanded version of the Lantian section. The laboratory data at the Huanxian section in the northern part of the eastern Loess Plateau are quite similar to those at the Qinan section in the central part of the western Loess Plateau. At all sections investigated with an exception of the Lantian section where the particle-size difference between the L1 and S1 was blurred by a strong weathering of the L1, not only are the paleosols but also the loess units S1L1 and S1L2 within the S1 remarkably distinguishable from the overlying L1 and underlying L2 by particle size distribution, implying that the S1 parent material was considerably finer in the source areas during interglacial periods than during glacial periods. To conclude, because a number of factors might have involved in shaping the particle size distribution curve in the S1 profiles, it is thus unrealistic to reconstruct high-resolution climatic records from the S1 paleosols.

## 80-12 BTH 130 Wu, Naiqin

RAPID CLIMATE VARIABILITY RECORDED BY MOLLUSK ASSEMBLAGES IN THE LOESS PLATEAU DURING THE LAST GLACIAL MAXIMUM

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A high-resolution terrestrial mollusk record from the Loess Plateau of China has been studied to characterize climate variability during the Last Glacial Maximum (LGM). The studied section is located at Weinan, Shaanxi Province, in the southern Loess Plateau. In this study, a total of 81 samples with a sampling interval of 3 cm were analyzed for fossil mollusks of the LGM. Fifteen species of terrestrial mollusk fossils were identified. Of them, six typical species with distinct ecological significance were selected to infer climate and environmental changes. The successions of mollusk species reflect the variability of the LGM climate in the Loess Plateau and relationships between temperature and precipitation. At least four times of sharp climate changes occurred at this period with the characteristic of millennia-scale fluctuations. The changes in temperature and precipitation were evidently not in phase during the LGM. Temperature decrease or increase is leading precipitation. Consequently, the climate in the Weinan region experienced cold-wet, cold-dry, temperate-dry, and temperate-humid condition during the last 22 kaBP., which is attributed to the effect of winter and summer monsoon interactions on the loess region. Our results also reveal that the East Asian summer monsoons could reach continuously the southeast part of the Loess Plateau during the whole LGM. The intensification of winter monsoons during the LGM led to short duration of summer monsoons annually impacting on the Loess Plateau, but the intrinsic intensity of summer monsoon would have not changed significantly, that ensured thermo-hydrological condition for temperate-humidiphilous mollusks to persistently grow and develop in the glacial age.

## 80-13 BTH 131 He, Xiubin

PALAEOPEDOSEDIMENTARY AND ANTHROPOGENIC CHARACTERISTICS IN HOLOCENE LOESS PROFILES OF CHINA

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Holocene loess-palaeosol profile is of special importance in loess-based palaeo-climatic studies as it usually serves as the basis for interpreting the eco-environmental conditions under which the older loess-palaeosol sequences were developed. In China, a long agricultural history on the Loess Plateau has caused extensive destruction of natural vegetation cover and led a profound modification on the Holocene loess profiles. Micromorphology, heavy minerals, pollen and soil properties are examined in three typical Holocene loess profiles at three locations along a south-north transect across the Loess Plateau. Results show that the profile consists of a palaeosol layer developed in the middle Holocene, which is underlain by the Malan loess and covered human disturbed fresh loess. The palaeosols were well preserved, consisting of an upper humus-rich (AB) horizon and a clay-rich (Bt) horizon. The humus-rich horizons are intensely weathered, contain precipitated calcitic material derived from the overlying modern loess, and have both high pollen content and diversity. Clay coatings are common in the clay-rich horizons. The pedogenetic types of the palaeosols varied from Ustalfs to Argiustolls and Haplustepts in the USA system along the S-N transect with paleo-bioclimatic pattern of the middle Holocene. The cover layers (Ap horizons) are newly-deposited loess of the later Holocene, 10%-25% of which in the south area was caused by human activities such as application of plaggen manure and irrigation with sediment˘Crich water.

## 80-14 BTH 132 Lim, Jae-Soo

EAST ASIAN MONSOON VARIATIONS AND THEIR LINKS TO THE NORTH ATLANTIC DURING THE LAST 6,000 YEARS

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We reconstructed the changes in the East Asian monsoon during the last 6000 years by high resolution maar sediments in Cheju Island, Korea situated leeward of eolian dust source areas, China. From the recovered monsoonal proxy data including eolian-originated lithogenic minerals and authigenic total organic matter, we defined intensified winter monsoon events (WME 1-9) with peaks at ca. 970, 1600, 2000, 2900, 3300, 3900, 4500, 5100, 5700 yr BP showing persistent centennial fluctuations, and summer monsoon variations showing asynchronous climatic trends in Cheju Island compared with the inner part of China, eolian dust source areas. These climatic events (WME 1-9) show close correlation with the ice-rafted debris (IRD) cooling events in the North Atlantic, implying teleconnection between both regions through cold air mass activity and the related atmospheric pressure system. Our results demonstrate that a succession of persistent centennial-scale variability in the East Asian monsoon during the last 6000 years may be linked and amplified by the North Atlantic cooling events synchronously affected by the variability of solar activity.

## 80-15 BTH 133 Catto, Norm

LATE QUATERNARY LOESS–PALAEOSOL SUCCESSIONS AND ATMOSPHERIC CIRCULATION, CENTRAL SIBERIA

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Aeolian sediments and palaeosols represent the principal forms of sedimentation and hold the record of climate events in unglaciated central Siberia. Loess-palaeosol records in the Gorno-Altaisk, Biysk, and Krasnoyarsk regions indicate establishment of periglacial steppe-tundra during OIS 4 and OIS 2, replaced by parkland steppe and boreal forest during warmer intervals within OIS 3. The last interglacial maximum occurred ca. 125,000 BP, earlier than OIS 5e in Europe and North America. A gradual transition from parkland-steppe (OIS 5a) to moist tundra conditions (OIS 4) occurred ca. 75,000 BP. General cooling, punctuated by isolated short warm intervals, marked the period from ca. 75,000 to ca. 25,000 BP. OIS 2, ca. 25,000-18,000 BP, was marked by a sharp change to a dry tundra climate, followed by rapid warming ca. 15,000-8,000 BP. Mid- and latest Holocene conditions were warmer than those recorded during the OIS 5e maximum. Textural, magnetic susceptibility, and mineralogical analyses indicate that the OIS 4 and OIS 2 loess units were derived from different source areas. The mineralogy of the clay-rich OIS 4 loess indicates derivation from the Altai Mountains to the south, and is associated soft sediment deformation indicates niveo-aeolian deposition. The OIS 2 loess is coarser, distally derived from western sources, and was deposited under colder, drier conditions. The changes in loess mineralogy and texture thus record a shift from southerly winds during OIS 4 to western zonal/hemispheric circulation during OIS 2. OIS 2 was marked by an abrupt change in climate, in contrast to the gradual transition evident from OIS 5a through OIS 3. Each successive interstadial was marked by cooler and drier conditions than its predecessor. The similarity between climate successions in Siberia with those recorded in the central Russian Plain suggests that continental-scale changes in airmass circulation were ongoing during the Late Quaternary in northern Eurasia.

## 80-16 BTH 134 Horváth, Erzsébet

POSITION OF THE LAST INTERGLACIAL IN THE HUNGARIAN LOESSES – RECENT EVIDENCES FROM LUMINESCENCE DATINGS

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Based on the most recent combined luminescence dating of four Hungarian loess profiles the most accepted theory of the loess stratigraphy has to be changed, as it was already suggested in some earlier works. In the upper part of these profiles (Paks, Mende, Basaharc and Albertirsa) we discovered a time gap which can be as much as 70 ka or larger. Generally the Mende Upper paleosoil complex (MF1 and MF2) is situated in this time gap. The only exception is at Paks, where between 20-100 ka there was either no loess deposition or the sediments were totally eroded. The lower part of this complex (MF2) was formed on the loess of the penultimate glaciation suggesting that the pedogenesis took place during the Last Interglacial period (OIS 5e). At the Mende and Basaharc sections the amino acid racemization dating supports this hypothesis. The surprising value of 65 ka obtained by the luminescence dating of the lowermost soil horizon at Albertirsa indicates that it developed on a loess younger than the Last Interglacial. Thus the soil labeled stratigraphically as MF2 in this section does not correspond to those recognized as such for the other sections. Soros Foundation and OTKA T 029798 supported this research.

## 80-17 BTH 135 Sümegi, Pál

LOESS AND UPPER WEICHSELIAN ENVIRONMENT IN THE CARPATHIAN BASIN (EUROPE)

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Most species of the Quaternary Mollusc fauna exist even today thus their extrapolation for the Quaternary is feasible. Quaternary malacological studies give the most detailed information about palaeoenvironmental, palaeoclimatological conditions of the Quaternary periods. First of all for times of loess deposition, because Mollusc shells are well preserved in these layers. The species composition of land snail assemblages is largely dependent on microclimatic conditions and factors of local habitat, especially vegetation cover. The Quaternary malacological analysis of the loess area in the Carpathian Basin is quite promising, since indicator species of various palaeoecological conditions appeared and migrated rapidly from different palaeobiogeographical parts of Europe, primarily from the lower Danube region. The Late Pleistocene environmental history of the Carpathian Basin can be regarded as one of the missing links to our understanding of the last glacial development of Europe. In terms of its location and geology the Carpathian Basin provides an important unglaciated area of low relief within the main mountain ranges of Central Europe (Carpathians, Alps, Dinaric Alps). We collected fine-stratigraphic samples from 29 Late Pleistocene loess sequences for sedimentological, quartermalacological analysis and radiocarbon dating. Chronology was obtained from 121 radiocarbon age determinations.Changes in the Mollusc fauna refer to nine short-lived (1000 - 3000 years), cyclical palaeoclimatological alter-

ations, which repeatedly transformed the palaeoecological conditions and vegetation in the Carpathian Basin between 34 – 12 kyr. On the other hand the composition of the Quaternary Molluscs suggest that the Upper Weichselian environment was mosaic-like and inhomogeneous in the analysed region with the development of some palaeoecological barriers parallel on the micro-, meso-, and macro level. According to the Quaternary Mollusc fauna the Carpathian Basin was a large fluctuation and migration zone between the different palaeobiogeographic units of Europe. Furthermore two forest types, some grasslands, and forest steppes can be reconstructed for the Upper Weichselian.

### 80-18 BTH 136 Jary, Zdzislaw

LOESS GRAIN-SIZE AND MAGNETIC SUSCEPTIBILITY AS A PROXY RECORD OF CLIMATIC CHANGES DURING OIS2 IN POLAND AND WEST UKRAINE

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Polish loess areas are situated in the central part of the European loess belt and, because of its geographical position, they belong to the most interesting in Europe. Loess in the Eastern part of the country has relatively big thickness (max. 40 m) and is similar to the Ukrainian loess. Loess patches in SW Poland are thinner (3-5 m, max. 15 m) and sediment properties are much the same as of the western European loess. The development of loess covers in Poland reflects therefore present and Pleistocene climatic conditions; continental in the east and more oceanic in the west. As a result of extensive field research, ten of the most complete last glacial loess sequences from Poland and West Ukraine were chosen for detailed investigation. All profiles were sampled at close intervals (5 or 10 cm) and documented in respect to their stratigraphy, sedimentology and palaeopedology. The grain-size distribution, determined by laser diffraction, magnetic susceptibility, CaCO3 and organic carbon content were measured in order to recover records of changing climatic conditions during OIS 2. The results indicate the occurrence of short-term depositional cycles within the thick loess sequences; relatively coarse loess is alternated with fine-grained loess. Periods of high dust influx coincide with severe climate conditions, as inferred from grain-size variations. Periods of decreased accumulation of fine-grain loess and development of weak pedogenic gley horizons, marked by relatively low values of magnetic susceptibility, represent warmer episodes. Short-duration climatic cycles recorded in Upper Weichselian loess sequences from Poland and West Ukraine can be correlated with the Dansgaard-Oeschger events in ice-core records. This implies that the influence of Dansgaard-Oeschger events during the Last Glaciation was not confined to Greenland but extended as far as central/eastern Europe borderzone.

### 80-19 BTH 137 Trombino, Luca

AGE AND ENVIRONMENT OF LOESS SEDIMENTATION IN NORTHERN ITALY DURING THE EARLY UPPER PLEISTOCENE (STAGES 4 AND 3)

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Recent research on loess deposits in Northern Italy and systematic TL and radiocarbon dating of the loess deposits, put in light an innovative scenario of glacial loess environment. Furthermore, loess are systematically associated to Mousterian sites, testifying adaptation to open environments in its paleoenvironmental and geoarchaeological implication ad the loess sedimentation was contemporary on both Alpine and Apennines fringes and it spanned from 60 to 26 ky. Phases of intense dust accumulation were contemporary to the coldest and driest phases of the Upper Pleistocene, and were interrupted by phases of absence of sedimentation, during which soil forming processes occurred; three interstadial isohumic soils were formed at this period. Early Upper Pleistocene loess, is systematically connected to Mousterian sites, some consisting of thick sequences insides caves; at the lower margin of loess sedimentation area, most of them are related to hunting camps widespread inside the loess covered area. A number of these sites are related to raw material procurement, located in marginal areas very close to the glacier front or at the upper limits of the loess sedimentation area, close to periglacial regions.

### 80-20 BTH 138 Schaetzl, Randall J

A POSSIBLE DISJUNCT OF PEORIA SILT (LOESS) IN NORTHERN LOWER MICHIGAN

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Loess is rare in Michigan, and where present it is thin and usually incorporated into the sandy or clayey soil below. Most of the Peoria Silt, a widespread loess in the midwestern USA, was deposited before northern Michigan became ice-free (about 13 ka), and most meltwater streams in lower Michigan were short and terminated in one of the Great Lakes, minimizing any opportunity for eolian entrainment of silt. It has also long been thought that the Peoria Silt thinned so rapidly to the east of the Mississippi River that deposits in Michigan would be undetectable. Lastly, most of the glacial deposits in southern Michigan are sandy; the ice sheet was carrying less silt than in other areas of the midwest. Our research, however, has documented the existence of a thin, silt-rich, surficial deposit in northern lower Michigan, USA, that may be an notable outlier of Peoria Silt or a later correlative. The silt exists on flat uplands and in dry kettles on an otherwise sandy upland known locally as the Grayling Fingers. This landscape was an interlobate area between the Saginaw and Lake Michigan lobes of the Laurentide ice. Till in this interlobate area is extremely sandy, with 4-8% clay and almost no silt. Above this basal till is an ice-ablation deposit less, i.e., the possible Peoria Silt, than a meter thick that commonly has >60% silt. It is unlikely that the silt in this deposit originated from the ice proper, as it had almost no silt in its drift. Thus, we believe it to be an eolian deposit that was transported into this region and retained/concentrated on top of the ice sheet, as this region was probably a topographic low on the ice surface. Upon melting, much of the silt was retained, because this area was a subglacial high and many of the uplands within it were minimally influenced by meltwater. Work on the silt deposit is continuing.

### 80-21 BTH 139 Sweeney, Mark R.

EUREKA FLAT: A LONG-TERM DUST-PRODUCTION ENGINE OF THE PALOUSE LOESS, PACIFIC NORTHWEST, USA

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Thick and expansive loess accumulations require long-term sources of dust and relatively stable climatic conditions as demonstrated by deposits of the Palouse loess in the U.S. Pacific Northwest. Eureka Flat, a narrow, 80-km-long deflationary plain oriented parallel to prevailing southwesterly winds, has been a source of Palouse loess throughout the Pleistocene. During this time, episodic glacial outburst floods have replenished the supply of fine-grained sediment that mantles Eureka Flat. Wallula Gap, a bedrock canyon incised by the Columbia River, funnels the prevailing winds that flow across Eureka Flat. These winds have persistently re-entrained sand, silt, and clay-rich flood sediment into sand dunes, sand sheets, and downwind loess. The upwind margin of Eureka Flat contains actively deflating fine-grained outburst flood deposits that are discontinuously capped by stabilized to partially stabilized parabolic dunes, sand sheets, and thin sandy loess. The central to downwind margin of Eureka Flat is devoid of dunes and is blanketed by 1.5 m of post-last glacial maximum (LGM) loess. Coring at the downwind end of Eureka Flat has revealed an extensive sand sheet buried by loess. The sand sheet to loess transition is characterized by a gradual change from unimodal, stratified eolian sand, to structureless, bimodal eolian sand and silt with insect burrows and rhizoliths, to unimodal, sandy loess. This stratigraphy marks a bioclimatically driven change from arid eolian sand deposition to less arid loess deposition as the density of dust-trapping vegetation increased. Up to 4.5 m of post-LGM sandy loess mantles topography adjacent to and downwind from Eureka Flat as linear ridges aligned parallel to the prevailing wind. These linear loess ridges occur immediately downwind from dust-producing basins and apparently extend in the wind shadows of topographic obstacles, including basalt knobs. Loess isopach maps reveal a relatively thick finger of loess that extends directly downwind of Eureka Flat for approximately 150 km. Up-building of loess on this finger-shaped accumulation has continued through much of the past 75 ka, illustrating the profound influence of the Eureka Flat dust engine.

## SESSION NO. 81, 8:00 AM

## Wednesday, July 30, 2003

## S3. Changes in Atmospheric Trace Gases and Aerosols on Glacial-interglacial Time Scales: A Key Challenge for Earth System Models

## Reno Hilton Resort and Conference Center, Carson 1&2

### 81-1 8:10 AM Martinerie, Patricia

METHANE CYCLE AND ATMOSPHERIC OXIDATION CAPACITY SINCE THE LAST GLACIAL MAXIMUM, A REVIEW OF MODELLING STUDIES

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Ice core data indicate a large increase in greenhouse gas concentrations (CO2, CH4, N2O) between last glacial maximum and the Holocene. The change in methane concentration can be due to changes in its sources (mostly wetlands) and/or its major sink (oxidation by OH). Through its sink, the methane cycle is related to other atmospheric species controlling the oxidation capacity of the atmosphere: (CO, NOx, VOCs). Therefore atmospheric chemistry modelling is required to simulate the methane budget. As for methane, the major sources of OH-controlling species are located on continental surfaces: vegetation emissions (VOCs), soil emissions (NOx), biomass burning emissions (CO, NOx, VOCs). NOx also have a major atmospheric source from lightning.

A number of 1D, 1.5D or 2D atmospheric chemistry studies followed the first publication of glacial/interglacial signal for methane. They all converge to suggest that the change in methane concentration is mostly due to its sources rather than its sink. However, these studies are based on somewhat crude estimates of emissions for all species involved. We should note that modelling methane sources and sinks that allow to simulate observed methane concentrations represents a strong constraint on the plausible model results. Other ice-core data such as CO concentrations or CH4 and CO isotopes can further help constraining the model scenarios.

To the author's knowledge, there is no published study of the LGM atmospheric chemistry with a 3D model. A complete study with currently available modelling tools would involve an important effort for establishing global maps of chemical species emissions, and require a vegetation model, a wetlands model, and a fire model with physically-based parameterizations of chemical species emissions, together with a chemistry-transport or chemistry-climate model. The study of past methane cycle can provide a mean for validating the earth-system models currently under development. Key validation data include indicators of past vegetation, wetland extent, and fire activity. Although there are palaeo indicators for all these data, a global database is available only for past vegetation. The presentation will include information about on-going work known from the author.

### 81-2 8:30 AM Kaplan, Jed O.

THE ISOTOPIC SIGNATURE OF ICE AGE TERRESTRIAL METHANE

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Atmospheric methane ($CH_4$) concentrations varied between ca. 350 and 700 ppb over the last 400 000 years. Between the Last Glacial Maximum (LGM, ca. 21 000 yr BP) and pre-industrial Holocene (to ca. 1850), $CH_4$ concentrations increased nearly 100% and more closely parallel the fast variations of polar temperature records than any other measured gas. Recent analysis of ice core $CH_4$ concentrations and carbon isotopic composition ($\delta^{13}CH_4$) indicate that $CH_4$ emissions from wetlands and fires drove prehistoric changes in ice-core $CH_4$, but conflict as to the location of wetlands, magnitude of burning, and the environmental controls on $CH_4$ emission. Wetlands and fires are the most important contributors to the global $CH_4$ isotope mass balance because wetlands have the highest emission rates of all natural sources and biomass burning has a unique isotopic signature. To investigate the effect of climate change on natural $CH_4$ emissions I used the BIOME4 global vegetation model coupled with simple algorithms for determining wetland area based on topography and soil moisture, and $CH_4$ emissions based on ecosystem carbon turnover in wet soils and intensity of biomass burning. Observed climate drove the vegetation model for a present-day control experiment; a paleoclimate scenario was provided by coupled AGCM/mixed-layer ocean model simulations at 1000-year intervals from the LGM to present. LGM wetland area was 15% larger than present, but $CH_4$ emissions were 24% less, and ca. 2‰ more depleted in $^{13}C$ because of the increase in tropical wetland area relative to northern wetlands. $CH_4$ emissions from fires were slightly greater at the LGM due to tropical aridity. The relative prevalence of $C_4$ grasslands at the LGM affected a shift in $\delta^{13}CH_4$ from fires by up to 10‰. Wetland $CH_4$ emissions did not change drastically during the deglaciation because new wetland areas formed as ice sheets retreated, while other wetland areas were flooded by rising sea-level. Rapid changes in atmospheric $CH_4$ concentrations over the last 21 ka cannot be completely attributed to climate change on millennial time-scales, however much of the isotopic shift in $CH_4$ emissions may be due to the increased importance of boreal wetlands in the Holocene.

## 81-3 8:50 AM Flückiger, Jacqueline

NITROUS OXIDE MEASURED ALONG POLAR ICE CORES: INSIGHT INTO GLOBAL PROCESSES

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Greenhouse gas measurements performed along polar ice cores show a close relation to the global temperature on glacial-interglacial time scales with high $CO_2$, $CH_4$ and $N_2O$ concentrations during interglacial and low concentrations during glacial periods.

During climatic variations on millennial time scales in the last glacial and the transition to the Holocene, however, the evolutions of $CO_2$, $CH_4$, and $N_2O$ experience significant differences. While $CO_2$ shows a close relation to the temperature reconstructed for the Southern Hemisphere, $CH_4$ and $N_2O$ are linked to the temperature variations recorded in the Northern Hemisphere and vary in parallel to Dansgaard-Oeschger (DO) events. High resolution records of $CH_4$ and $N_2O$ unveil further significant differences which give important insight into the processes during fast climatic variations and the response of different ecosystems to climatic changes during the last glacial.

1) The response of the two greenhouse gases $CH_4$ and $N_2O$ to fast climatic changes does not show the same relative magnitude for all events and seems to be determined by different mechanisms. While the amplitude of $CH_4$ variations parallel to DO events is modulated with the Northern Hemisphere summer insolation, the $N_2O$ concentration change depends on the duration of the DO event.

2) At the beginning of DO events $N_2O$ starts to increase several hundred years earlier than $CH_4$ and the temperature reconstructed for the Northern Hemisphere. Therefore, $N_2O$ seems to be a precursor to DO events.

Both $CH_4$ and $N_2O$ have important soil sources, but in contrast to $CH_4$, $N_2O$ also has a substantial oceanic source. The two records and their different behaviour at the beginning and during DO events suggest that the variations are at least partly caused by soil sources in different latitudes and that $N_2O$ is further influenced by changes in the oceanic source.

## 81-4 9:10 AM Gerber, Stefan

A MODEL STUDY ON HOLOCENE ATMOSPHERIC $CO_2$ VARIATIONS

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The mechanisms governing atmospheric CO2 and 13CO2 variations during the Holocene are investigated by comparing model results and ice core data. Between 11 and 8 ka BP, atmospheric CO2 fell from 265 to 260 ppm, then it increased again towards the pre-industrial level of about 280 ppm. Indermuehle et al. (1999) suggest that the observed CO2 variations were caused mainly by uptake and subsequent release of terrestrial carbon. An alternative explanation is that the steady CO2 rise after 8 ka is due to the CaCO3 compensation mechanism, responding to the earlier extraction of carbon from the atmosphere by terrestrial uptake during the last deglaciation (Broecker et al., 2001). Uncertainties in the existing 13CO2 data do not allow us to discriminate reliably between the two hypotheses based on observations alone.

The LPJ dynamical global vegetation model coupled to the atmosphere-ocean-sediment carbon cycle component of the Bern CC model was forced by a 21 ka-long time series of snapshot simulations from the Hadley Center climate model (Kaplan et al.,2002). Atmospheric CO2 was prescribed during the deglaciation (21-10.5 ka BP) and simulated thereafter.

The model results matched the Holocene CO2 ice core record within a few ppm. A large part of the CO2 rise after 8 ka BP is explained by the CaCO3 compensation mechanism in response to earlier terrestrial uptake. A terrestrial carbon uptake of 680 GtC is simulated during the transition, in agreement with current reconstructions. Storage increased by 170 GtC during the early Holocene and varied little after 5 ka BP. There was no period of sustained terrestrial carbon loss as required by the hypothesis of Indermuehle et al. Increasing sea surface temperature contributed with about 4 ppm to the modeled CO2 rise after 7 ka BP.

Modeled atmospheric d13C increased by about 0.2 permil from early to mid-Holocene due to biospheric uptake. After 5 ka atmospheric d13C decreased by about 0.03 ppm until 1800 AD. These variations are relatively small compared to the uncertainties in the available ice core data.

In conclusion, the observed atmospheric CO2 variations can be explained by initial terrestrial carbon uptake during the deglaciation and the early Holocene followed by a slow release of CO2 from the ocean due to CaCO3 compensation and sea surface warming.

## 81-5 9:50 AM Thonicke, Kirsten

CLIMATE, FIRE AND BIOMASS BURNING EMISSIONS AT THE LAST GLACIAL MAXIMUM

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There is abundant evidence for changes in fire regimes during the Late Quaternary, associated with changes in climate, vegetation or both. Burning conditions are driven by climate and vegetation status (including fuel moisture and amount). Fire has implications for vegetation dynamics, biogeochemical cycles, atmospheric chemistry and radiative forcing. We have investigated possible global changes in fire regime using climate model simulations of the last glacial maximum (LGM) and the dynamic global vegetation model LPJ. Much work has been done on reconstructing climate and vegetation changes between LGM and present, and on the causes of milennial scale variability during the glacial, but the potential implications for changes in fire regime and atmospheric chemistry have not previously been analysed. LPJ (with its embedded fire regime model Glob-FIRM) predicts changes in fire regime as a complex consequence of changes in vegetation productivity, carbon cycling and ecosystem water balance. Emissions of reactive trace gases are computed from CO2 release using empirical emissions factors. Simulated vegetation patterns are compared with the "BIOME 6000" data set of site-based biome reconstructions for the LGM, and simulated fire regimes can be compared with sedimentary charcoal records and other indicators of past changes in fire. As a first step towards an improved understanding of ice-core records of atmospheric greenhouse gases other than CO2, we will briefly consider the potential of the simulated changes in fire regime to feed back to atmospheric composition and climate.

## 81-6 10:10 AM Levis, Samuel

CCSM SIMULATED CLIMATE AND VEGETATION FOR 6K NORTH AFRICA

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The Community Climate System Model (CCSM) consists of four synchronously coupled components: atmosphere, ocean, sea ice, and land. The land model (Community Land Model) now includes a vegetation dynamics module with most routines from the Lund-Potsdam-Jena dynamic global vegetation model (LPJ-DGVM) of Sitch et al. (2003) and phenology adapted from the IBIS-DGVM (Kucharik et al. 2000). Three simulations are performed using the CCSM: (1) a present-day simulation (Control), (2) a 6000 year before present (6 kaBP) simulation with vegetation cover fixed at the present-day extent simulated in the Control (R), (3) a 6 kaBP simulation (RV). Present-day CO2 is set to 355 ppmv, while 6kaBP CO2 is set to 280 ppmv. CO2 for photosynthesis calculations only is kept at 355 ppmv in all three simulations, so CO2 fertilization of plants is not addressed here. Focusing on North Africa, simulation R shows an intensified monsoon compared to the Control. In simulation RV, grasslands expand northward and result in a positive feedback which intensifies the monsoon further. In particular, in the region from 15 to 25°N and 12°W to 34°E, July through September precipitation increases from 1.79 mm day-1 in the Control to 4.26 in R to 4.39 in RV. Previous coupled experiments (eg, Doherty et al. 2000) have shown similar results. Here we also show the trends in dust and biogenic volatile organic compound (BVOC) emissions in response to expanding grasslands. Annual dust emission decreases from 6 g dust m-2 day-1 in the Control to 5 in R to 4 in RV. Annual BVOC emission increases from 153 ugC m-2 day-1 in the Control to 434 in R to 1427 in RV. The CCSM does not yet simulate climate feedbacks due to these emissions. Inclusion of these feedbacks will add one more piece to the puzzle we call the Earth System.

## 81-7 10:30 AM Wolff, Eric W.

AN ICE CORE INDEX OF ANTARCTIC SEA ICE PRODUCTION

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Sea salt aerosol is one of the most common impurity components of polar ice cores. Until recently, it was assumed that the source of this sea salt was bubble bursting over open water. With this assumption, greater sea ice extent would lead to lower sea salt flux to Antarctica, and so it has been difficult to explain why (even with enhanced storminess) concentrations in both aerosol and snow, and in both Greenland and Antarctica, tend to peak in the winter half-year, and to increase in the last glacial maximum. For coastal Antarctica, it has been shown that the main source of sea salt is not open water, but rather the brine layer and frost flowers on the sea ice surface. We now suggest that the sea ice surface is also the source of sea salt to inland sites, and that sea salt in ice cores is closely related to the amount of annual sea ice production. With this re-interpretation, the profile of sea salt from the LGM to the present is consistent with our expectations based on marine evidence. The Antarctic sea salt record should no longer be considered as indicating past meridional circulation. We can also use the sea salt index to investigate the relationship between sea ice production, Antarctic bottom water production, and carbon dioxide uptake in the Southern Ocean. Finally we briefly consider how this interpretation affects what we see in Greenland ice cores.

## 81-8 10:50 AM Bender, Michael L.

TRIPLE ISOTOPE COMPOSITION OF $O_2$ AND THE RECORD OF GLOBAL PHOTOSYNTHESIS DURING THE PAST 150 KA

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Records of the global rate of photosynthesis have the potential to reveal the nature of large scale interactions between biology, biogeochemistry and climate. We have developed a 150 ka record of the global rate of photosynthesis using the $^{16}O$, $^{17}O$, and $^{18}O$ content of $O_2$ in air bubbles in Greenland and Antarctic ice sheets. Our approach takes advantage of mass independent effects in the isotopic composition of $O_2$. These effects arise from stratospheric exchange reactions between $O_3$, $CO_2$ and $O_2$ that cause the $\delta^{17}O$ of $O_2$ to decrease by a factor of 1.7 times the decrease in $\delta^{18}O$, rather than the common, "mass dependent" factor of 0.5. The magnitude of the mass-independent anomaly ($^{17}\Delta \sim \delta^{17}O - 0.5^* \delta^{18}O$) depends on the relative rates of stratospheric reactions and biological cycling by photosynthesis and respiration. We have made a preliminary calculation of past rates of photosynthesis by correcting for past atmospheric $CO_2$ concentrations (higher $CO_2$ promotes stratospheric exchange and enhances the anomaly) and for changes of biological isotope effects associated with shifts in the C3/C4 composition of plants. The paleoproductivity record reveals that global photosynthesis fell to ca. ~90% of the modern rate during glacial periods and that it was near Holocene levels during the last interglacial. There is no statistically significant variability in paleoproductivity at orbital frequencies of precession or tilt.

The existing paleoproductivity record provides a target for models of the biosphere during the Holocene and Pleistocene. Calculated values of paleoproductivity will evolve and become more accurate as we gain a better understanding of isotope fractionation associated with hydrology, $O_2$ consumption and stratospheric exchange.

## 81-9 11:10 AM Loutre, Marie-France

PREDICTING A CO2 RECORD FOR THE LAST MILLION YEARS

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Atmospheric $CO_2$ played an important role in the climate of the past. Up to now only the Vostok ice core provides a direct record of $CO_2$ concentration over the last 400 kyr although the new Dome C EPICA ice core will extend this record. Meanwhile we are looking for methods that could provide a prediction of the CO2 changes over the last million. Some of them could also be used for future natural $CO_2$ scenarios. Several attempts were already made in the past. It includes statistical approaches based on the correlation between marine ice volume and Vostok $CO_2$ records. The statistical scenario from Li et al (1998) assumes that the correlation between Vostok $CO_2$ concentration (Jouzel et al., 1993) and SPECMAP (Imbrie et al., 1984) over the last 200 kyr can be extended over the last million year. The same procedure is applied here by using the 400 kyr Vostok record (Petit et al., 1999) and the marine record from Bassinot (1994). Multiple regressions using insolation sea level, marine $\delta^{18}0$ and $\delta^{13}C$ records were used by Berger (1997). Another reconstruction for the last million years is presented here, using spectral analysis. The major periodical components of the Vostok $CO_2$ record are extracted using the Thomson multi-taper method. These terms are then used to reconstruct a signal for the last million years, which contains the low frequency part of the $CO_2$ record. Our reconstruction assumes, in a first attempt, the stationarity of the periods in the $CO_2$ record over time. However climatic reconstruction, in particular marine records, indicates a change in the major period of variation, from a dominating 40-kyr to a 100-kyr period, occurring around 700 kyr BP, or earlier. As $CO_2$ concentration is strongly influenced by climate, the reconstruction technique for the $CO_2$ time series must also take into account this transition between these two periods. Although empirical and descriptive, conceptual models can account, in some way, for this transition. They consider different states. Thresholds, depending on the continental ice volume, the insolation and the climate states, are crossed following a simple time evolution of the $CO_2$ concentration

## SESSION NO. 82, 8:00 AM

## Wednesday, July 30, 2003

## S11. The Extinction of the European Neanderthals During Isotope Stage 3 (*Commission on Human Evolution and Paleoecology*)

## Reno Hilton Resort and Conference Center, Crystal 1&2

### 82-1 8:10 AM Straus, Lawrence G.

THE LANDSCAPE OF EUROPE IN STAGE 3: A HUMAN & CULTURAL MOSAIC

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Neither the biological replacement of the Neandertals nor the cultural shift from Middle to Upper Paleolithic was abrupt in Europe. To the contrary, the "transition" was a process played out unevenly during c.10 kyr of late stage 3, a time when the continent, with its great diversity of environments, saw a mosaic of adaptive experiments, some rooted in the Mousterian, but others either new local inventions or products of diffusion. Some so-called "transitional" industries (& possibly even the initial Aurignacian) were the work of Neandertals, while others of this group failed to change at all—as in the case of southern Iberia, despite proximity to Africa. The transition in Europe first must be understood in relation to the differing circumstances of each macro-region. The approach to the cultural changes taken here is that they represent more of a frequency distribution shift than an absolutely revolutionary punctuation event, particularly in light of the fact that changes had already occurred during the late Middle Paleolithic and many more were yet to come during the remainder of the Upper Paleolithic in the complex landscapes of Europe during stage 2.

### 82-2 8:30 AM Vermeersch, Pierre M.

THE EUROPEAN POPULATION CHANGES DURING MIS 2 AND 3

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Starting from an extensive database of Palaeolithic sites with their characteristics and the available dating, a GIS based approach is used to investigate the spatial distribution of the sites over Europe. The CalPal (Cologne Radiocarbon Calibration & Paleoclimate Research Package) software is used to correlate the sites with the rapidly changing climatic conditions during MIS 2 and 3. On a background of the present-day natural vegetation distribution, the poster maps the presence of sites in the area. Maps are reflecting the changing conditions in relation to the Heinrich events, the succession of stadial and interstadial conditions. A critical selection of available dating is applied. Although the resolution of the dating is still poor, the human distribution over Europe is clearly related to the changing climatic conditions.

### 82-3 8:50 AM Stewart, John Robert

THE DISAPPEARANCE OF THE NEANDERTHALS AS PART OF THE LATE PLEISTOCENE MEGAFAUNAL EXTINCTIONS OR DUE TO COMPETITION WITH MODERN HUMANS?

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It has been suggested recently that the Neanderthals went extinct as a result of the deterioration in climatic conditions and the accompanying ecological changes that occurred in Europe as the Late Glacial Maximum (LGM) approached. To evaluate this hypothesis, I compiled information about European hominid specimens, archaeological assemblages and non-hominid mammalian fossils that are absolutely dated between 60 and 20 Kyr.

Thereafter, I carried out a two-part analysis. In the first part of the analysis, I evaluated the frequencies of 40 large non-hominid mammalian taxa in three time periods that were delineated on the basis of climatic and dating considerations: 60-37 Kyr, 37-28 Kyr and 28-20 Kyr. In the second part of the analysis, I examined the geographic distribution of these taxa in the three time periods.

The frequency and geographic distribution data for the Neanderthals indicate that they retreated westwards and possibly southwards before going extinct some time before 20 Kyr. Thus the Neanderthals are most similar to the extinct species Elephas antiquus and Stephanorhinus kirchbergensis as well as the smaller canivores which simply decreased in numbers towards the LGM. This supports the hypothesis that the Neanderthals became extinct because they were unable to cope with the extreme deterioration in environmental conditions associated with the LGM. The results of the analysis suggest that there may have been a marked decline in carrying capacity between 28 and 20 Kyr, which may have contributed to the disappearance of the Neanderthals. The alternative hypothesis that Neanderthals became extinct due to competition with Modern Humans was discounted because recent ecological studies show that competition does not generally lead to extinctions.

### 82-4 9:10 AM Hockett, Bryan S.

NUTRITIONAL ECOLOGY AND THE EXTINCTION OF EUROPEAN NEANDERTHALS

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Nutritional ecology is the study of the relationships between essential nutrient intake and human health patterns. Nutritional ecology states that diverse diets lower infant mortality rates and increase average life expectancies. This may positively effect demographic trends, and lead to the spread of human populations at the expense of others. Diets consisting of numerous species of terrestrial mammals were not diverse from the nutritional ecology perspective because most mammals hunted by Paleolithic foragers contained relatively equal proportions of essential nutrients per 100 grams of flesh. Diverse diets could only be achieved by consuming a variety of food items such as terrestrial mammals, birds, fish, shellfish, and plants. Northern populations of Neanderthals consumed mainly terrestrial mammals, while the southern Neanderthals consumed a more diverse diet; therefore, southern Neanderthals probably were healthier and lived longer than northern Neanderthals. Early Upper Paleolithic diets associated with AMHS show a trend toward even greater diversification. Early AMHS populations probably were healthier than most of the Neanderthal populations with which they may have had contact. Some have suggested that "economic competition" contributed to Neanderthal extinction; nutritional ecology adds an explanatory framework to these propositions. Healthier Neanderthals living in southern latitudes may help to explain the delay in the occupation of these regions by AMHS populations, as well as the dating of Neanderthal skeletons as late as 28,000 BP. Many Neanderthal populations were part of a long list of large, terrestrial carnivores that went extinct in Europe in the face of rapidly changing and diversifying ecosystems between 30,000 and 40,000 BP. Neanderthals successfully competed with other large carnivores for tens of thousands of years across much of their range; but they were eventually demographically swamped by healthier hunter-gatherers exhibiting a "broader-spectrum" subsistence base.

### 82-5 9:50 AM Smith, Fred H.

NEANDERTAL-EARLY MODERN HUMAN INTERACTIONS IN EUROPE AND THE ASSIMILATION MODEL OF MODERN HUMAN ORIGINS

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Chronological evidence indicates that Neandertals survived well into OIS 2 (ca. 28 ka)in parts of Central Europe, Iberia and perhaps Eastern Europe. The earliest skeletal remains of modern humans in Europe are dated to ca. 35 ka at Mladec (Czech Republic) and ca. 32 ka at Vogelherd (Germany). Thus there is evidence of temporal overlap of populations in Central Europe. At Vindija (Croatia) there is evidence of a cultural assemblage combinig Middle and Upper Paleolithic types, and there are indications in various sites that late Neandertals developed tools and other items that seem similar to those of early modern people. This may well suggest contact between these peoples, and the presence of certain anatomical details in early modern Europeans indicates Neandertal biological contributions. The combined biocultural data support a model of assimilation of Neandertals into the early modern populations of Europe.

### 82-6 10:10 AM Conard, Nicholas J.

THE DANUBE CORRIDOR MODEL FOR THE COLONIZATION OF EUROPE BY MODERN HUMANS

CONARD, Nicholas J., Department Early Prehistory and Quaternary Ecology, University of Tübingen, Schloss Hohentübingen, Burgsteige 11, Tübingen 72074 Germany, nicholas.conard@uni-tuebingen.de.

This paper reviews the evidence for the early entry of modern humans into central Europe via the Danube Corridor. The weight of evidence suggests that modern humans arrived in the upper reaches of the Danube and settled in the Swabian Jura by ca. 40.000. This region shows little evidence for the interaction between Neanderthals and modern humans, and it appears that Neanderthals were absent or maintained low population densities in Swabia immediately preceding the arrival of modern humans. This "population vacuum" may well have been a reflection of the rapid climatic fluctuations during oxygen isotope stage 3. This paper presents the newest archaeological, chronological and paleoenvironmental data from the upper Danube region within the context of refining models for the colonization of Europe by modern humans and the replacement of Neanderthals.

### 82-7 10:30 AM Hopkinson, Terry

LEAF POINTS, LANDSCAPE USE STRATEGIES AND ENVIRONMENT CHANGE IN THE EUROPEAN LATE MIDDLE PALAEOLITHIC

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The replacement of European Neanderthals by anatomically-modern Upper Palaeolithic peoples in the period after 45ka suggests strongly that competition from the latter was a critical factor in Neanderthal extinction. However, the particular domains of behaviour in which Neanderthals were at a relative competitive disadvantage remain poorly understood. This paper presents an analysis of late Middle Palaeolithic (ca 60-40ka) landscape use and sensitivity to environmental change in central and southeastern Europe, and therefore provides a basis for comparison between late Middle and early Upper Palaeolithic behaviour in these domains and their possible implication in the Neanderthals' disappearance.

Lithic assemblages with leaf points are a key element of the Middle Palaeolithic in the study region and period, although there are also many assemblages in which leaf points are rare or absent. It is shown that the latter occur in archaeological contexts indicating relatively intensive occupation, while leaf point assemblages occur in contexts consistent with the occasional use of peripheral locations for specific purposes. This pattern implies land-use strategies founded on a complementary relationship between occupation centres and satellite task-specific sites. Leaf points were associated with the latter. Pollen evidence is also advanced which shows that leaf points occur only in those regions of Europe that experienced alternations between forested and open landscapes on wavelengths of two or three millennia in the late Middle Palaeolithic. These patterns are supported by a specific focus on the Altmühl Valley, Bavaria.

It is therefore proposed that late Middle Palaeolithic land use strategies were based upon the logistically-organized integration of action in social centres and in the landscape periphery, and that the association of leaf points with landscape change on sub-glacial wavelengths argues against Neanderthal incapacity to respond behaviourally to short-cycle environmental instability. In both of these domains, this analysis suggests that late Neanderthal behaviour was not very different from that of early modern humans and that we should seek elsewhere for answers to the problem of Neanderthal extinction.

### 82-8 10:50 AM Lebreton, Vincent

ENVIRONMENT AND CLIMATE OF THE LIGURIAN PREHISTORIC MEN DURING OIS 3

LEBRETON, Vincent, RENAULT-MISKOVSKY, Josette, KANIEWSKI, David, and KARATSORI, Elena, Département des Sciences Préhistoriques, Muséum National d'Histoire Naturelle, 1, rue René Panhard, Paris, 75013, France, lebreton@mnhn.fr

The replacement of the Neanderthals by Homo sapiens sapiens in Europe occurs at the same time than the cultural transition from the Middle to Upper Palaeolithic. This phenomenon took place during oxygen isotope stage 3 (ca. 50-25 ka) in the climatic fluctuating stadial/interstadial context of the Weichselian glaciation. Actual vegetation and climate distributions all-over the continent of Europe is very varied and reliable transfers to OIS 3 must be ascribed to small geographical areas. The Ligurian area is examined is this poster. Numerous pollen analyses from Ligurian archaeological deposits focusing on this period allow to present direct landscape data of this biological and cultural transition. But these data are always discontinuous and they must be closely correlated with long continuous pollen sequences from lacustrine or peaty deposits in order to present reliable reconstructions of palaeoenvironment and palaeoclimate. The environmental background synchronous of the transition will offer an exhaustive vision of the replacement phenomenon.

**82-9 11:10 AM** van Kolfschoten, Thijs

THE EVOLUTION OF THE MAMMALIAN FAUNA AND FLORA AND THE HUMAN OCCUPATION IN WESTERN, CENTRAL AND EASTERN EUROPE DURING THE PLEISTOCENE – HOLOCENE TRANSITION (25 - 8 KYR B.P.)

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The period between 25 – 10 kyr B.P., covering the second part of last glaciation and the Pleistocene – Holocene transition, is for many disciplines intriguing. This period is characterized by rapid climatic changes, the extinction of several mammalian species and the expansion of human occupation. The natural formation of the present-day faunal and plant communities took place in a relatively short period. The mammalian communities, for instance, underwent several stages of evolutionary and structural rearrangements from glacial faunas, without any modern analogues, to the typical interglacial zonal fauna associations. The strong climatic fluctuations led to shifts in distribution of many species and to extinction. The biodiversity changed rapidly and dramatically between 25 – 8 kyr B.P.. In order to study the impact of climatic changes on the environment a group of researchers from Russia and The Netherlands started a joint, large-scale investigation of the ecological changes in Western, Central and Eastern Europe trough time during the period following isotope stage 3 i.e. the later part of the Pleistocene and the Pleistocene – Holocene transition. The main goal of the research project is the interaction between flora and fauna and the impact of the environmental changes on the human occupation of the area. To reach this goal we made an inventory of the theriological and botanical record from the area and electronic maps with the distribution of species and communities as well as the distribution of archaeological sites for different time intervals. The palaeo-ecological, geological and archaeological data will be analysed. The preliminary results such as the presence of refugia and their role in the re-colonisation of the area after the Last Glacial Maximum as well as the relation between the distribution of hominids and larger herbivores will be discussed during the presentation.

## SESSION NO. 83, 8:00 AM

## Wednesday, July 30, 2003

## S15. Were Abrupt Climate Changes at the Last Glacial Termination Globally Synchronous? (*Commission on Palaeoclimate; Commission on Tephrachronology and Volcanism*)

## Reno Hilton Resort and Conference Center, Reno Ballroom

**83-1 8:10 AM** Colhoun, Eric

ANTIPODAL TERRESTRIAL DEGLACIAL EVENTS FROM IRELAND AND TASMANIA

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Major phases of ice retreat and readvance since the LGM have been studied in Ireland and Tasmania. In Ireland, glacial deposits from the Leinster and Mourne Mts were dated using in-situ cosmogenic 10Be, 26Al, and OSL, and in Tasmania, using 10Be and 26Al. Our aim was two-fold; first, to map and date the LGM limits and, second, the timing and mode of subsequent younger deglaciation events. We compare these glacial chronologies from quite similar oceanic mid-latitude regions in opposite hemispheres for synchronicity and amplitude. The Midland ice that formed the South Ireland End Moraine and Glacial Lake Blessington was coeval with maximum ice advance at Athdown in the Leinster Mts. Two OSL dates from Athdown suggest a maximum age of 30-25 ka BP for this LGM ice limit. Ice retreated through the Irish Sea Basin to the Plain of Mourne by 21 ka BP though glaciers still occupied Mourne mountain valleys. Readvance of Midland ice, associated with drumlins, formed moraines on the southern Plain of Mourne at 17-16 ka BP. Several, undated, retreat valley glacier stages occurred in the mountain valleys before a final cirque glaciation at 10-12 ka BP in both Leinster and Mourne. In western Tasmania, we studied three glacial valley sites exhibiting moraine sequences of the last deglaciation cycle. Our data suggests that valley glaciers of Stage 2 were formed by 25 ka BP, but a prominent extent of ice associated with sharp-crested moraines in valleys and cirques occurred at 18-20 ka BP. Episodic retreat occurred from 18-15 ka BP and by 14 ka BP the highest cirques were ice-free. Comparisons with North Atlantic cores and GRIP delta-18O records indicate glacial advances in Ireland at H3(?), H1 and HO times. Evidence for H2 is not clear. In Tasmania, valley and cirque glaciers attained recent maxima at 18-19 ka BP during H2 time, as did minima in delta-18O records of adjacent marine and Antarctic ice cores. There is no evidence for ice during the ACR or YD periods. Although not exhaustive, our set of cosmogenic ages is sufficient to show a distinct lack of correlation between Ireland in the North East Atlantic with Tasmania in the South West Pacific.

**83-2 8:30 AM** Newnham, Rewi M.

PALYNOLOGICAL EVIDENCE FOR THE LAST GLACIAL MAXIMUM AND LATEGLACIAL CLIMATE CHANGE IN NEW ZEALAND

NEWNHAM, Rewi M., Dept. of Geography, Univ. of Plymouth, Plymouth, PL4 8AA, United Kingdom, rnewnham@plymouth.ac.uk, VANDERGOES, Marcus J., Institute for Quaternary Studies, Univ of Maine, Orono, ME 04469, and LOWE, David J., School of Science & Technology, Univ of Waikato, Bag 3105, Hamilton, New Zealand

Terrestrial records of past climate from the Southern Hemisphere (SH) should be able to help resolve several key issues in climate change research. In particular, SH records of climate change events during the transition from the last Glacial to present Interglacial in relation to comparable events in the North Atlantic region, should provide a clear picture of the global extent and patterns of change and insights into the mechanisms involved. This paper presents a synthesis of palaeoecological records from New Zealand in the mid-latitudes of the SH, spanning the interval from the LGM to early Holocene with the objective of identifying and explaining points of coherence and divergence. Key questions concern the timing of maximum cooling during the last glacial maximum (LGM), the last glacial termination and the spatial and temporal patterns of subsequent lateglacial climate change.

**83-3 8:50 AM** Bennett, K.D.

INTERPRETATION OF POLLEN DATA FROM SOUTHERN CHILE AND CLIMATE CHANGE AT THE LAST GLACIAL/INTERGLACIAL TRANSITIION

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A number of high-quality pollen records have recently been published from southern Chile, with conflicting conclusions with respect to the timing and nature of climate change at the last glacial/interglacial transition. Bennett et al. (2000, Science 290, 325-328) found no evidence for climatic cooling during the Younger Dryas Chronozone at 45 degrees South. On the other hand, Moreno et al. (2001, Nature 409, 804-808) found cooling events at 41 degrees South that were nearly synchronous with climatic changes during the YDC in the North Atlantic.

Both papers rely heavily for their conclusions on the interpretation of pollen data, as percentages and accummulation rates. The range of taxa involved are similar and the dominant pollen types are the same in both regions. The different conclusions originate in differences of two aspects of interpretation.

1. Different interpretations of similar base data. Increases in tree pollen types can be interpreted as increasing warmth at the beginning of an interglacial or as occurrence at lower altitudes than today, indicating cooling.

2. The extent to which changes in pollen accummulation rates can (without simultaneous changes in pollen percentages) be used to infer climatic change rather than changing local sedimentary environments.

Both issues are fundamental to many pollen analytical questions. In this particular case, both are the key to understanding the nature of last glacial / interglacial climate change in southern Chile, with implications for the synchroneity of global climatic changes. This paper will raise and discuss these issues, with the aim of furthering understanding events in southern Chile, and hence attempting to resolve an issue of relevance to global climate change.

**83-4 9:10 AM** Shulmeister, James

THE LAST DEGLACIATION IN NEW ZEALAND; LOCAL MANIFESTATIONS OF GLOBAL SIGNALS

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The New Zealand region is recognized as a critical region for understanding global paleoclimatology, because it is a prime location to examine the Southern Hemisphere westerly circulation, which is the interface between the Antarctic and the rest of the global circulation. It has become a major focus for inter-hemispheric climatic teleconnection studies.

Much effort has gone into reconstructing the Last Termination in New Zealand, but the results are contradictory. Biological proxy evidence has consistently failed to reproduce Northern Hemisphere (or more precisely North Atlantic) patterns. Most pollen records yield either a monotonic climatic amelioration during the deglaciation, or a two step deglaciation, with the first warming phase completed by 14 ka and the second initiated after 11.5 ka. They do not support simple trans-hemispheric teleconnections. Marine records from the New Zealand shelf show an Antarctic Cold Reversal (ACR) signal but no Younger Dryas (YD) chron signal. In contrast, there is unambiguous evidence for a major glacial re-advance at, or very close, to the YD chron, but no ACR signal.

We present a high resolution (probably annual) record of change from a Maar lake the Auckland region, New Zealand. This record has been analysed spectrally for three time intervals; an eight hundred year period just prior to the last glaciation maximum, two thousand years during the deglaciation and a three hundred and fifty year period during the early Holocene. Strong spectral power in 2-7 year, 15-20 year and a centennial (80-120 year) timescale during two brief intervals during the deglaciation contrasts with virtually no spectral power during the rest of the deglaciation. The ACR appears to be the younger (and stronger) deglacial event. In contrast, the YD is not defined in these records.

The results indicate that El Nino Southern Oscillation (ENSO) and the Pacific decadal oscillation (PDO), two of the primary drivers of modern New Zealand climate, pulsed on and off during the deglaciation. Under modern conditions ENSO and PDO are strongly associated with modification of south-westerly flow over northern New Zealand and we infer enhanced westerly flow over New Zealand during the two deglaciation spectral events. The implications of these findings for global climate teleconnections will be discussed.

**83-5 9:30 AM** Turney, Chris

ASYNCHRONOUS CLIMATE CHANGES BETWEEN THE SOUTH PACIFIC AND THE NORTH ATLANTIC DURING THE LAST GLACIAL-INTERGLACIAL TRANSITION (LGIT; 14-9 KA 14C BP)?

TURNEY, Chris[1], MCGLONE, Matt[2], WILMSHURST, Janet[2], KERSHAW, Peter[3], VAN DER KAARS, Sander[3], VANDERGOES, Marcus[4], BRYANT, Charlotte[5], LOWE, John[6], JOHNSON, Rochelle[3], RULE, Sue[3], and TIBBY, John[3], (1) School of Archaeology and Palaeoecology, Queen's Univ, Belfast, BT7 1NN, United Kingdom, c.turney@qub.ac.uk, (2) Landcare Rsch, PO Box 69, Lincoln, 8152, New Zealand, (3) School of Geography & Environmental Science, Monash Univ, Melbourne, 3800, Australia, (4) Geography, Univ of Plymouth, Plymouth, PL4 8AA, United Kingdom, (5) NERC Radiocarbon Laboratory, Scottish Enterprise Technology Park, Rankine Avenue, East Kilbride, G75 0QF, United Kingdom, (6) Geography, Royal Holloway, Univ of London, Egham, TW20 0EX, United Kingdom

The LGIT was characterized by a series of abrupt climatic changes, with broadly similar trends identified in palaeoclimate records obtained from many sites throughout the North Atlantic region. The extent to which the North Atlantic sequence of climatic changes is reflected in palaeoclimatic records from the Southern Hemisphere is, however, far from clear. Conflicting evidence has been reported from various parts of South America and New Zealand, seemingly supporting both hypotheses that events in the Southern Hemipshere were synchronous with, or markedly asynchronous with, those of the North Atlantic. There is also some evidence that suggests that climate changes in the Southern Hemisphere were more gradual ('progressive') during the LGIT than is inferred for the northern hemisphere. Little in the way of detailed LGIT reconstructions have been reported from Australasia and Southeast Asia. Few studies from these regions have been undertaken with sufficient temporal resolution required to establish high-resolution correlations with other regions of the world. Here we present the results of multi-proxy investigations of several terrestrial sites which form a transect from Indonesia, through Australia and New Zealand, and terminating at Campbell Island (52degS). Comprehensive series of radiocarbon dates are available for each sequence. The collective data provide a robust chronology for estimating fluctuations in atmospheric radiocarbon content, and the reconstruction of palaeoclimatic events on a calendar timescale. The results underpin a new palaeoclimate scheme for the LGIT for the low- and mid-latitudes of the Southern Hemisphere and will be compared with global terrestrial, marine and ice core palaeoclimatic records.

## 83-6 10:10 AM Nakagawa, Takeshi

ASYNCHRONOUS CLIMATE CHANGES BETWEEN JAPAN AND THE NORTH ATLANTIC DURING THE LAST DEGLACIATION: IMPLICATIONS

NAKAGAWA, Takeshi[1], KITAGAWA, Hiroyuki[2], TARASOV, Pavel E.[3], GOTANDA, Katsuya[4], SAWAI, Yuki[4], and YASUDA, Yoshinori[4], (1) Institute for Geothermal Sciences, Kyoto Univ, Noguchibaru, Beppu, 874-0903, Japan, nakagawa@mail.dotcom.fr, (2) Graduate School of Environmental Studies, Nagoya Univ, Furo-cho, Chikusa-ku, Nagoya, 464-8601, Japan, (3) Department of Geography, Moscow State Univ, Vorob_fevy Gory, Moscow, 119899, Russia, (4) Int'l Rsch Ctr for Japanese Studies, 3-2 Oeyama-cho, Goryo, Nishikyo-ku, Kyoto, 610-1192, Japan

High-resolution pollen analysis of the annually-laminated lacustrine sediments of Lake Suigetsu, Japan indicates that climatic changes in Japan during the Last termination were not synchronous with those of the North Atlantic. We have analyzed more than 400 horizons from the part of the Suigetsu profile which spans the period ca. 16,000 to 10,000 Suigetsu varve years BP (SG vyr BP). The conventional pollen data were converted into thermal indices (e.g. mean annual temperature; January and July temperatures; etc.) using a modern analogue technique. The results are correlated with the grayscale curve from Cariaco Basin, Venezuela, using the varve chronologies established independently from the two basins.

The results from Lake Suigetsu suggest fluctuations between cold and warm phases. Alhough the overall trends resemble those that characterise North Atlantic records over the same interval, the abrupt transitions are markedly asynchronous between the two regions. A warm phase in the Suigetsu profile (SGPl-1c) that seems to correspond to the Bölling event, started at 15,000 SG vyr BP, about 3 centuries earlier than the onset of the equivalent phase in the Cariaco sequence. Conversely, a Younger Dryas-like cold phase in Japan (SGPS-1) started about 4 centuries later (ca. 12,000 SG vyr BP) than the onset of the YD in the North Atlantic. The amplitude of cooling in Japan was bigger in winter than in summer, though the amplitude of both was smaller than that reconstructed for the North Atlantic region.

We propose that the ocean circulation system in the Pacific responded more quickly (and probably more linearly) to the increase of solar insolation during the last deglaciation, whereas the North Atlantic system could only jump from one circulation pattern to another when external forcing became strong enough to overcome the threshold. This explanation is also supported by results obtained from a longer core sequence from a second lake, adjacent to Lake Suigetsu.

As for the abrupt cooling during the YD, we propose that thermohaline circulation changes in the North Atlantic extended their influence to Japan through an oceanic mechanism which was delayed by several centuries. However, the Asian winter monsoon might have also played an important role in "Connecting" these two distant regions.

## 83-7 10:30 AM Shanahan, Timothy M.

PRELIMINARY DATA ON THE TIMING OF POST GLACIAL CLIMATE CHANGE IN WEST AFRICA FROM LAKE BOSUMTWI SEDIMENT RECORDS

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Paleoclimate records of the last glacial termination with good age control are difficult to find in tropical locations. Records with annual or near annual resolution are even more difficult to find. Typical records with annual resolution (e.g. ice cores, tree rings, varved sediments) are rare or nonexistent in the tropics. For this reason, the timing of climate change in equatorial Africa is poorly known. Thus, it is difficult to test whether climate change in tropical Africa is synchronous with that of other tropical regions and with the high latitudes. Lake Bosumtwi, a varved lake in Ghana, West Africa, offers the potential to provide new information on the timing and character of hydrological change in West Africa during the last deglaciation. Here we present a revised lake level curve for Lake Bosumtwi, based on new radiocarbon dates of lake level high stands and on preliminary studies of the varved sediments preserved in Bosumtwi lake sediment cores. While the trend of lake level change following the last deglaciation and through the Holocene appears to reflect the influence low latitude summer insolation on the West African monsoon, changes following deglaciations were also characterized by several abrupt changes that appear to be synchronous with those recorded in northern hemisphere paleoclimate records. If true, this result would indicate a teleconnection between the climate in the eastern tropical Atlantic and that of the high latitude Northern Hemisphere.

## 83-8 10:50 AM Zielhofer, Christoph

THE CENTENNIAL SCALE LATEST PLEISTOCENE TO MID-HOLOCENE STANDARD PROFILE OF THE MID-MEDJERDA VALLEY (NORTHERN TUNISIA)

ZIELHOFER, Christoph[1], FAUST, Dominik[1], MOLDENHAUER, Klaus-Martin[2], and BAENA ESCUDERO, Rafael[3], (1) Dresden, Germany, christoph.zielhofer@mailbox.tu-dresden.de, (2) Eichstätt, Germany, (3) Sevilla, Spain

In the course of the latest Pleistocene to mid-Holocene, the Medjerda river system in Mediterranean Tunisia shows events of increased flooding and aggradation of relatively coarse overbank deposits. Active geomorphodynamics in river systems do correlate with an aridification of the climate, but not with temperature. The centennial scale latest Pleistocene to mid-Holocene standard profile of the Ghardimaou floodplain (mid-Medjerda river) indicates active fluvial dynamics during 12.4 to 11.8, 6.6 to 6.0 and as of 4.8 ka cal BP. Correlations with secondary palaeoclimatical findings imply global and regional causes of the latest Pleistocene to mid-Holocene climatic development as there are North Atlantic Deep Water formation, fluctuations in Saharan humidity (monsoonal systems) and autochthonous impacts of Mediterranean weather phenomena. Medjerda sediment-archives show a short activity (12.4 to 11.8 ka cal BP) during the Younger Dryas in comparison to other archives of the mid-latitudes.

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## 83-9 11:10 AM Cacho, Isabel

CHANGES IN WESTERN MEDITERRANEAN SURFACE, INTERMEDIATE AND DEEP WATER DURING THE LAST DEGLACIATION, AND THEIR LINK WITH ATMOSPHERIC PROCESSES

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The Last Deglaciation evolution of the water properties in the Alboran Sea (W Mediterranean Sea) are reconstructed based the combined approach of Mg/Ca and $\delta^{18}O$ analyses from different species of planktonic and benthic foraminifers. The exceptional high sedimentation rates (20-80 cm/kyr) of core MD952043 allow a time resolution of few centuries-decades for the period considered here. The chronostratigraphy of the last 24 kyr is well constrained based by 17 AMS $^{14}C$ dates. Sea surface temperature (SST), as recorded on both Mg/Ca from *G. bulloides* and by alkenone results, warmed abruptly (~4°C/700yr) at the first stage of Last Deglaciation and almost synchronous with the atmospheric warming recorded in GISP2 at the onset of the GI-1. In parallel, the Mg/Ca record from *N. pachyderma* shows a rapid cooling suggesting a deepening of the thermocline. In addition, deep basin conditions changed suddenly to a less oxygenated environment reflected by the benthic comunity and also the organic matter records. The sequence of events of the last deglaciation are not equally represented in all the considered parameters. Overall, both *G. bulloides* and *N. pachyderma* $\delta^{18}O$ profiles follow a structure parallel to Greenland temperature record. The YD chronozone is well represented in the SST record from alkenones by a ~4°C cooling but this is less marked in the *G. bulloides* Mg/Ca reconstruction possibly due to a change in the bloom season. Holocene SST in the Alboran Sea was rather stable but, in contrast, rapid and intense changes are observed in the thermocline and also deep water mass. While SST cooled slightly at 8.2 cal. kyr BP deep water changed rapidly towards more ventilated conditions. This change preceded by ~2 kyr a sudden warming (~3°C) of the thermocline layer while *G. inflata* became a dominant species in the planktonic assemblage. This event also marks the end of a pronounced positive salinity anomaly occurring in the thermocline layer (10.5-7 kyr BP). These intense changes during the Holocene reflect the instability of the Mediterranean system even during "stable" periods. A combination of mechanisms such as sea level changes, atmospheric circulation, changes in seasonallity and insolation due to orbital configuration may have resulted in these abrupt changes of the Alboran Sean during the last 20,000 years.

## 83-10 11:30 AM Rinterknecht, Vincent R.

LATE PLEISTOCENE DEGLACIATION CHRONOLOGY OF THE SCANDINAVIAN ICE SHEET SOUTHERN MARGIN

RINTERKNECHT, Vincent R.[1], RAISBECK, Grant R.[2], YIOU, Françoise[2], CLARK, Peter U.[3], BROOK, Edward J.[4], BITINAS, Albertas[5], LUNKKA, Juha P.[6], MARKS, Leszek[7], PAVLOVSKAYA, Irina[8], and PIOTROWSKI, Jan A.[9], (1) Oregon State University, Corvallis, OR, rinterkv@geo.orst.edu, (2) Centre de Spectrométrie Nucléaire et de Spectrométrie de Masse, (3) Oregon State University, (4) Washington State University, (5) Geological Survey of Lithuania, (6) University of Oulu, (7) Polish Geological Institute, (8) National Academy of Sciences of Belarus, (9) University of Aarhus

Prominent moraines crossing the Baltic region mark the late Pleistocene maximum extent and recessional phases of the southern margin of the Scandinavian Ice Sheet (SIS). Five moraines present between the advance during the Last Glacial Maximum (LGM) and the Younger-Dryas Salpausselkä Moraines in Finland suggest a millennial-scale signal for this sector of the ice sheet. However, dating control constraining the age of the LGM and retreat phases of the southern SIS margin in the region is all but lacking. We have sampled boulders for surface exposure dating with the cosmogenic nuclide $^{10}Be$ from moraines along a broad south-to-north transect spanning Poland, Lithuania, Latvia, Belarus, Estonia, and Finland. Here we report $^{10}Be$ concentrations on 138 boulders measured by accelerator mass spectrometry at the Tandetron facility, Gif-sur-Yvette, France. We calculated exposure ages assuming a production rate of 5.1 ± 0.3 atoms $g^{-1}$ $yr^{-1}$ at 1013.25 mbar pressure and high latitude, scaled for each site altitude and latitude. No corrections for snow cover or erosion have been applied. Eleven boulders from the LGM have a weighted mean age of 18.6 ± 2.8 $^{10}Be$ ka. Forty-one samples from the Pomeranian Moraine have a weighted mean age of 14.0 ± 1.7 $^{10}Be$ ka. Thirty-three samples from the Middle Lithuanian Moraine have a weighted mean age of 13.1 ± 1.6 $^{10}Be$ ka. Nine samples from the North Lithuanian Moraine have a weighted mean age of 13.0± 0.8 $^{10}Be$ ka. A single boulder on the Pandivere Moraine was dated at 13.0 ± 1.1 $^{10}Be$ ka. Eight samples from the Palivere Moraine have a weighted mean age of 10.0 ± 1.3 $^{10}Be$ ka. We interpret this moraine age as being too young since all the boulders were submerged beneath various phases of the Baltic Ice Lake, which would have substantially reduced the production rate for that period of time. Nine samples from the Younger Dryas Salpausselkä I Formation have a weighted mean of 11.8 ± 0.9 $^{10}Be$ ka. We chose to present here the moraine age standard deviations as the moraine age uncertainties. Most of the standard deviations are larger than the analytical uncertainties, indicating a geological source of uncertainties in addition to the analytical ones. This prevented us so far to use the analytical uncertainties as the uncertainty of the moraine ages. These results define a primary time frame for the deglaciation of SIS southern margin in this region.

## 83-11 11:50 AM Hughen, Konrad A

SYNCHRONOUS HIGH AND LOW-LATITUDE NORTH ATLANTIC CLIMATE CHANGE DURING THE LAST DEGLACIATION

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Abrupt climate shifts during the last deglaciation, similar to the Glacial-Bolling/Allerod-Younger Dryas-Preboreal sequence of the high-latitude North Atlantic region, have been identified in tropical South America, primarily through changes in precipitation and trade wind intensity. Records of vegetation, dustiness, wind strength and river runoff from northern tropical South America reveal dry and windy conditions during the Glacial and Younger Dryas, and non-windy, wet climates during the Bolling/Allerod and Preboreal. This pattern of changes is consistent with a southward shift of the ITCZ during times of cold high-latitude northern climate, with northward ITCZ shifts during northern warming. Such ITCZ variability could be forced by mechanisms originating at high northern latitudes (e.g., cooling following shutdown of North Atlantic Deep Water formation) or possibly in the tropics (e.g., an ENSO-like mechanism operating at longer time scales). These different forcing scenarios might be identifiable through leads and lags between tropical and high-latitude sites. The Cariaco Basin, off the coast of Venezuela, is an ideal location for recovering high-resolution records of both tropical and high-latitude North Atlantic variability.

Cariaco records of the Younger Dryas onset show a dramatic reduction in North Atlantic thermohaline circulation at the same time as low-resolution pollen data from Cariaco and elsewhere in

northern South America record a shift from humid rainforest during the Bolling/Allerod to dry grasslands during the Younger Dryas. To investigate the relative timing of these rapid changes, we have constructed high-resolution records of tropical vegetation change from vascular plant biomarkers in Cariaco Basin sediments. Molecular composition and stable isotopic analyses of higher plant leaf waxes were used to distinguish grasslands from rainforest vegetation, and show distinct evidence of drier/cooler and wetter/warmer conditions during the Glacial-Younger Dryas and Bolling/Allerod-Preboreal climatic periods, respectively. At the current decadal sampling resolution, shifts in northern South American vegetation appear synchronous with NADW changes in the high latitude North Atlantic, consistent with either high- or low-latitude forcing of the Younger Dryas.

### 83-12 12:10 PM Kaiser, Klaus Felix

LATE GLACIAL TREE-RING CHRONOLOGIES – STATUS AND PERSPECTIVE

KAISER, Klaus Felix[1], KROMER, Bernd[2], FRIEDRICH, Michael[3], and SCHAUB, Matthias[1], (1) Land Dynamics, Swiss Federal Rsch Institute WSL, Zuercherstrasse 111, Birmensdorf, CH-8903, Switzerland, kf.kaiser@access.unizh.ch, (2) Institute for Environmental Physics, Heidelberg Academy of Sciences, INF 229, Heidelberg, D-69120, Germany, (3) Institute of Botany (210), Univ of Hohenheim, Garbenstrasse 30, Stuttgart, D-70593, Germany

Tree-ring chronologies provide a versatile archive for late Quaternary dating and climate research. Over the past 30 years we have been engaged in the construction of Holocene and Late-glacial tree-ring series. The absolute chronology developed by the Hohenheim lab is based on German oak for most of the Holocene and dates back to 10,340 yr BP. The older part, based on pine samples also from Switzerland, extends the absolute record back to 12,454 yr BP. In the pine series we observe a drastic growth reduction at c. 11,590 yr BP, which we associate with the YD/PB transition. Hence the absolute chronology extends for c. 860 years back into the Younger Dryas.

For the Bølling/Allerød, a number of floating chronologies have been developed based on samples from the Swiss Plateau (Daettnau, Gaenziloh, Ollon), Germany (Reichwalde, Pfuhl, Eching, Danube Valley, Lausitz, Guenz valley), and Northern Italy (Avigliana). The oldest sections are 14C dated to 12,350 yr BP (c. 14,300 cal BP) with the Bølling/Allerød well covered by >300 individual tree records, most of them dated by 14C. We observe regional dendro-matches within the series from Germany and within those from Switzerland, as well as between several of the Swiss and German chronologies. However, the sequences cannot yet be amalgamated into one continuous record.

The earliest two centuries of the Younger Dryas, between 10,850 and 10,600 BP, are represented by only one tree sample which has 245 annual rings, while there are several specimens that fall within the interval between 10,600 BP and the start of the absolute chronology. The collective data already enable us to calculate the minimum duration of the Bølling/Allerød and of the Younger Dryas.

Presently the pre-12 ka INTCAL98 14C calibration data-set is based on marine 14C data which assume a constant marine reservoir error of 400 years for conversion to atmospheric 14C levels. Because our chronologies for the Late-glacial are floating, they are not yet suitable for 14C calibration. Due to their annual nature, however, we can at least test the assumption of a time-invariant marine reservoir age. Using a 400-yr marine reservoir correction, our data are compatible with the high-resolution Cariaco 14C data-set during the Bølling and the first half of the Allerød, but suggest a much higher reservoir age for the later half of the Allerød.

## SESSION NO. 84, 8:00 AM

## Wednesday, July 30, 2003

## S24. Environmental Catastrophes and Recovery in the Holocene (*Holocene Commission; Neotectonics Commission, Commission on Sea-Level Changes and Coastal Evolution*)

## Reno Hilton Resort and Conference Center, Crystal 3&4

### 84-1 8:10 AM Leroy, Suzanne A.G.

ARE AN EARLY BYZANTINE SEISMIC EVENT AND THE END OF THE BEYSEHIR OCCUPATION PHASE LINKED?

LEROY, Suzanne A.G.[1], KAZANCI, Nizamettin[2], EMRE, Omer[3], ILERI, Ozden[4], SCHWALB, Antje[5], STEWART, Iain, ONCEL, Salim[2], and COSTA, Pedro[1], (1) Geography and Earth Sciences, Brunel Univ, Uxbridge, UB8 3PH, United Kingdom, suzanne.leroy@brunel.ac.uk, (2) Gebze Yuksek Teknoloji Enstitüsü, Gebze, Kocaeli, 41400, Turkey, (3) Department of Geological Research, MTA, Anakara, 06520, Turkey, (4) Maden ve Tetkik Arama Genel Mudurlugu, Ankara, 06535, Turkey, (5) Institut für Geowissenschaften, Technische Universität Braunschweig, Pockelsstrasse 3, Braunschweig, 38106, Germany

Multidisciplinary palaeolimnological studies are used to explore the possible impact of a cluster of earthquakes on the North Anatolian Fault (NAF, Turkey) on the collapse of an arboricultural civilisation (Beysehir Occupation Phase, BOP) stressed by deteriorating climatic conditions at the beginning of the Byzantine Empire.

The end of the BOP at AD c. 200-800 is marked by the collapse of a rich arboriculture in Western Turkey. It is shown to be relatively sudden and dramatic in palaeoenvironmental terms and coincides with changes in the distribution and lifestyles of people. It is still however impossible to establish if this event is synchronous across western Turkey. In Turkey and parts of the Middle-East, the BOP is considered as being a time when the climate is more humid..

A transect of cores across lake Manyas (10 km south of the Sea of Marmara) has revealed a seismite at 4 m depth dated to AD 240-420. Detailed analysis of the sediment structure and biological material contained within the 4-8 cm thick seismite is presented here.

The lake water quality changed suddenly (broken shells, sediment cracks) and briefly (25 years?) with an increased of the biomass and a salt inundation (an expulsion of hydrothermal fluids along the fault?). Our hypothesis is a movement of the Manyas Fault running just south of the lake. This may have diverted briefly the main incoming river, causing a temporary concentration of nutrients.

Events of a similar type/amplitude on the Manyas Fault were rare (1 or 2 in c. 4100 years). The effect of the earthquake was major and more long-lasting than a catastrophic event with a permanent change in terrestrial vegetation on an area that must have extended outside of the drainage basin of lake Manyas.

Attributing the event to a particular known earthquake is difficult, although the historical catalogue for the Sea of Marmara region is one of the longest and most complete in the world. The mid- to –late 4th century AD corresponds to a period of enhanced seismicity. Consequently, several destructive earthquakes fall within our narrow time window. Intriguingly, this period of heightened seismicity appears to affect the wider eastern Mediterranean area during this time, making it is tempting to link this apparent 'seismic crisis' with the termination of the BOP.

### 84-2 8:30 AM Moriwaki, Hiroshi

HOLOCENE CATASTROPHIC COASTAL EVOLUTION RELEVANT TO VOLCANIC ACTIVITIES IN SOUTHERN KYUSHU VOLCANIC FIELDS, SOUTH JAPAN

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Volcanic activity in coastal region is one of the factors greatly responsible for catastrophic coastal change. Southern Kyushu coastal area presented here is most suitable for constructing a model for catastrophic change in coastal landforms, because some Quaternary gigantic calderas and intra-caldera volcanoes are characteristically developed in the southern Kyushu coastal area. They have resulted in various modes and magnitudes of eruptions in the Holocene. The volcanic ejecta and volcano-tectonic activities have catastrophically affected coastal evolution. Here I present a model for mid- and late Holocene catastrophic coastal evolution dominated by two modes of volcanic activities in this region: rapid deposition by volcanic ejecta and geomorphic deformation by volcano-tectonic activity. Tephrochronological and coastal studies show that four eruptions 6,400 - 8,100 cal BP caused most distinct coastal progradation in the Holocene, because contemporaneous sea level attained the culmination, which formed intricate coasts with shallow sea. Various modes and magnitudes of eruptions occurred in this period influenced different modes of coastal evolutions : base surge from Yonemaru maar (8,100 cal BP ,VEI 3), tephra fall from Sakurajima volcano (8,000 cal BP, VEI 4 ), gigantic pyroclastic flow and tephra fall from Kikai caldera (7,300 cal BP, VEI 7), and pyroclastic flow and tephra fall from Ikeda caldera (6,400 cal BP, VEI 5 ). In addition to these volcanic products, volcano-tectonic activity has characteristically caused coastal deformation in the Holocene as evidenced by distinctly raised mid- to late Holocene coastal remnants with a maximum elevation of c. 15 m a.s.l. in the Aira caldera volcanic field. Their occurrences indicate Holocene upwarping of Aira caldera. Its comparison with recent crustal movements of Aira caldera associated with recent volcanic activities of intra-caldera active volcano suggests that magma inflation of Aira caldera has been affected the Holocene upwarping. Coastal evolution studies in Quaternary volcanic fields provide fundamental data on assess future volcanic eruptions in this region.

### 84-3 8:50 AM Torrence, Robin

PROBLEMS OF SCALE: EVALUATING THE EFFECTS OF VOLCANIC DISASTERS ON CULTURAL CHANGE IN WEST NEW BRITAIN, PAPUA NEW GUINEA

TORRENCE, Robin, Anthropology, Australian Museum, 6 College Street, Sydney NSW 2010 Australia, robint@austmus.gov.au.

Human societies in many parts of Papua New Guinea have experienced numerous volcanic disasters since the region was first colonised. The most recent event, the August 2002 eruption of Pago volcano on the north coast of New Britain, only disrupted the lives of c. 10,000 people for about 4 months. In contrast, significantly long periods of abandonment—in the order of 200-1000 years—following many of the 13 preceding Holocene events from this volcano demonstrate that they had much more devastating effects on human settlement. Not only were key economic resources (e.g. fields, forest, reefs) destroyed, but major changes to the shape of the landscape, drainage patterns, coastlines etc. also resulted from massive pyroclastic flows and falls of airborne tephra. Apart from periodic abandonment, the effects of these sudden environmental catastrophes on long-term trends in human behaviour are surprisingly slight. Very few changes in the cultural lives of the people within the affected region can be directly related to individual volcanic events.

The 6,000 years of disasters in New Britain raises important issues about the temporal and spatial scales that are relevant for understanding the impact of environmental disasters on human societies. A prehistoric archaeological perspective on disasters is likely to vary from those using historical or modern case studies because of the very different scales that are examined. On the short-term abandonment represents a significant impact on human societies, but it may not lead to different subsistence, settlement, or economic behavior when the region is re-colonised. Over the long run the nature of change within the affected area is determined more by the impacts of the event on the region whose scale is defined by the nature of societal interaction at that time, than what happened locally. A comprehensive understanding of the effects of disasters on human societies requires an analysis that focuses on a range of different scales.

### 84-4 9:10 AM Weiss, Harvey

HOLOCENE ABRUPT CLIMATE CHANGES: ALTERING THE TRAJECTORY OF HISTORY

WEISS, Harvey, Anthropology and Near Eastern Languages and Civilizations, Yale Univ, Hall of Graduate Studies, B13, New Haven, CT 01002, harvey.weiss@yale.edu.

Global, abrupt, century-scale climate changes occurred at 12.7, 8.2, 5.2 and 4.2 kaBP. Each abrupt climate change forced radical social adaptations to changed environmental conditions: societal collapse, habitat-tracking, and/or or subsistence technology innovation. The effects of these climate changes are available archaeologically for quantification in the early agricultural villages, states, and empires of west Asia.

The Younger Dryas forced hunter-gatherer collapse across west Asia and the adoption of agriculture. Why this did not happen elsewhere forces consideration of the unque situation of post-Pleistocene west Asia.

The 8.2 kaBP event forced habitat-tracking into arid southern Mesopotamia and the first adoption of irrigation agriculture, the abandonment of PPNB agricultural villages from the Euphrates to the Mediterranean, and perhaps the alteration of Nile Valley settlement.

The 5.2 kaBP event caused the collapse of dry-farming cities, villages, and southern colonies in northern Mesopotamia, and the nucleation of regional settlement in southern Mesopotamia's earliest civilization. Synchronous alterations of Egyptian settlement and social organization were likely caused by the same century-scale aridification event

The 4.2 kaBP event forced the collapse of dry-farming agriculture states and empires in southeastern Europe, Egypt, Palestine, Mesopotamia and the Indus, the widespread adoption of pastoral nomadism across West Asia, and habitat-tracking into the still-productive irrigated plains of Mesopotamia and the Indus Valley.

The variable signature of these events in the proxy records suggests each event's unique causality. The magnitude of these changes in the proxy records challenges understanding of the Little Ice Age proxy records' magnitudes—-because the instrumental variability for the Little Ice Age is so slight.

### 84-5 9:30 AM Hassan, Fekri A

DYNAMICS OF CATASTROPHIC COLLAPSE AND RECOVERY OF EGYPTIAN CIVILIZATION 2200-2000 BC

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A series of exceptionally low Nile floods ca. 2150 BC was instumental in the sudden collapse of centralized government in ancinet Egypt signaling the end of the Old Kingdom. Famines, social disorder, and fragmentation during a period of approximately 40 years were followed by a phase of rehabilitation and restoration of order in various provinces. Egypt was eventually reunified with-

in a new paradigm of kingship. The process of recovery depended on capable provincial adminstrators, the deployment of the idea of justice, irrigation projects, and an adminstrative reform.

### 84-6 9:50 AM Verosub, Kenneth L.

VULNERABILITY OF THE GLOBAL AGRICULTURAL ECONOMY TO VOLCANIC ERUPTIONS: LESSONS FROM TAMBORA

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In the past, agricultural products were consumed close to where they were grown, and what farmers planted was determined by the balance between what people wanted locally and what could be grown locally. As agriculture has become part of the global economy, the rules have changed and farmers can often maximize the return on their investment by growing high demand crops that can't be grown in those regions which have less favorable climatic conditions. In effect, the primary goal has become one of taking almost full advantage of the available growing season. However, the curve of mean daily temperature versus time is relatively flat during the summer. As a result, a slight reduction in actual daily temperatures caused by cooling associated with a volcanic eruption can significantly reduce the length of the growing season in a given year, leading to a major perturbation of the global agricultural economy. The eruption of Tambora volcano in Indonesia on April 10, 1815 produced significant atmospheric cooling and led to the designation of 1816 as the Year Without a Summer. Accounts of the impact of this eruption on climate and agriculture around the world can be used to assess the impact that a similar eruption might have on the current global agricultural economy.

### 84-7 10:10 AM Haas, Jean Nicolas

CAUSES AND PRINCIPLES OF THE CATASTROPHIC, LARGE-SCALE DEMISE OF HEMLOCK (TSUGA CANADENSIS) AND ELM (ULMUS SPEC.) ON THE NORTHERN HEMISPHERE AROUND 3700 BC

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Holocene forest ecosystem changes happen normally on a long-term scale. Therefore, the sudden, catastrophic and famous decline of hemlock (*Tsuga canadensis*) in north-eastern North America and of Elm (*Ulmus* spec.) in (northern) Europe during the first half of the 4th Millennium BC is very intriguing. Both tree species more or less disappeared within a few years (or decades) from the Northern Hemisphere after having been important forest trees for centuries before. Today, both declines are commonly attributed to pathogen attacks and in case of the elm-decline also to human impact. However, in view of these nearly synchronous events on both sides of the Atlantic Ocean the possibility of a common triggering mechanism of these major tree declines has to be assessed. Several proxies point to the possibility that global climatic factors may have been involved in this rapid and unprecedented arboreal declines, which finally lead to major forest composition changes within the dense American and European forest after 3500 BC.

### 84-8 10:30 AM Thompson, Lonnie G.

HOLOCENE CLIMATE CHANGE IN THE TROPICS: EVIDENCE OF ABRUPT CLIMATE CHANGE PAST AND PRESENT

THOMPSON, Lonnie G.[1], BRECHER, Henry[2], DAVIS, Mary E.[2], LEON, Blanca[3], LES, Don[4], LIN, Ping-Nan[2], MASHIOTTA, Tracy[2], MOSLEY-THOMPSON, Ellen[2], and MOUNTAIN, Keith[5], (1) Department of Geological Sciences, The Ohio State Univ, 108 Scott Hall, 1090 Carmack Road, Columbus, OH 43210, thompson.3@osu.edu, (2) Byrd Polar Research Center, The Ohio State Univ, 108 Scott Hall, 1090 Carmack Road, Columbus, OH 43210, (3) Herbarium, Plant Rscs Ctr, University of Texas at Austin, Austin, TX 78712, (4) Department of Ecology and Evolutionary Biology, The Univ of Connecticut, Storrs, CT 06269, (5) Department of Geography and Geosciences, Univ of Louisville, Louisville, KY 40292

Abrupt climate change now underway in the Peruvian Andes is placed within a longer time perspective using additional tropical ice core records augmented by a 5200-year old plant exposed in 2002 by the retreating ice. The well-preserved plant provides evidence that: (1) the Quelccaya ice cap is older than the originally determined age of 1.5 ka; (2) temperatures in the high Peruvian Andes were warmer before 5.2 ka than after; and (3) climate conditions abruptly reversed about 5.2 ka following a cold, humid event that buried the plant growing at 5200 m asl. An abrupt mid-Holocene cold event marked the transition from an early Holocene "Hypsithermal" to a cool, late Holocene "Neoglacial" and was widespread and coincident with structural changes within several civilizations. Abrupt climate change has also been documented around 4 ka in the tropical ice cores, coincident with the "First Dark Age," the period of the greatest historically recorded drought in tropical Africa, which apparently extended to the Middle East, western Asia and into tropical South America.

### 84-9 10:50 AM Liu, Kam-biu

HOLOCENE HISTORY OF CATASTROPHIC HURRICANES AND FIRES ALONG THE U.S. GULF COAST

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Hurricanes and wildfires are two of the most important natural hazards in the U.S. Gulf Coast region. Recent developments in paleotempestology have suggested that for any given place along the Gulf coast, the return period of a direct hit by a catastrophic hurricane (defined as Saffir-Simpson category 4 or 5) is in the order of 300 years, or a landfall probability of 0.33% per year. Sedimentary records from a series of coastal lakes and marshes show that over the past 5000 years, each Gulf coast site was struck by catastrophic hurricanes at least 9-12 times, with a hyperactive period during 3400-1000 yr BP. Detailed proxy records of catastrophic wildfires are still lacking for the Gulf coast region, but a paleotempestological record based on a study of overwash sand layers, fossil pollen, and microscopic charcoal from Little Lake provides a rare opportunity to reconstruct a history of intense hurricane strikes and wildfires in coastal Alabama during the last 1300 years. The data suggest that coastal Alabama was directly struck by intense hurricanes (category 3-5) seven times during the past 1300 years. Remarkably, three of the four charcoal concentration peaks occur immediately above the more distinct overwash sand layers, implying that catastrophic fires are likely to occur shortly after an intense hurricane strike. It has been hypothesized that fire hazard increases significantly after an intense hurricane strike due to increased fuel accumulation and drier microclimatic conditions. Our data from Little Lake and other coastal sites seem to support the notion of a hurricane-fire interaction in the maritime pine-oak forests of the Gulf coast region.

### 84-10 11:10 AM Larsen, Lars Berg

ABSOLUTE DATING OF THE CLIMATIC EVENT IN THE 6'TH CENTURY

LARSEN, Lars Berg and CLAUSEN, Henrik B., Department of Geophysics, Univ of Copenhagen, Juliane Maries Vej 30, Copenhagen, 2100 OE, Denmark, lbl@gfy.ku.dk

Various sources, historical, archaeological, geological and geophysical indicate a climatic catastrophe in the 6'th century. In the Greenland ice cores we have a candidate for creating such a catastrophic event. We have a spike in the record of sulfuric acid, followed by a temperature decrease. Investigations of the chemical data indicate a very large unknown volcanic eruption in the order of magnitude of the Tambora AD 1815 eruption. That it was a global event is verified from the Antarctic ice cores. Using the latest data, from the North GRIP ice core correlated to the other ice cores drilled in Greenland and applying a new technique in counting annual layers, we were able to make an absolute dating of the climatic event in the 6'th century.

### 84-11 11:30 AM Starkel, L.

CLASTERING OF EXTREME RAINFALLS AND RECOVERY OF GEOMORPHIC SYSTEMS

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Extreme event means an event during which the threshold of varies processes is passed and this leads to the transformation of equilibrium of slope or/and river channel systems. The frequency of extreme rainfalls fluctuate in space and time. In the aride zone it may happen vary rare, sometime once in century or millennium. In temperate and mediterranean zone the recurrence interval varies from several years to decades. In extreme tropics such extremes repeat every year or even several times in one year. In most climatic zones it is enough time for relaxation and recovery of the system.Only in the extreme tropics like in Cherrapunji it is no time for relaxation and new equilibrium of the system has been formed. In the nature we observe also the clustering of extreme events. It happens when in some periods the events repeat every 2-3 years, every year or several times in one year, when due to missing of time for relaxation it follows the disturbance of slope or fluvial system and finally new equilibrium creates. Such circumstances have been observed in last decade in Central Europe and at the margin of the Bhutanese Himalaya. The detail examination of rainfall and flood records from the Little Ice Age as well from the phase 8.5 -8.0 kyr C14 BP help to distinguish frequent clusters of extreme events, which jointly form the phase with higher anomalies and humidity. This clusterings seem to be responsible for the transformation of natural systems characteristic for the wetter phases of the Holocene, for cut and fill sequences in alluvia or glacial advances and debris flow activity in high mountains.

### 84-12 11:50 AM Yanko-Hombach, Valentina

GEOLOGY OF A CATASTROPHE - THE WHEN AND WHERE OF THE BLACK SEA FLOOD

YANKO-HOMBACH, Valentina, Avalon Institute of Applied Sci, Charleswood Technology Centre, 3227 Roblin Boulevard, Winnipeg, MB R3R 0C2, Canada, valyan@avalon-institute.org and TSCHEPALIGA, Andrei, Institute of Geography, Russian Academy of Sci, 29, Staromonetniy per, Moscow, 109017, Russia

Deeply engrained in the collective memory and religion of humanity is the Great Flood, also called Noah's Flood. Recently, W. Ryan and W. Pitman, (1999,2003)have attributed this flood to the Black Sea basin. Their proposal that a catastrophic postglacial (8.35 ka BP)rise in the level of the Black Sea accelerated the dispersion of early Neolithic foragers and farmers into the interior of Europe, forming the historical basis for the biblical story of Noah's Flood, has spurred a tremendous interest by the public, the scientific community, and the media. This presentation summarises the results of extensive geological and palaeooceanograpic studies of the Black Sea and the former Manych Strait undertaken since 1970. Thousands of cores as well as thousands of kilometres of high-resolution seismic profiles were studied in a large-scale marine-geological survey. The samples obtained were subjected to multidisciplinary studies (micropalaeontology, geochemistry, sedimentology), and correlated with 14C, O and C isotope data. A large amount of geological and archaeological publications were reviewed for comparison. In the context of the Ryan&Pitman Noah Flood hypothesis, the time span of 15.0 ka - 7.0 ka BP is discussed in six crucial stages: (1) The lowest level (about -100 m) of the freshwater Novoeuxinian Lake before 14 ka BP; (2) The rapid increase of the level (from -100 m to -20 m) between ~14.0 and 11.0 ka BP due to a massive overflow from the Caspian Sea to the Black Sea through the Manych Strait; (3) The re-establisment of the Black Sea / Sea of Marmara connection and the concurrent first appearance of Mediterranean immigrants in the Black Sea at ~9.0 ka BP; (4) Alternative to the Bosporus connections between the Black Sea and the Sea of Marmara; (5) The gradual and fluctuating character of Holocene transgression; (6) The influence of sea-level change on coastlines and surrounding human culture. It will be shown that although there seems to be not much room for the Ryan&Pitman Noah Flood hypothesis, there does exist much stronger possibility of an earlier flood in the basin due to the massive water overflow from the Caspian Sea through the ancient Manych Strait, reducing available space and food resources for Palaeolithic people and likely causing inland migration and the transition from hunting and gathering to farming and cattle breeding in the region.

## SESSION NO. 85, 8:00 AM

## Wednesday, July 30, 2003

## S26. Neglected Environmental Proxy Archives: Continental Shelves, Karst, and Drylands

## Reno Hilton Resort and Conference Center, Carson 3&4

### 85-1 8:10 AM Derbyshire, Edward

"CHANGES": CARBON, HYDROLOGY AND GLOBAL ENVIRONMENTAL SYSTEMS - INTRODUCTION, BACKGROUND AND RATIONALE

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Models of global change, either incorporating, or tested against data from palaeoenvironmental proxies, are a vital means of advancing understanding of future global change.

Despite the fact that continental shelves, karstlands and drylands together extend over more than 50% of the Earth's landsurface area, they remain under-researched. "CHANGES" has brought together four international geological programmes in order to stimulate collaborative work across this broad environmental range, with particular reference to the last Glacial/Interglacial cycle. Data from these generic environments have great potential for refining and testing global change models, and their relevance to global carbon cycling is only beginning to be recognized; this link, still

relatively little investigated in some earth environments, may have an important bearing upon carbon dynamics. When sea and lake levels fall, vegetation carbon storage decreases in deserts at the same time as it is enhanced on the emerging shelves. Such negative feedback responses need to be quantified in terms of both timing and relative change between environments.

Asking similar questions of specialists working in diverse and very different earth environments frequently stimulates scientific advance. "CHANGES" is using this approach in order to formulate key questions likely to reveal new research directions. Although the launching strategy of "CHANGES" has been to concentrate on karst, continental shelves, and drylands as three major terrestrial environments that have so far been under-utilized in climate modelling, it is to be expected that other neglected environments will be identified and incorporated as work progresses. Concerted and increasingly integrated collection and assessment of data on under-researched environments are now needed in order to fill some major gaps in current global climate modelling. Initial results of this database construction will be described and its likely future deployment briefly discussed.

## 85-2 8:30 AM Buddemeier, Robert W.

CORALS, COASTS, AND CARBON: THE CONTINENTAL SHELF, CLIMATE CHANGE, AND A DYNAMICALLY-COUPLED ECOSYSTEM

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Corals are important recorders of paleoenvironments, and coral reef ecosystems contribute to the earth's CO2 feedback processes – their calcification is enhanced by the high surface ocean carbonate mineral supersaturation that typically accompanies low atmospheric CO2 concentrations. However, their calcification liberates CO2 from the marine bicarbonate pool into the surface ocean and atmosphere, providing negative feedback to the calcification process. Coral distributions and productivity are sensitive to other climatic factors, including temperature, water quality, and salinity. Because reef-building corals contain algae as obligate endosymbionts, they require light, and therefore relatively shallow water.

Depth restrictions mean that most suitable coral habitat is close to land, and that the bottom area within a suitable depth range changes dramatically between glacial and interglacial conditions. Changes in potential benthic habitat over sea level cycles interact with changes not only in temperature and carbonate saturation state, but also with hydrologic variations – freshwater runoff and suspended sediment tend to make coastal habitats less suitable for coral reef development. Together with the circulation and erosion changes associated with shelf flooding, reproduction mechanisms and the distribution of coral population centers at lowstands will influence the rates at which the ecosytems shift in both location and function as climate changes.

Modern reef ecosystems have been shaped by a protracted highstand, culminating in a period of often devastating human alteration of the coastal environment. Reconstructing the history and causation of coral and reef variations under conditions of natural environmental forcing represents an interdisciplinary challenge, but one with payoffs in terms of better understanding both past shelf and coast dynamics and the probable future of coastal habitats and ecosystems under conditions of anthropogenic climate change.

## 85-3 9:10 AM García, Adriana

LATE PLEISTOCENE PALAEO-ENVIRONMENTAL HISTORY FROM THE GULF OF CARPENTARIA, AUSTRALIA: INTERPRETATION BASED ON FORAMINIFERA, OSTRACODA AND CHARALES

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The Gulf of Carpentaria, located in tropical Australia, is an epicontinental sea with maximum water depth of 70 m. The connection with the Pacific Ocean by Torres Strait is only 12 m deep, while the connection with the Indian Ocean to the West by Arafura Sill is 53 m deep. During low sea levels a palaeo-lake called 'Lake Carpentaria' developed in the basin. Six sediment cores spanning the last 125 ka (Last Interglacial) where collected, and two non-marine/marine transitions have been identified. A multi-proxy approach based on microfossils and geochemistry is under development to produce the palaeoclimatic reconstruction of the area. The upper six metres of the two longest cores (MD-31 and MD-32) have been analysed. The age spans between the last regression (~ 75 ka) up to the last transgression (~ 9.7 ka), including the Last Glacial Maximum time (~ 20 ka). The foraminifers, ostracods and charophytes are studied, and the environmental reconstruction of the 'Lake Carpentaria' is discussed in relation with fluctuations in sea level and monsoon input. Core MD-31 located in the west of the basin, has a higher topographic position, changing from saline lake to freshwater lake to saline lake to a time of highly saline events within dry periods. Core MD-32, collected towards the east, and deeper part of the basin, have a nice sequence of facies from estuarine environment to a saline lake to a freshwater lake. Euryhaline taxa such as *Ammonia* sp., *Leptocythere* sp., *Cyprideis* sp. and *Pistocythereis* sp., were replaced by an association of *Ammonia* sp., *Helenina* sp., *Cyprideis* sp., and *Ilyocypris* sp., indicating lower salinity. The disconnection of the lake from the ocean, and increasing freshwater input, produced a change in the biota to taxa of fresher-water affiliation as *Ammonia tepida*, *Ilyocypris* sp., *Cyprinotus* sp., *Cypretta* sp., *Darwinula* sp., together with charophytes *Chara vulgaris, C. zeylanica* and *Lychnothamnus barbatus. Lamprothamnium*sp., a euryhaline genus, is present in only one level, indicating fluctuating environment. After the last transgression, the assemblages changed to a highly diverse fauna of marine foraminifers and ostracods (including several species of *Textularia, Bolivina, Asterorotalia, Pararotalia, Ammonia, Neonesida, Paranesidea, Cyteroptheron Echinocythereis).*

## 85-4 9:30 AM Clemmens, Samuel

ALLUVIAL FANS, A MUCH NEGLECTED DRYLAND ENVIRONMENTAL PROXY: EVIDENCE FOR LANDSCAPE EVOLUTION, PALAEOENVIRONMENTAL CHANGE AND NEOTECTONICS ALONG A TRANSFORM PLATE BOUNDARY, SOUTH-CENTRAL CALIFORNIA

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Many authors have suggested that alluvial fans sensitively record environmental change (notably climate and hydrology) and tectonics. However, deciphering the potentially strong environmental record preserved within alluvial fan deposits has traditionally been severely restricted by a lack of adequate chronological control. Cosmogenic radionuclide (CRN) surface exposure and optically stimulated luminescence (OSL) dating remove this restriction by providing techniques to directly determine the timing of fan formation and/or incision. Using geomorphic and sedimentological analysis combined with CRN $^{10}Be$, $^{26}Al$ and $^{21}Ne$ surface exposure and OSL dating we examined a succession of alluvial fan surfaces from Whitewater and Mission Creek to define the timing of fan formation and to help elucidate the relative roles of climate, tectonics and autocyclic processes in their formation. CRN exposure ages on surface boulders define two periods of alluvial fan growth: 70-60ka and between 8ka to present. Deformation of fan surfaces, however, are clearly also controlled by tectonics and the age of alluvial fan formation helps define rates of displacement along segments of the San Andreas fault.

The extensive dates (>50) on these surfaces show the applicability of CRN dating methods in such tectonically and geomorphically dynamic alluvial fan systems. However, the study also highlights a potential limitation to CRN exposure dating. The Mission Creek succession clearly shows younger ages on fan surfaces that are morphostratigraphically older than well-dated surfaces of 60-70 ka. These results suggest that boulder erosion and fan surface denudation potentially limit the use of surface exposure dating in this setting to deposits younger than 70ka, highlighting the need for careful field geomorphic and sedimentological evaluation in combination with CRN sampling.

## 85-5 9:50 AM Jäger, Klaus-Dieter

ON THE ROLE OF KARSTIFIED REGIONS FOR UNDERSTANDING HOLOCENE CLIMATIC CHANGE IN INTERIOR CENTRAL EUROPE

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The actual state of knowledge on Holocene climatic change in interior Central Europe is mainly based on investigations in humid regions providing a lot of lakes and mires. Deposits as peat and lacustrine sediments have enabled excellent conditions for applying well-tried methods of examination as e.g. pollen analysis. In contrast to these regions karstified ones are in want of such deposits and methodical possibilities. However, karstified regions offer other evidences of Holocene climatic change.

Mainly they are based on two groups of sedimentary sequences consisting of limestone detritus on the one hand an of freshwater lime deposits on the other one. A common feature of both these types of sequences is the lime content providing the preservation of calcareous fossils as bones and molluse shells. Therefore, in the Holocene sequences of karstified regions the methodical approach by means of pollen analysis may be replaced by palaeomalacology. Especially this methodical access has been qualified mainly by Czech scientists during the last century. The succession of mollusc assemblages reflects the change of palaeoecological conditions as well as pollen analysis in other regions, deposits, and sequences.

Frequently the evidence of fresh-water lime deposits includes and exceeds the indications of palaeomalacology, especially in discontinuous sequences. Fresh-water lime deposits comprise mainly calcareous tufa and marl. Discontinuous sequences are caused by the occurrence of buried humus horizons alternating with sedimentary layers in the stratigraphy. Frequently they appear in the exposures, and frequently their synchroneity can be proved by archaeological observations. Archaeological discoveries from the buried soils testify traces of ancient human settlement on previous subaeric surfaces intercalating the sedimentary sequences of subaquatic calcareous deposits.

Synchronuous datings prove that distinct time slices during the Holocene have favoured the drying of flat beaches and bottoms surrounding lakes and rivers in different karstified regios of Central Europe, alternating with others favouring a higher water level everywhere. This means that the alternation of calcareous sedimentary layers with buriel soils in the stratigraphy of freshwater lime exposures reflects changing climatic conditions of regional validity.

## 85-6 10:30 AM Mylroie, John E.

CARBONATE ISLAND KARST AND THE QUATERNARY PALEOCLIMATE REOCRD

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The oceanic setting of carbonate islands creates a karst record of Quaternary climatic change, primarily through sea-level change. Sea-level highstands are also indicated by carbonate sediment depositional cycles. Fossil coral reefs in the tectonically-stable Bahamas define the last interglacial highstand (oxygen isotope substage 5e) as approximately 12,000 years in duration by U/Th dates (131,000 to 119,000 years ago). Flank margin caves develop at the edge of the freshwater lens, thus their magnitude and lateral extent are a measure of the duration of sea level position, and fresh-water lens position, at the time of cave formation. Sea-level lowstands result in speleothem growth in caves drained by sea-level fall. Bahamian flank margin caves formed during the last interglacial sea-level highstand time window of 12,000 years, proven by the lack of stalagmites older than 100,000 years. Blue holes, with depths over 100 m below modern sea level, are older and contain stalagmites in >350,000 years of age, indicating numerous marine fill and drain cycles caused by glacioeustasy. On tectonically uplifted carbonate islands, caves and speleothems avoid fresh or marine phreatic water overprints, and may detail aspects of climatic change by stable isotope variation. Paleomagnetic records of cave deposits provide minimum ages for caves, and show that some flank margin caves such as Cueva del Aleman on uplifted Isla de Mona, Puerto Rico, developed ~2 million years ago, before the onset of rapid glacioeustasy in the early Pleistocene. Paleosols entomb paleokarsts, and through paleomagnetic measurements of secular variation, can provide an independent chronology of karst formation. Carbonate dissolution/deposition cycles affect $CO_2$ flux ($Ca^{++} + 2HCO_3^- \leftrightarrow CaCO_3 + H_2O + CO_2$). Karst denudation of exposed carbonate platforms during glacioeustatic sea-level lowstands results in $CO_2$ sequestering of potentially 1.1 x $10^{13}$ g/y carbon, while carbonate deposition during highstands results in a potential $CO_2$ release of 1.2 x $10^{14}$ g/y carbon. Quaternary sea-level lowstands sufficient to expose carbonate banks are about ten times longer than highstands that flood the banks (100,000 years versus 10,000 years), creating a carbonate flux that is approximately balanced (1.2 x $10^{18}$ g carbon versus 1.1 x $10^{18}$ g carbon, respectively).

## 85-7 10:50 AM Shopov, Yavor Y.

SPELEOTHEM RECORDS OF THE GLOBAL CHANGE

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Potential, resolution and limitations of high resolution speleothem records of Paleotemperature, Past Precipitation, Paleosoils, Paleoseismics, Past Precipitation, Rock displacement, Solar Insolation, Solar Luminosity, Geomagnetic field, Plants Populations, Chemical Pollutions, Air Composition, Glaciations, Sea Level advances, Advances of Hydrothermal Waters, Cosmic Rays Flux variations, Cosmogenic Isotopes production and Supernova Eruptions in the Past, Advances of Hydrothermal Waters, and Techtonic Uplift are discussed. It is demonstrated that speleothems allow extremely high resolution (higher than in any other paleoclimatic terrestrial archives) and long duration of records. Some speleothems can be used as natural climatic stations for obtaining of proxy records of Quaternary climates with annual resolution. Once formed speleothems preserve this records and they can be read by different techniques. Speleothems are formed at almost constant temperature and humidity and remain unaltered with time. They allow reading

their records with remarkably high resolution. So speleothems appear to be one of the best paleoenvironmental archives.

Financial support from the INQUA Executive Committee

### 85-8 11:10 AM Alverson, Keith

PAGES-CHANGES LINKAGES AND SOME THOUGHTS ON GLACIAL/INTERGLACIAL CHANGES IN ATMOPSHERIC CO2 CONCENTRATION

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The primary goal of this talk is to present the IGBP-PAGES program, Past Global Changes, which seeks to facilitate interdisciplinary and international cooperation in those aspects of paleoenvironmental research most relevant to future concerns. I will draw particular attention to activities within PAGES concerned with carbon, hydrology and global environmental systems on glacial/interglacial timescales and will seek feedback from the CHANGES community on how to better incorporate the relatively neglected archives continental shelves, karst and drylands within PAGES.

In addition, I will present an inverse ocean box modeling effort to address the question of what may have caused decreased atmospheric CO2 concentration during glacial periods. The inverse procedure seeks solutions that are consistent, within prescribed uncertainties, with both applied paleodata constraints and box model conservation equations while relaxing traditional assumptions such as exact steady state and precise prescription of uncertain model parameters. Decreased ventilation of Southern Ocean deep water, decreased Southern Ocean air-sea gas exchange, and enhanced high latitude biological pumping are all shown to be individually capable of explaining available paleodata constraints provided that significant calcium carbonate compensation is allowed. The role of increased solubility of CO2 associated with cooling of low and mid latitude surface waters plays only a minor contributing role in these scenarios scenarios. However, we further show exact solutions to the 7-box ocean carbon cycle model, found using the inverse procedure, which indicate that low and mid latitude sea surface temperature changes could have served as the primary driver of atmospheric CO2 variability on glacial-interglacial timescales. The most substantial difference between glacial and interglacial climates is, after all, temperature. In this hypothesis, additional systematic feedbacks, such as those which have been suggested as possible primary mechanisms the scenarios listed above, play a secondary role.

## SESSION NO. 86, 8:00 AM

## Wednesday, July 30, 2003

## S29. Quaternary History of the Antarctic Ice Sheets from Geochronology of Marine and Terrestrial Glacial Deposits

## Reno Hilton Resort and Conference Center, Tahoe

### 86-1 8:10 AM Anderson, John

DIACHRONOUS ADVANCE AND RETREAT OF THE ANTARCTIC ICE SHEETS DURING THE LATE QUATERNARY

ANDERSON, John, HEROY, David, LOWE, Ashley, MOSALA, Amanda, and WELLNER, Julia, Department of Earth Sciences, Rice Univ, Houston, TX 77251-1892, johna@rice.edu

The last decade has been a time of significant advancement in our understanding of the magnitude and timing of Antarctic Ice Sheet expansion and retreat during the past 30 ka. One of the most significant observations has been that the ice sheet did not advance and retreat in concert with Northern Hemisphere ice sheets. Indeed, the various components of the Antarctic ice sheet did not advance and retreat from the continental shelf at the same time.

Marine geological data from around East Antarctica indicates that during the most recent glacial maximum the East Antarctic Ice Sheet (EAIS) advanced to the middle or mid-outer continental shelf in those areas that have been surveyed to date. While the timing of ice sheet expansion is unconstrained, retreat from the shelf was diachronous and occurred between approximately 30 ka and 25 ka in Prydz Bay (Domack et al., 1998) and Lutzow-Holm Bay ( ) and off the Queen Maud Land coast (Anderson et al., 2002). Off Northern Victoria Land, where the EAIS flowed over and through the Transantarctic Mountains and onto the continental shelf, retreat from the shelf took place between approximately 15 ka and 9 ka (Anderson et al., 2002).

Data from eastern Ross Sea and off Marie Byrd Land include spectacular subglacial geomorphic features that extend to the outer shelf. Radiocarbon ages of the oldest glacial marine sediments resting above subglacial deposits indicate that ice sheet retreat from the shelf was diachronous, as in East Antarctica. The earliest retreat from the shelf occurred in the eastern Ross Sea, prior to 20 ka years ago. This area was occupied by very extensive ice streams, hundreds of kilometers in length, flowing across a deforming bed. This implies gentle profiles, high rates of flow and discharge, and possibly contributed to the early, and apparently rapid, retreat of the ice sheet from the shelf. Offshore of Marie Byrd Land, the WAIS retreated from the shelf after approximately 15, 000 ka.

Geomorphic features on the seafloor either side of the Antarctic Peninsula indicate that the ice sheet was grounded on the outer shelf during the past, but the timing of ice sheet expansion and retreat is yet to be resolved.

### 86-2 8:50 AM Domack, Eugene Walter

REVIEW OF RADIOCARBON DATING IN ANTARCTIC MARINE SEDIMENTS

DOMACK, Eugene Walter, Geology, Hamilton College, 198 College Hill Road, Clinton, NY 13323, edomack@hamilton.edu.

Radiocarbon dating in Antarctic marine sediments is associated with several problems unique to the Southern Ocean but its careful application over the last ten years has contributed greatly to the development of near-continuous time series for late Quaternary paleoclimate research. Problems that need careful consideration when applying the method include: corrections for marine reservoir variation, vital effects between different marine species, seasonal differences in marine phytoplankton 14C activity and resuspension of organic particulates. Reservoir corrections for modern calcareous species range over 600 years for modern living organisms. Vital effects may explain some variability but differing regional reservoirs and post-bomb mixing of deep waters are also involved. This variation is equal to estimates for changes in reservoir correction during the Holocene as based upon independent radioisotope methods. Such corrections may be premature until we understand the regional variation in 14C activity in living marine carbonates. Reworking of organic matter is a pervasive problem amplified by: strongly pulsed seasonal flux of organics, resuspension induced by icebergs and deep infaunal mixing, bottom currents, and the presence of deep shelf basins which serve as repositories for resuspended marine detritus. Use of particulate organic matter for radiocarbon dating is generally discouraged but in many instances such material provides the only 14C carrier within the sediment. In such cases standard corrections based upon the surface age of organic particulates are routinely applied but the results do not always produce an accurate chronology for sediment horizons deeper in the stratigraphy. Yet, the method has produced reliable chronologies where the input of reworked organic matter is strictly limited by either basin geometry and/or limited sedimentary source terrain (Palmer Deep). In cases where these conditions are not met separation of organic matter into compound classes, such as sterols, can produce more reliable ages (a method pioneered by the NOSAMS). Important sequences do not always contain sufficient sterol abundance for widespread application of this method. New guidelines for radiocarbon dating in Antarctic marine sediments are provided for the benefit of the community.

### 86-3 9:10 AM Gilbert, Robert

SEDIMENTARY EVIDENCE OF THE RECENT BREAK-UP OF THE NORTHERN LARSEN ICE SHELF: IMPLICATIONS FOR ASSESSING THE HISTORY OF ANTARCTIC ICE SHELVES

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Study of rates of accumulation based on 210Pb dating, and of the particle size of sediments deposited beneath the former Larsen-A, Larsen-B, and Prince Gustav ice shelves on the northern Antarctic Peninsula provides evidence of the processes associated with the disintegration of the ice shelves. Glacimarine deposition both under the ice shelves and in open water beyond is characterized by fine-grained sediments (silt and clay size) and occurs at rates of about 0.2 to 0.5 mm/a. This indicates that advection of particulates beneath the ice shelf occcurred prior to the early stages of disintegration of the ice shelf. At a number of sites, sediment texture coarsens upward with up to 40% sand at the surface and rates of accumulation increase to 4 mm/a. Radiometric 210Pb dating shows this to have occurred between 1985 and 1993, several years before break-up of the ice shelves. These events are related to the release of eolian sediment in periodic rapid draining of small lakes and crevasses on the ice shelf before break-up. Spacing of these lakes and thus the points of release of this sediment is 0.5 – 2 km; in addition the timing and thus the location of release is irregular as the ice shelf advances about 0.5 km/a. When considered with the pattern of spreading associated with settling through the water column of sediment released from point sources, this suggests that the footprint of these deposits covers somewhat less than one half of the sea floor. X-ray radiographs of sediment cores also document the recent influx of coarse particles (gravel) related to ice rafting during ice shelf disintegration. In this case, the catastrophically rapid break-up of the shelf into a mix dominated by brash ice and small bergs allows a significant part of the dominantly englacial basal and lateral morainal debris to be released. Because the content of this material varies spatially through the ice, again, only a part of the sea floor receives these materials. These coarser sediments associated with break-up which are deposited at much greater rates provide a signal that may be used to assess the history of ice shelves in Antarctica, although that record is probably not evident everywhere beneath the shelves because they occur in a spatially irregular pattern.

### 86-4 9:30 AM Berger, Glenn W.

PHOTONIC-DATING TESTS OF GLACIMARINE SEDIMENTS AROUND THE ANTARCTIC PENINSULA

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Numeric chronologies for the waxing and waning of antarctic Quaternary ice sheets as recorded in the glacimarine sediments surrounding the continent have been difficult to obtain for the time range of $^{14}C$ dating (<35 ka), and nearly impossible for deposits >30-40 ka. For Holocene antarctic glacimarine sediments, the reservoir effect and sediment reworking lead to large $^{14}C$ age overestimates. AMS $^{14}C$ ages for surface (0-10 cm) glacimarine sediment near the Larsen Ice Shelf are in the range 9-10 ka B.P. (for acid insoluble organic matter) and 1.1 to 0.9 ka (for modern biogenic calcite).

We are testing the accuracy of photon-stimulated-luminescence (PSL) dating methods for glacimarine sediments from around the Antarctic Peninsula. We report here results from the use of the multi-aliquot, fine-silt, IR-PSL method on 15 samples from 9 box-core sites from 6 areas: Admiralty Bay (King George Island, north of the Peninsula); Gerlache Strait (western side of the Peninsula); Larsen-A Ice Shelf, Larsen-B Ice Shelf, James Ross Island, Erebus-Terror Gulf (all on the eastern side).

Have detrital fine-silt feldspar grains been exposed to sufficient daylight to "zero" the light-sensitive IR-PSL clock? Only one (1-3 cm depth) of the Larsen-B samples (all collected within a few 100 m of the ice shelf) could be dated, yielding age overestimates of 38-90 ka (depending on laboratory bleaching conditions): the other 4 samples showed near-saturation signals, indicating no effective clock zeroing. All 5 Larsen-A samples (up to 30 km from the ice shelf), and the single sample from near James Ross Island, revealed little clock re-setting. Four samples from the Erebus-Terror Gulf yielded apparent ages from 10 ± 1 ka to 23 ± 4 ka as a function of location, sample depth and laboratory bleaching conditions. Similarly, the sample from the Gerlache Strait provided apparent ages from 13 to 22 ka. The Admiralty Bay box core yielded an apparent age reversal: 16 ± 2 to 25 ± 2 ka for the 1-2.5 cm sample depth and 3.0 ± 0.5 to 6.9 ± 0.7 ka for the 8.5-10 cm sample depth. These results reveal suggestive intra-area and inter-area differences. Perhaps the PSL method can provide more information about the sediment transport history than the numeric age. Even this information is extremely important as we try to unravel the history of ice-shelf fluctuation from the sediment record.

### 86-5 9:50 AM Brachfeld, Stefanie

GEOMAGNETIC FIELD PALEOINTENSITY DATING AS A CHRONOLOGICAL TOOL FOR ANTARCTIC HOLOCENE SEDIMENT

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We explore the potential to develop and apply geomagnetic field paleointensity dating as a chronological tool for Holocene sediment accumulating on the Antarctic continental shelf. The crux of the method involves tuning the geomagnetic paleointensity record at one's undated site with an independently dated reference curve. Paleomagnetic analyses of sediment accumulating in fjords and inner-shelf basins on both sides of the Antarctic Peninsula have yielded mixed results. Here we examine the characteristics of sediment that make them suitable or unsuitable for geomagnetic paleointensity dating. We illustrate the success of the method using an example from the Northwest Weddell Sea. We apply the paleointensity dating method to a sedimentary record collected from beneath the former Larsen-A Ice Shelf. This record contains a complete Holocene sequence beginning with the transition from grounded ice to a floating ice shelf and ending with the modern recession of the Larsen-A ice shelf. This approach provides chronological control to a sediment sequence that lack appropriate material for radiocarbon dating. Geomagnetic paleointensity features with wavelengths of 2000-3000 years can be recognized and interhemispherically correlated, illustrating the potential to use geomagnetic paleointensity variations as a long-range correlation tool at sub-Milankovitch time scales.

### 86-6 10:30 AM Bentley, Mike

RELATIVE SEA LEVEL CURVES AND ICE SHEET HISTORY FROM THE ANTARCTIC PENINSULA

BENTLEY, Mike[1], HODGSON, Dominic[2], and SMITH, James[1], (1) Dept of Geography, Univ of Durham, South Rd, Durham, DH1 3LE, United Kingdom, m.j.bentley@durham.ac.uk, (2) British Antarctic Survey, High Cross, Madingley Rd, Cambridge, CB3 0ET, United Kingdom

The configuration of the Last Glacial Maximum (LGM) Antarctic Peninsula ice sheet is not yet well-constrained. We present here new relative sea level curves from sites in both the southern and northern Antarctic Peninsula, which help constrain both the size and post-LGM history of the ice sheet. The southern curve is from the Marguerite Bay region (c. 67deg S), and has been derived from dating penguin remains within beaches, and marine-freshwater transitions in isolation basins. The curve shows dominant uplift since formation of the marine limit. The northern curve is from the South Shetlands region (c. 62deg S) and is derived from isolation basins and dated material within beaches. The curve is more complex and shows initial uplift was followed by a period of mid-Holocene relative submergence until uplift has again dominated in the Late Holocene.

We will present initial results from glacio-isostatic modeling experiments using these new curves as constraints. We also suggest that analysis of the raised beaches around Marguerite Bay curve can be used to infer the extent of sea ice through the mid- to late-Holocene.

### 86-7 10:50 AM Hall, Brenda L.

LATE QUATERNARY ICE FLUCTUATIONS IN SOUTHERN VICTORIA LAND

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Knowledge of the extent, volume, and chronology of Antarctic ice-sheet fluctuations during the late Quaternary is key to understanding the Southern Hemisphere contribution to sea-level, ocean-circulation, and paleoclimatic changes. Over the past several years, detailed surficial geologic mapping, coupled with radiocarbon and uranium-thorium chronologic data, have led to an improved understanding of ice-sheet history in southern Victoria Land. AMS radiocarbon dating has allowed chronologies to be constructed for features, such as raised beaches, that could not be dated previously. Improved techniques in uranium-thorium dating have resulted in better age control for earlier glaciations. As a result, there are now more than 400 dates from southern Victoria Land that bear on the history of both the East Antarctic Ice Sheet and grounded ice in the Ross Sea Embayment during late Quaternary time.

Data from the Dry Valleys confirm the out-of-phase relationship between East Antarctic outlet glaciers and Ross Sea ice in this region. For example, during interglacial periods, Taylor Glacier thickens and advances. During glaciations, however, it retreats, while the Ross Sea Embayment fills with a grounded ice sheet, derived largely from West Antarctica. This Ross Sea ice sheet flows landward into the mouths of the valleys opening onto McMurdo Sound. Chronology comes from AMS radiocarbon dates of algae that lived in ice-dammed and lateral lakes. These data indicate that grounded Ross Sea ice was present along the coast between 23,800 and 8340 14C yr B.P. Ice reached 350 m elevation at the mouth of Taylor Valley, where a moraine dating to 12,700-14,700 14C yr B.P. marks the upper limit. Ice was still near this position as late as 10,800 14C yr B.P. The timing of retreat, ~6600 14C yr B.P., comes from relative sea-level curves from the adjacent coast. Larger-scale reconstruction indicates that most grounding-line recession in the Ross Sea Embayment occurred during the Holocene.

### 86-8 11:10 AM Stone, John O.

TIMING AND EXTENT OF THE LAST GLACIAL MAXIMUM IN EAST AND WEST ANTARCTICA

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The last glaciation in Antarctica culminated 5000-10,000 years after ice sheets in the Northern Hemisphere reached their maximum extent. The continental East Antarctic Ice Sheet (EAIS) and marine West Antarctic Ice Sheet (WAIS) grew and retreated out of phase with one another. Evidently, these ice sheets respond slowly, and at different rates, to changes in surface temperature, snow accumulation and sea level.

In East Antarctica, the Lambert Glacier reached its maximum thickness 17,000-13,000 years ago, and then retreated to its present configuration by 9000 yr B.P.. Exposure ages of erratics from coastal areas overrun by the EAIS in Lutzow-Holm Bay (39° E), the Vestfold Hills (78° E) and Vincennes Bay (111° E) record rapid deglaciation starting 12,000 years ago, and subsequent stabilization of the continental ice-sheet margin by ~10,000 yr B.P.. Exposure dates on erratics from the Bunger Hills (101° E) confirm published suggestions that parts of this oasis remained ice-free during the glacial maximum. As at other East Antarctic coastal sites, ice margins surrounding the Bunger Hills stabilized by ~10,000 yr B.P..

In contrast, exposure dates from the Ford Ranges in Marie Byrd Land show that ice stood more than 700 m above its present height along the West Antarctic coast, 10,000 years ago, and has retreated steadily since. These results, together with other published evidence from the Ross Sea, show that thinning and retreat of the WAIS post-dated both the onset of climatic warming in Antarctica, by ~10,000 years, and all but the final stages of eustatic sea-level rise.

Supported by Australian ASAC awards and NSF grants OPP-9909776 and OPP-9909778.

### 86-9 11:30 AM Baroni, Carlo

ARCHAEOLOGY OF RELICT ADELIE PENGUIN ROOKERIES AS AN AID IN RECONSTRUCTING HOLOCENE DEGLACIATION OF ANTARCTIC COASTS

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Deglaciation, in particular the timing of the initial phase of ice recession, is poorly known but it is critical for understanding the cause of glacier retreat, the relationships among climate variations, sea-level rise, and ice-sheets dynamics. Uninhabited by humans before ca. 1900 AD, Antarctica can be regarded as the continent of penguin settling. Unlike Emperor penguins that are able to bread directly on the ice surface, the Adélie Penguins (Pygoscelis adeliae) nest on ice-free areas around Antarctica. Nests are patches of selected pebbles that penguin parents arrange year after year. In a long-term occupied rookery, penguin guano seeps through the permeable pebbly nests and accumulates at their base to form ornithogenic soils. The older is the rookery, the thicker is the accumulation of pebble and guano. A single enduring occupation of a rookery drops a thick layer of superimposed nests, penguin remains, bones and guano. Abandoned penguin nesting sites in areas where the Adélies do not nest at present were recognized as relict rookeries and are common landscape features along the Antarctic coasts. The heritage of penguin communities is preserved in the fossil rookery's distribution and in ornithogenic soils. Applying the techniques commonly used in archaeological research, through the accurate stratigraphic excavation of penguin settlements, it is possible to identify multi-occupational phases of the rookeries, and to reconstruct the history of penguin populations. Furthermore, penguin guano and remains can be radiocarbon dated. More than 100 conventional and AMS dates (0-12 Kyr) have been so far obtained in the Ross Sea area. Adélie penguins occupied several localities between Ross Island and Terra Nova Bay since 8 kyr BP; coastal deglaciation was completely accomplished about 7 kyr BP. Penguins played a key role in affording a very useful set of dates also: 1) to reconstruct the Holocene curves of the coastal emersion; 2) to investigate the isostatic rebound of the lithosphere unloaded after the retreat of the Antarctic ice sheets; 3) on the Holocene paleoenvironmental conditions that favored or inhibited the presence and distribution of the penguin population; and 4) for studies on Adélie penguin's DNA evolution.

### 86-10 11:50 AM Hindmarsh, Richard C.A.

SAMPLING AND PHYSICAL EFFECTS ON SPACE/TIME DISTRIBUTION OF ANTARCTIC AGE DATA FROM A GLACIO-GEOLOGICAL DATABASE

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A digital database of absolute dates relevant to ice-sheet geometry has been established at BAS. This will be used to constrain models of the Holocene retreat of the Antarctic ice sheet. The amount of Antarctic absolute age data spanning the last glacial cycle has grown considerably, especially in the last decade. The present database (AGGD) forms the first ever that links geological field-data on a continent wide scale to inverse ice sheet modelling. Data from 124 different research papers are reviewed and divided over thirteen different geographical areas. The requirement for absolute age input in the AGGD is that each date is tied to a specific physical environment. The reconstruction of physical (or sedimentary) environments in this study is highly promoted by the sophisticated nature of recent studies in the field. Limitations of dating and calibration methods, quantitative errors, and 'reservoir' correction are reviewed and implemented within the AGGD.

Frequency distributions of absolute ages (time slices) show a number of similarities and differences between West- and East-Antarctica. We discuss how these can be attributed to sampling, physical and historical effects.

## SESSION NO. 87, 1:30 PM

## Wednesday, July 30, 2003

## Stratigraphy and Geochronology (Posters)

## Reno Hilton Resort and Conference Center, Pavilion

### 87-1 BTH 1 Fenton, Cassandra R.

COSMOGENIC $^3$HE AGES OF ALLUVIAL-FAN TERRACES IN THE LOWER COLORADO RIVER

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Along the lower Colorado River corridor below Hoover Dam, Quaternary alluvial fans shed from the adjacent Black Mountains near Topock, AZ interfinger with and overlie main-stem Colorado River sands and gravels. These alluvial fans, referred to as piedmont gravels by previous researchers, grade to various terrace levels that correspond with previous elevations of the Colorado River. Using cosmogenic $^3$He, we have dated seven of these alluvial surfaces with ages ranging from 5 ka to 2.5 Ma. Quaternary geologists have suggested that hillslope response to climate change in the southwestern United States is largely controlled by an increase in drainage density which follows aridification and a decrease in vegetation cover during a glacial-to-interglacial transition. For example, it has been reported that during the Pleistocene-Holocene climate transition in the southwest, summer precipitation increased, runoff decreased, and desert areas with intense monsoonal rains had a major phase of hillslope debris-flow activity followed by fan-head trenching and distal fan progradation. Researchers have published a few cosmogenic isotopes, magnetostratigraphic, and uranium-series dates in California, Arizona, and Nevada that suggest a regional correlation between the deposition of alluvial terraces and transitions from glacial to interglacial climates. Geologists have also hypothesized that the aggradation and downcutting of the Colorado River is controlled primarily by climate and that mainstem and tributaries response to climate changes is recorded in fluvial and alluvial-fan terraces. Absolute dates for the ages of Quaternary deposits on the lower Colorado River are rare. Our preliminary $^3$He ages con-

strain the timing of aggradation and incision in the lower Colorado River corridor and can be used to test these hypotheses. Our exposure ages can also be used to develop a regional correlation of coarse-grained sediments deposited during periods of climate change.

## 87-2 BTH 2 Matmon, Ari

COSMOGENIC AND OSL DATING OF THE LATE PLEISTOCENE SHORELINES OF LAKE LISAN, SOUTHERN ISRAEL: TWO DIFFERENT HISTORIES

MATMON, Ari[1], CROUVI, Onn[2], ENZEL, Yehouda[2], BIERMAN, Paul[3], LARSEN, Jennifer[4], AMIT, Rivka[5], PORAT, Naomi[3], and CAFFEE, Marc[6], (1) U.S. Geol Survey, 345 Middlefield Rd, Menlo Park, CA 94025, amatmon@usgs.gov, (2) Geology, Earth Science Institute, Hebrew Univ, Gival Ram, Jerusalem, 91904, Israel, (3) Geology Department, Univ of Vermont, Burlington, VT 05405, (4) Geology, Univ of Vermont, Burlington, VT 05405, (5) Israel Geol Survey, 30 Malkhe Yisrael St, Jerusalem, 95501, Israel, (6) Prime Laboratory, Physics Department Physics Department, Purdue Univ, West Lafeyette, IN 47907

A series of beach ridges, along the southern end of the Dead Sea, southern Israel, 160-177 meters below sea level were studied in order to establish their relationship to the late Pleistocene Lake Lisan, precursor of the Dead Sea. Optically stimulated luminescence dating of sandy sediments from these ridges yielded ages of 20.0± 1.4 ka and 36.1± 3.3 ka. These ages are supported by the degree of soil development on the beach ridges and correspond well with previously determined ages of Lake Lisan, which suggest that the lake reached its highest stand ~27,000 cal yr B.P.

Five chert clasts from two of these beach ridges were sampled for $^{26}$Al and $^{10}$Be measurements. The measured activities indicate low rates of chert bedrock erosion and complex exposure, burial, and by inference, transport histories. The chert clasts were derived from the Senonian Mishash Formation, a chert-bearing chalk, which is widely exposed in the Nahal Zin drainage basin, the drainage system that supplied most of the material to the beach ridges.

By assuming only exposure at the sampling sites, $^{26}$Al and $^{10}$Be activities suggest exposure ages that range from 35 to 354 ky. These ages do not correspond with the OSL and soil ages of the beach ridges. Furthermore, using the ratio $^{26}$Al/ $^{10}$Be, total clast histories range from 460 to 4300 ky, unrelated to the clasts' current position and exposure period on the late Pleistocene beach ridges. If the clasts were exposed only once and than buried beyond the range of significant cosmogenic nuclide production, the minimum initial exposure and total burial times before delivery to the beach ridges range from 50 to 1300 ky and 390 to 3130 ky, respectively. Alternatively, the initial cosmogenic dosing could have occurred during steady erosion of the source bedrock. Calculating such rates of rock erosion suggests very low erosion rates between 0.4 and 12 m My$^{-1}$.

The relatively long burial periods indicate extended sediment storage as colluvium on slopes and/or as alluvial deposits in Plio-Pleistocene Nahal Zin river terraces and only washed on to the shores of Lake Lisan during the late Pleistocene. The results suggest that using cosmogenic nuclides to date arid-region, terminal lake shorelines is problematic because nuclides are inherited and accumulate from prior periods of exposure.

## 87-3 BTH 3 Marchetti, David

COSMOGENIC EXPOSURE AGES OF DESERT PAVEMENTS: WHAT ARE THEY REALLY TELLING US?

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Desert pavements are common surface features in arid environments. Their origin has been long debated, but in the past two decades a prevailing hypothesis has emerged of stone clast surfaces that are formed and maintained at the air-earth interface and inflated through time via air fall accretionary pedogenesis. Evidence for this mechanism stemmed from both soil studies and exposure age dating. Exposure ages of desert pavement samples on several lava flows in southern California were nearly identical to radiometric ages of the flows, suggesting uninterrupted exposure at the surface. Other research has shown that pavement continuity is closely tied to vegetative abundance and that vegetation shifts due to climate change play a pivotal role in pavement destruction and formation. This research argues that all but the lowest elevation pavements were disrupted by down slope vegetative shifts during the LGM. 3He exposure ages of desert pavements from two locations having differing elevations and source materials (Whitmore Cascade-basalt flow, 750-1120m, Western Grand Canyon National Park, USA and Johnson Mesa-debris flow deposit, 1710-1780m, Capitol Reef National Park, USA) demonstrate two end members of pavement exposure age interpretations. In the Grand Canyon, exposure ages of desert pavements on the Whitmore Cascade appear to be slightly older than exposure ages of primary flow surfaces. This suggest that the flow surfaces have been eroded and that in this case, desert pavements were likely not disrupted by vegetation during the LGM and may be the best indicator of the "true" exposure age of this surface. On Johnson Mesa, however, desert pavement exposure ages are all 30-98ka younger than exposure ages of large boulder clasts within the debris flow deposit which have an average 3He exposure age of 190±12ka (zero erosion, n=3). The average desert pavement 3He exposure age on Johnson Mesa is 127±9ka (zero erosion, n=9), which coincides with the penultimate interglacial period, suggesting a link between pavement formation and climate. This data demonstrates that not all pavements record the exposure age of the surface they are forming on and suggests that climate strongly controls the timing of pavement inception at higher elevations.

## 87-4 BTH 4 Gosse, J.

COSMOGENIC NUCLIDE DATING OF ARID REGION ALLUVIAL FANS

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Cosmogenic nuclide exposure ages have been used to infer rates and styles of surface and tectonic processes responsible in evolving arid region landscapes. Precise Pliocene-Quaternary fan chronologies in arid regions are necessary for calculating strain rates and seismicity recurrence intervals. Soils geomorphology and cosmogenic 10Be in quartz on alluvium in the U.S. southwest (Providence Mtns., Fish Lake Valley, and Amargosa Valley) reveal that it is not always possible to attain high precision fan chronologies. Examination of alluvial fan sediments and surfaces from four lithologically distinct catchments in the Providence Mtns (eastern California) indicates that although fan aggradation is approximately synchronous around 75±10 ka (QF3 fans), older and younger fans correlated along the same range front do not show this synchronicity. Instead of invoking geomorphological explanations of the exposure age disparities among correlative fans, we turned to the assumptions of the dating method. For the Mojave region, the 75-kyr aggradation event may be the most optimally suited for exposure dating. Older fans have significantly and variably disturbed surfaces (erosion, mixing, and burial also vary with elevation), so exposure ages (from surface boulders and subsurface and pavement pebbles) of correlated fans will vary. Large changes in bulk densities during pedogenesis also need to be considered. For younger fans, inheritance is the dominating control on the ages. In the Providence Mtns. and Amargosa Valley (western Nevada), modern wash sediment has as much as 70-kyr worth of inherited 10Be. Even with concentration-depth profiles using amalgamated pebble samples it is not possible to estimate this amount of inheritance with sufficient accuracy to correct a Holocene fan exposure age. The influence of inheritance diminishes with depositional age of a fan. Furthermore, when the option exists, we suggest choosing fans from rapidly eroding or previously glaciated catchments for dating, and correlating other fans along a range front with soils. Ages on a Holocene fan emanating from a glaciated catchment in Fish Lake Valley show lower standard deviations and are closer to radiocarbon ages than ages on a correlated radiocarbon-dated fan from a non-glaciated adjacent catchment.

## 87-5 BTH 5 Hill, Christopher L.

LUMINESCENCE DATING OF GLACIAL LAKE GREAT FALLS, MONTANA, U.S.A

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Stratigraphic sequences related to glacial Lake Great Falls are exposed along the Missouri River valley. They help to determine the timing and extent of continental glaciation on the Great Plains of North America. Near Holter Lake, Montana, laminated silts of glacial Lake Great Falls are buried by sands. An infrared-stimulated luminescence (IRSL) age of 13.2±0.9 ka was obtained for the lake silts (sample UW355). Anomalous fading, or loss of thermally stable signal through time, is evident. Thus, this age can only be taken as a minimum; correction for fading provides an age with a large standard deviation (35.4±18.3 ka). Optically-stimulated luminescence (OSL), using the single aliquot SAR method, gave an age of 17.1±1.4 ka for the lake silts. Multi-aliquot OSL analysis gave an age of 14.7±1.1 ka for the overlying sand (sample UW356), while single aliquot analysis gave an age of 13.1±0.5 ka. Based on these measurements, a Late Wisconsinan (oxygen isotope stage 2) assignment does not seem unreasonable for the Holter Lake sequence. A stratigraphic sequence near Hower Coulee, Montana, contains fluvial gravels and sands that are buried by silts (the "lower lake") of glacial Lake Great Falls. The lower lake silts lie below till of the Laurentide Ice Sheet (LIS). The till is overlain by a set of deposits collectively referred to as the "upper lake." Luminescence measurements of the lower lake suggest the sediments were deposited during the early part of oxygen isotope stage 2. Single-aliquot OSL ages range from 24.6±4.39 ka (UW469) to 14.5±2.03 ka (UW468), while multi-aliquot IRSL ages after correction for fading range from 24.7±6.78 ka (UW468) to 17.6±2.24 ka (UW469). There are two ages on sandy and silty lithofacies of the upper lake sequence, using the single-grain leading edge technique: 10.5±3.33 ka (UW454) and 14.3±3.66 ka (UW467). These ages imply that the deposits of the upper lake sequence likely date to the last part of oxygen isotope stage 2. Sediments of glacial Lake Great Falls were deposited in a lake formed when the Missouri River was blocked by a lobe of the LIS. Direct dating of sediments using luminescence measurements appears to support a late Wisconsin age for these stratigraphic sequences. This implies that a lobe of the LIS advanced into northern Montana and reached the present-day location of the Missouri Valley during oxygen isotope 2.

## 87-6 BTH 6 Hill, Christopher L.

PLEISTOCENE STRATIGRAPHY AND CHRONOLOGY OF THE LOWER YELLOWSTONE BASIN, NORTH AMERICA

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The Pleistocene stratigraphic record in the Lower Yellowstone basin, in eastern Montana, consists of a variety of lithofacies associated with geomorphic features and vertebrate fossils. Middle Pleistocene or possibly Sangamonian age gravels form high terraces in the Yellowstone River Valley. Some of these deposits, such as the Doeden gravels, contain Illinoian/Sangamonian(?) age fossil vertebrates, including ground sloths, mammoth, mastodon, horses, musk ox, and giant short-faced bear. Dates on tephra and calcrete from within the Yellowstone River and Tongue River valleys indicate that these high terraces were formed in the Middle Pleistocene or early Late Pleistocene. Lower terrace gravels at Glendive, Montana, contain mammoth fossils dated to 20,470 +/-80 RCYBP (Beta-155642), while gravels along Beaver Creek, near Wibaux, Montana, contain tusk fragments dated to 26,000 +/- 120 RCYBP (SR-6086). Upland settings within the lower Yellowstone drainage indicate that Late Glacial environments were associated with intervals of aeolian deposition interrupted by periods of increased landscape stability and soil formation. Pedogenic features consist of secondary carbonates perhaps linked to arid climates as well as well-developed A-horizons possibly connected to wetter or cooler climates. Upland silts within the South Fork of Deer Creek overlie bedrock and contain buried A-horizons and secondary carbonates. The silts contain the remains of a mammoth, with dates on collagen of 11,500 +/- 80 RCYBP (Beta-102031) and 12,330 +/- 50 RCYBP (SR-5576). Stratigraphic sequences south of the Yellowstone River, at OTL ridge (south of Glendive, Montana), contain buried A-horizons developed within aeolian silts dated to between 9,330 +/- 80 RCYBP (Beta-155708) and 11,415 +/- 35 RCYBP (SR-6089). These upland lithostratigraphic sequences can be correlated with the Aggie Brown Member of the Oahe Formation. The lower Yellowstone Valley contains fluvial gravels that form Middle and Late Pleistocene-age terraces. Vertebrate fossils recovered from the lower terraces provide dates of about 26,000-20,000 RCYBP. Upland silts contain mammoth remains dated to about 12,000 RCYBP. Soil forming episodes occurred close to the Pleistocene-Holocene transition, generally within the interval of 11,000-9,000 RCYBP.

## 87-7 BTH 7 Smith, Larry N.

GLACIAL LAKE MISSOULA DEPOSITS ALONG THE CLARK FORK RIVER DOWNSTREAM FROM MISSOULA, MONTANA: STRATIGRAPHIC CONTEXT OF THE NINEMILE SECTION

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Ice dams created by the Purcell lobe of the Cordilleran ice sheet near the current Idaho/Montana border impounded Glacial Lake Missoula, which inundated valleys of NW Montana to altitudes of 1265 m. Varved, cyclic, and silt-dominant glacial-lake deposits along the Clark Fork River valley, such as the Ninemile section, have been argued to represent one or more lake stands. Recent mapping of unconsolidated deposits from Missoula, downstream to the confluence of the Clark Fork and Flathead Rivers, revealed a variety of deposits that are interpreted to be products of glacial-lake impoundment and catastrophic drainage. The stratigraphic relations between the glacial-lake silt and older and younger gravelly deposits, and erosional and depositional landforms in the valleys suggests that some lake stands reached vastly different altitudes.

Where exposed, the alluvium is stratified, with a few <50 cm-thick interbeds of laminated silty clay. However one exposed paleovalley contains a basal diamicton of cobble- to very coarse boulder-sized clasts, possibly a debris flow deposit. Imbricated boulder-sized clasts and planar cross-stratified gravel, with set heights of 2 to >35 m, display down-river, and up-tributary paleocurrents, indicating a high-energy, high-volume alluvial environment. In limited exposures, the contact between underlying alluvium and overlying glacial-lake silt shows soft-sedi-

ment deformation, suggesting a rapid transition in depositional conditions. The glacial-lake silt unit is overlain by thin (mostly < 2 m) gravel deposits on strath terraces and fans, and alluvium in channels and floodplains.

Landforms within the 0.6 to 3.5 km-wide alluvial valley are 0.1–0.5 km-wide bedrock channels or alluvial floodplains; strath terraces; upper flats covered by glacial-lake silts, 50–110 m above local base level (albl); streamlined alluvial bars and large-scale dunes, with crests 95–170 m albl; and scabland erosional topography and gulch fills that are 40–270 m albl. The large-scale landforms represent erosion and deposition by catastrophic draining of an early, high stand (~1200 m) Glacial Lake Missoula. Most glacial-lake silt, such as at the Ninemile section, was deposited on the earlier high-energy deposits, and must represent one or more later and much lower lake stand(s) (<1000 m?).

## 87-8 BTH 8 Donoghue, Susan L.

A NEW PARADIGM FOR ANDESITIC TEPHRA CORRELATION

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Tephra beds can be widely dispersed from their source volcano, with emplacement occurring in a very short time (i.e. hours to weeks). Tephra beds are therefore essentially isochronous geologic marker horizons and are valuable for correlation and geochronology.

The vast majority of studies for which tephras have been used as chronostratigraphic marker beds have relied on the correlation of rhyolitic tephras. These tephras are typically well-preserved and readily distinguished by their ferromagnesian mineral assemblages and major-element glass chemistries. EMP and LA-ICPMS analysis of glass shards are now proven and routine techniques for identifying volcanic source and discriminating eruptives from the same centre.

Andesitic tephras are now also proving to be important marker beds within Quaternary sedimentary sequences, and there is thus a growing need to correlate distal andesitic tephras to known eruptives at source. Analysis of andesitic tephras from two arc volcanoes, Mounts Ruapehu (NZ) and Rainier (USA), however, shows that discriminating andesitic eruptives is problematic due to their petrographic complexity, restricted mineral assemblages, and similarity in major-element glass and phenocryst geochemistry.

Andesitic eruptions, typified by smaller melt volumes and more complex processes, produce tephras that show only small-scale variations. Understanding this variation in near source eruptives is necessary to elucidating distal tephra records. We are, therefore, cognizant of the need to approach the correlation of these tephras from a different perspective to that used for rhyolitic tephras.

Our approach is to geochemically 'fingerprint' the magmatic system (to identify characteristic geochemical behaviour) and use this to determine inherent geochemical variability within the eruptive sequence. In essence, this allows the determination of the 'correlation potential' of various formations and member units at source, and thus identification of geochemical parameters useful to correlating distal tephras.

In hindsight this would appear a logical approach, but it is one that has emerged only as a result of the establishment of a geochemical data base for andesitic tephras (that demonstrates the difficulties in discriminating tephras and that permits modeling) and stratigraphers working more closely with geochemists.

## 87-9 BTH 9 Nakamura, Yugo

HOLOCENE TEPHRA IDENTIFICATIONS BASED ON REFRACTIVE INDICES OF DEHYDRATED GLASS AND ITS CONTRIBUTION TO QUATERNARY RESEARCH IN HOKKAIDO, NORTHERN JAPAN

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The Holocene sedimentary record of Hokkaido, northern Japan, is dominated by tephras. Tephras have been commonly identified by comparing their petrographic properties and in particular their volcanic glass refractive index. The widespread availability of the electron microprobe, beginning in the late 1960s, saw a significant shift toward reliance on chemical fingerprinting for tephra correlation. The present study revives the use of glass refractive index by dehydration procedures for reversing the secondary hydration of the glasses.

The incomplete hydration in volcanic glass influences the refractive index with relatively severe extent. For example, refractive indices of hydrated Tarumae-a tephra (Ta-a: AD1739), Tarumae-b tephra (Ta-b: AD1667), and Tarumae-c tephra (Ta-c: ca.3ka) glass vary widely: their standard deviations are s=0.0034, s=0.0033, and s=0.0036, respectively. Thus, refractive indices of non-treated tephra glass are not a practical tool for identifying Holocene tephras. Heterogeneity of tephra glasses due to variable hydration increases the spread of refractive indices.

Hydration near the surface of tephra glass shards can be removed by 400 _‹C 12-hour annealing. The refractive indices of dehydrated (annealed) Ta-a, Ta-b, and Ta-c glass are 0.006-0.014 lower than those of the incompletely hydrated (non-treated) glass. Standard deviations of the refractive indices of dehydrated glass are small (s=0.0014-0.0018), in contrast with those of non-treated glass. It is strongly recommended that the refractive index of dehydrated glass be measured for Holocene tephra identification.

Most of the Holocene tephras in Hokkaido can be easily identified based on the refractive index of dehydrated glass in addition to some other petrographic properties. On the basis of the identifications, some Holocene phenomena such as the tsunami deposits in the coastal region of eastern Hokkaido, the periglacial phenomena in the alpine area of Mts. Daisetsu, and the paleo-earthquakes and the Satsumon culture horizon in the northern part of Ishikari Lowlands were examined. As a time-marker of 6500 cal yBP, Komagatake-g tephra (Ko-g) is valuable for correlating various phenomena in extensive areas of Hokkaido.

## 87-10 BTH 10 Uchiyama, Takashi

THE VOLCANIC ACTIVITY AND VOLCANOGENIC IMPACT ON NATURAL ENVIRONMENT OF MT FUJI, BASED ON THE LAKE BOTTOM SEDIMENTS FROM FUJI FIVE LAKES AROUND FUJI VOLCANO, CENTRAL JAPAN

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Mount Fuji volcanic activity began about 100,000 years ago, and pyroclastic materials and lava flows had erupted actively in the past 10,000 years. A giant latest eruption happened about 300 years ago in the Edo Period, and pyroclastic falls occurred in the capital Edo. Five lakes (Fuji-goko), such as Motosu Lake, Shoji Lake, Sai Lake, Kawaguchi Lake and Yamanaka Lake existed on the north foot of Fuji volcano, dammed by lava flows from Mt Fuji.

Research has been done in our Institute from 1997 to study the volcanic activity from the lake sediments of Motosu Lake, Kawaguchi Lake and Yamanaka Lake in Fuji-goko at the north foot of Mt Fuji and which then can be read, an influence on the natural environment of that and environment change history from the viewpoint concerning study of the Quaternary stratigraphy.

Tephra such as scoria falls and lava flows of Mt Fuji origin were deposited in the lake sediments of Motosu Lake, Kawaguchi Lake and Yamanaka Lake. The importance of tephra and lava flows vary with the location of each lake. Lava flows dominate the lake bottom sediemnts of Motosu Lake located at the northwestern foot where many parasitic volcanoes occur, and there are a few tephra and lacustrine deposits. Fine and coarse grain-size sediments are dominant in such cases as mud and sand and gravel, and the lava flows in central part and tephra occur in the lake sediments of Kawaguchi Lake located at the north foot. Tephra such as scoria and lapilli are dominant in the lake sediments of Yamanaka Lake located at the northeastern foot, and lava flows are not found.

A microfossil assemblage analysis, especially fossil pollen, opal phytolith and diatom, was carried out to explain changes in natural environment around these each lakes and the influence of the volcanic activity. The local pollen zone is subdivided into four pollen zones in Mount Fuji north foot area in descending order, based on pollen analysis of bottom sediment from Kawaguchi Lake, as follows;

I. pollen zone; the increase of Pinus subgenus *Diploxylon*

II. Upollen zone; the increase tendency of *Cryptomeria* and the appearance of *Cyclobalanopsis*

III. pollen zone; the increase and decrease of *Quercus*, accompanying of the broadleaf tree pollen

IV. pollen zone; the appearance of the conifer pollen of the high rate and the increase and decrease of the pollen of the broadleaf tree.

## 87-11 BTH 11 Cheong, C.-S.

DATING LATE PLEISTOCENE MARINE TERRACE SYSTEM IN SOUTHEASTERN KOREA

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In the last few years, marine terrace system in southeastern Korea has been intensively investigated in order to evaluate the capability of Quaternary faults near the site of nuclear power plants and heavy industrial complexes. The threat from a particular tectonic source is principally defined by the recurrence interval and slip rate which should be measured on the basis of sound geochronological data. We tried OSL (optically stimulated luminescence) and radiocarbon measurements on the marine terrace deposits in southeastern Korea. Five to six marine terraces have been recognized in southeastern Korea, but among these, only the age of the two well-developed terraces ($Q_2$ and $Q_3$) can help us to evaluate the capability of the tectonic source because the last fault movement in this area is believed to have occurred between formation periods of these two terraces. Of the two terraces, the lower one ($Q_2$, c.20m above sea level) has been dated to be 48 to 71 ka by the OSL SAR (single-aliquot regenerative-dose) protocol using quartz grains, which is supported by radiocarbon age of around 35 ka for the overlain terrestrial deposits. We correlate the age of the $Q_2$ platform with 60 or 80 ka high sea stand (MIS 3 or 5a) considering the variation in pore water content over time. Although the difference in weathering degree of beach gravels clearly demonstrates the time gap between the lower and middle terraces, previously measured OSL age of the latter ($Q_3$, c.50m above sea level) was in the range of 20 to 90 ka with considerable scatter and stratigraphic inconsistency. However, the SAR protocol at 220$^{o}$C cut-heat treatment, instead of 160$^{o}$C as usually used, yields stratigraphically consistent OSL ages ranging from 77 to 104 ka for five samples collected from the $Q_3$ terrace. This result was obtained by considering saturated water content of the samples which should be still underestimation in comparison with that during deposition underwater, because now the clays formed by severe weathering of pebbles fill the spaces among the pebbles. Our new OSL results for the $Q_3$ terrace are supported by optical and radiocarbon dating of aeolian sand dunes deposited on the terrace platforms. We correlate the age of the $Q_3$ terrace with MIS 5e or 5c and it can be concluded that the last fault movement occurred during MIS 5a or 3 in the southeastern part of the Korean peninsula.

## 87-12 BTH 12 Rawling, J. Elmo

QUATERNARY MESA STRATIGRAPHY IN THE WHITE RIVER BADLANDS OF SOUTH DAKOTA, USA

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The White River Badlands are well known for Tertiary strata and fossils. However, there are also significant Quaternary sediments there. These include: 1) Holocene eolian cliff-top deposits and eolian sand with millennial-scale cyclicity, 2) Pleistocene eolian sand, and 3) fluvial and lacustrine deposits that predate the initiation of Badlands erosion. Mesas containing and covered by these Quaternary deposits occur at ~830 and 950 m elevation.

Eolian cliff-top deposits are typical on mesa edges in the study area. They contain Holocene soils that were buried at ~ 1300, ~2500 and ~3700 $^{14}$C yrs BP. Soils beneath the cliff-top deposits are early Holocene on higher elevation mesas, and late Holocene on lower elevation mesas. Holocene millennial-scale periodicity evidenced here correlates temporally to that seen in Greenland ice cores and North Atlantic sediment cores (i.e. to "Bond Cycles").

Parabolic dunes also occur on mesa surfaces in the study area. An exposure sampled on an 830 m mesa has seven buried Holocene A-C soils that range in age from ~9600 to 800 $^{14}$C yrs BP. One optical luminescence age estimate from the base of the eolian sand is ~12,500 cal yr BP (11,000 $^{14}$C yrs BP) old (i.e. the Younger Dryas). These deposits also evidence a periodicity similar to the cliff-top deposits. Parabolic dunes on the higher 950 m surface contain older Pleistocene age sand.

All mesas in the study area have fluvial, colluvial, and lacustrine strata beneath the eolian deposits. These include the Red Dog Loess, which is probably a fluvial deposit. A thermal luminescence sample taken near the base of this deposit at Sheep Mountain Table yielded a minimum age estimate of 171,460±23,810 yrs ago. Continued dating of these deposits is aiding in the interpretation of the long-term evolution of the White River Badlands.

## 87-13 BTH 13 Aliyeva, Elmira

INTEGRATION OF DIFFERENT STRATIGRAPHIC METHODS APPLIED TO CLOSED BASINS (FROM THE EXAMPLE OF QUATERNARY CASPIAN SEA)

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The difference of opinions concerning the location of stratigraphic divisions boundaries brings the necessity to use integration approach to stratification of sedimentary series. Particularly it is topical for closed basins like Quaternary Caspian Sea having an extremely unstable sea level response to short-term climatic changes. It led to frequent variations of qualitative, quantitative and substantial composition of paleobiocoenosis through the time. High-frequency sea level fluctuations have also been reflected in formation of high order depositional sequences that makes very important the application of sequence stratigraphy principles to Caspian Sea Quaternary sedimentary series. Present research combined the results of bio-, sequence-, chemo- and biogeochemostratigraphic methods applied to Quaternary deposits of the Caspian Sea. Analysis of 18O/16O values in molluscs shells shows the distinct difference in oxygen isotope composition of fossils from different stratigraphic units. These values are divided into three groups clearly coinciding with the Lower, Middle and Upper Pleistocene. Detail stratification of Pleistocene-Holocene deposits have been obtained from microelemental composition of fossils and enclosing them sediments. It has been established a good correlation between biostratigraphic and chemostratigraphic boundaries, which are confined to contact zones of Pleistocene horizons. Data of trace elements contents also allowed to stratify more detail some offshore sections of Quaternary sediments, that was not possible on the base of results of paleontological investigations. Studies of Pleistocene-Holocene deposits in different areas of the Caspian region give an opportunity to distinguish depositional successions of different order and define the chronostratigraphic boundaries. One can distinguish one sequence of forth order and seven small scale sequences, which are good corresponded to biostratigraphic units. From the example of Quaternary deposits of the Caspian Sea it is possible to say about a good correlation of various startigraphic methods applied to closed basins. Such regularity comes from strong climatic dependence both the changes of biocoenosis composition and rapid sea level fluctuations accompanied by formation of sedimentary series.

## 87-14 BTH 14 Hinnov, Linda

EVIDENCE FOR A SYSTEMATIC ERROR IN GRIP ICE-FLOW CHRONOLOGY

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Dansgaard-Oeschger (D-O) cycles recorded in the GRIP ice core oxygen isotope series are spectrally bifurcated over 0-100 Ka, while their counterparts in the neighboring GISP2 ice core are not. Time-frequency analysis reveals that this bifurcation is caused by a frequency modulation affecting the cycles that is phased with the Earth's obliquity variation. The frequency-independent nature of the modulation suggests that it is the result of a systematic error in the GRIP ice-flow chronology. For times less than 50 Ka, this error can be estimated by correlation of the GRIP isotope series with the varve-calibrated GISP2 isotope series. For times previous to 50 Ka, where GISP2 chronology is not determined by varves, the error can be tracked by frequency modulation analysis of the GRIP D-O cycles over 0-100 Ka. This estimated error is then used to adjust the GRIP chronology over the entire 0-100 Ka interval. The adjustment brings the GISP2 and GRIP isotope series into close alignment over 0-50 Ka; timing deviations between the two series that remain prior to 50 Ka are assumed to be due to errors in GISP2 chronology. This adjusted GRIP chronology realigns the Earth's orbital modes in the isotope series to their proper frequency positions, whereas without the adjustment, spectral analysis detects obliquity and precession components with frequencies that are slightly higher than predicted. This discovery of an apparent systematic error in the GRIP ice-flow chronology raises the possibility that similar errors may exist in other ice core chronologies that rely on ice-flow dating techniques, for example, Antarctic ice stratigraphy, where annual accumulations are generally too low for varve resolution.

## 87-15 BTH 15 Crouvi, Onn

RELATIVE DATING OF ALLUVIAL SURFACES USING REFLECTIVE HYPERSPECTRAL REMOTE SENSING: A NEW TOOL FOR GEOMORPHOLOGIC MAPPING

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The conventional mapping method of alluvial surfaces in arid areas is based on estimation of relative time characteristics of the surfaces and their underlying soils. Most of the mapping is made manually on air-photos, which manifest the surface differences. Yet, this method is subjective and qualitative, and usually enables only rough discrimination between mapping units. In this study we examined the feasibility of mapping arid alluvial surfaces using hyperspectral remote sensing. This method identifies the surficial mineralogy based on specific spectral absorption features. Wadi Raham alluvial fan, in the southern Arava valley, Israel, was used as a case study.

The fan was divided by conventional field mapping into 5 alluvial surfaces, ranging in age from the late Pleistocene to present. The lithology of the surficial clasts is similar on all surfaces and consists mostly of carbonate, chert, and rhyolite. The surfaces differ mainly by the degree of desert pavement development and the degree of rock coating accretion. The results of the spectral field measurements showed that the surface reflectance was controlled mainly by the desert pavement development, and was only slightly effected by the rock coating accretion. All surfaces had a distinct carbonate absorption feature at 2.33µm due to the dominance of carbonate clasts. The fine particles in-between the clasts contributed hydroxyl and ferric absorption features (2.2µm, and 0.87µm, respectively) to the surface spectra. Our results revealed that as the percent of the surface covered by clasts increased, the absorption depth of the carbonate clast increased; whereas the absorption depth of the fine particle in-between the clasts, decreased.

The relationship that was established in the field between the degree of desert pavement development and the 3 spectral absorption depths was used to classify the airborne hyperspectral data. We used best-fit curves to transform the relevant spectral absorption depths of each pixel into percent of clast coverage. These classifications proved to be more accurate than the conventional map.

The methodology developed in this study for mapping alluvial surfaces can be used for other arid piedmonts throughout the world. The proposed approach is more objective, and potentially more accurate than the conventional mapping method.

## 87-16 BTH 16 O'Neal, Michael A.

A RHIZOCARPON GEOGRAPHICUM GROWTH CURVE FOR THE CASCADE RANGE OF WASHINGTON AND NORTHERN OREGON

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Lichen thalli measurements from 22 surfaces of known age on Mounts Baker, Hood, and Rainier are used to construct a regional Rhizocarpon geographicum growth curve that spans 189 years. Growth rates determined using the largest thalli diameters measured on the same surfaces at Mount Rainier in 1976 and 2002 are compared to lichenometric data from Mounts Baker and Hood. Similar lichen thalli diameter vs. age relationships identified in the data from the three mountains suggest the presence of uniform growth rates over the 400 km range. A regional growth curve developed during our study shows three growth phases of successively slower growth from 8 to 20 years, 20 to 145 years, and 145 to 189 years. Uncertainty in lichen growth rates beyond 189 years limits extrapolation past that age; however, the time frame covered by our growth curve is an important period of recent climate variability. When applied in appropriate settings, our growth curve can be used to determine accurate numeric ages (±10 years) for surfaces less than 145 years old in areas where other techniques are not applicable or do not provide unique or well-constrained ages.

## 87-17 BTH 17 Thome, Karl N.

NEW DATING OF EUROPEAN ICE SHEETS IMPROVES THE QUATERNARY OF THE RHINE REGION

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Deep sea sediments are dated by linear interpolation (IMBRIE et al. 1984:274) because they are believed to have not settled. But a remarkable settlement can be proofed safely by the comparison of layer thickness. So dating by linear interpolation is false (THOME 1997 - 2002b). The wrong dating of stage 5 (Eemian interglacial) with 125 kyr seemed to be confirmed erroneously by independent dating of an interglacial in coral reefs with a real age of 125 kyr. SHACKLETON & OPDYKE 1973:46: "This well dated episode remains the most important calibration point...". But interglacials of 125 kyr belong to stage 7. Regarding the settlement it becomes clear, that there are confused stage 5 (80 kyr) with stage 7 (125 kyr). Other fictitious confirmations are based on unsafe age estimations in recent ice sheets. The theory of Milankovich: ..."Ice age cycles, which occur at essentially the same frequency (every 100 000 years or so) as changes in the shape of the Earth`orbit" SCHRAG 2002:23 (also IMBRIE et al. 1984:269) connects wrong dated records of disqualified cores with unsafe orbital constructions. The development of ice sheets was ruled by other factors.

Reconstruction of the settlement enables the election of a core without severe sediment disturbances: V28-239. Its record, "based on oxygen isotope data from marine fossils that reflect the size of continental ice sheets" (SCHRAG 2002:23) is proportional to the known sequence of European ice sheets.

An application to the Rhine region shows more details: The largest sheets touched the Lower Rhine in the stages 22 (850 kyr), 16 (550 kyr) and 12 (300 kyr). In different stages ice sheets had different size and duration. Crustal movement, river erosion and volcanism were mobilized most in the stages 22 and 16, less in 12, still less in the other. Overridden sheets are distinguishable.

SHACKLETON NJ, OPDYKE ND (1973) Quaternary Research 3:39-55 IMBRIE J, HAYS JD, MARTINSON DG et al. (1984) NATO ASI Series C Vol. 126 pp 269-305 SCHRAG DP (2000) Nature 404:23 THOME KN (1997) Springer Berlin Heidelberg New York ISBN 3-540-62932-7 pp 25-26, 41-55, 69-111, 188-209 —(2000) Decheniana (Bonn) 153:241-259 ISSN 0366-872 X —(2001) DGG14:211-212 ISSN 1616-0606, ISBN 3-932537-14-9 —(2002a) Terra Nostra 2002/6:364-374 DEUQUA ISSN 0946-8978 —(2002b) GeoArchaeoRhein 4 Münster ISBN 3-8258-6009-4

# SESSION NO. 88, 1:30 PM

## Wednesday, July 30, 2003

## S15. Were Abrupt Climatic Changes at the Last Termination Globally Synchronous (Posters) (*Commission on Palaeoclimate; Commission on Tephrachronology and Volcanism*)

## Reno Hilton Resort and Conference Center, Pavilion

## 88-1 BTH 18 Hoek, W.Z.

WERE CLIMATIC OSCILLATIONS DURING THE LAST TERMINATION GLOBALLY SYNCHRONOUS? THE INTIMATE* DO-IT-YOURSELF POSTER

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*INTIMATE (Integration of Ice-core, Marine, and Terrestrial Records): a core project of the INQUA Palaeoclimate Commission, http://www.geog.uu.nl/fg/INTIMATE/

This poster is a joint effort of all congress delegates that contribute data to this poster.

The abrupt, millennial-scale climatic fluctuations of the Last Termination are among the most intensively-studied features of the Late Quaternary. High-resolution records of this period are available from the terrestrial, marine and polar ice realms. The principal objective of the INTIMATE project of the INQUA Palaeoclimate Commission is to synthesise marine, terrestrial, and ice-core data for the Atlantic region during the Last Glacial-Interglacial Transition (LGIT: ca. 13-10 14C kyr BP; ca. 15-11.5 ice-core kyr BP).

In this poster a number of high-resolution records covering the Last Termination are presented in order to compare them with each other. The results as presented during the associated symposium and current poster session are given, and, more important, INQUA congress delegates can add their own data and compare it to the other data sets on a common time-scale. Present all reconstructions on a calendar/ice-core timescale, where possible.

Please note the following important requirements for adding your data to this poster:

1) Add the name of the location, geographical coordinates, and author name to table 1. 2) Plot your location number from table 1 on the global map (figure 1). 3) Specify for your location the calibration used for conversion of 14C years to calendar years (e.g. INTCAL 98, Suigetsu) and indicate the reservoir correction used for marine 14C dates in table 2. 4) Plot the events (warm, cold, wet or dry) under the location number in table 3.

Now you should be able to solve the following question: Were climatic oscillations during the Last Termination globally synchronous?