

SESSION NO. 50, 8:00 AM

Monday, July 28, 2003

S30. New Developments in Quaternary Numeric Dating Methods

Reno Hilton Resort and Conference Center, Carson 3&4

50-1 8:10 AM Steig, Eric J.

THE MYSTIQUE OF ICE CORE CHRONOLOGIES

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Chronologies from ice cores are one of the most important benchmarks for Quaternary dating up to 100 ka. In addition to being used to define the timing of specific events such as the Younger Dryas termination, the GISP2 ice core in particular has been critical for radiocarbon calibration prior to 10 ka, since it provides the basis of the chronology of the Cariaco basin varve sequence. Furthermore, paleoclimate records from ice cores, due to their high resolution and the general agreement that they are representative of climate over broad areas, are frequently used as benchmarks for the interpretation of other Quaternary records as far back as 400 ka. For all of these reasons, it is important that uncertainties in ice core chronologies be well understood and, where possible, improved upon.

In this talk, I will briefly review the layer-counting method used to develop the most widely-used benchmark ice core chronologies – GISP2 and GRIP in central Greenland – the trace-gas-matching technique used to transfer these chronologies to cores in Antarctica, and published estimates of the uncertainties. I will then discuss possible improvements to the latter chronologies, based on the requirement of self-consistency among time series of ice accumulation rate, temperature and the difference between gas age and ice age (Δ age). Finally, I will highlight our recent work on an ice core from Mt. Logan, Yukon, which demonstrates the reliability of the chronology of this particular core at the sub-annual timescale.

50-2 8:30 AM Ku, Teh-Lung

U-SERIES DATING OF CONTINENTAL SEDIMENTS: RECENT PROGRESSES AND APPLICATIONS

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Among the many numerical dating tools of the Quaternary, those based on uranium-series disequilibria enjoy the widest range in terms of applicable material even if we limit ourselves to considering only the ^{230}Th - ^{234}U - ^{238}U systematics, as we shall do so in this presentation. Here, we will further confine our discussion to the dating of sedimentary deposits from the continental environment. As the ^{230}Th - ^{234}U method dates the time of U incorporation into a given sample, the nearly ubiquitous presence of traces of uranium in natural deposits explains the method's wide applicability. In this regard, recent advancement in the analytical capability (precision and sensitivity) of the long-lived U and Th isotopes of ^{238}U , ^{234}U , ^{232}Th and ^{230}Th using mass spectrometry has played an important role. In addition to having improved the age precision, this atom-counting technique has significantly expanded the dating range of 10-350 ka commonly quoted for the method when the radiation-counting technique of alpha-spectrometry is used. Examples will be given to show efforts in the dating of lake evaporites and carbonate, groundwater-precipitated and pedogenic carbonate and silica, and peat/permafrost peat deposits. These efforts entail attempts at coping with the problem of correcting the non-in-situ produced ^{230}Th often present in terrestrial deposits, using isochron schemes or micro-sampling of high U/Th aliquots to minimize the correction effect on ages. The general validity of results through external and internal cross-checks will also be examined.

50-3 8:50 AM Fairbanks, Richard G.

RADIOCARBON CALIBRATION USING HIGH PRECISION $^{230}\text{Th}/^{234}\text{U}/^{238}\text{U}$ AND ^{14}C MEASUREMENTS ON PRISTINE CORALS

FAIRBANKS, Richard G., Earth & Environmental Sciences, Lamont-Doherty Earth Observatory of Columbia Univ, 210 Isotope Laboratory, Rt. 9W, Palisades, NY 10964, fairbanks@LDEO.columbia.edu, MORTLOCK, Richard A., Lamont-Doherty Earth Observatory, Columbia Univ, Palisades, NY 10964-8000, GUILDERSON, Thomas P., Center for Accelerator Mass Spectrometry, Lawrence Livermore National Lab, Livermore, CA 94551, and CHIU, Tzu-chien, Earth & Environmental Sciences, Lamont Doherty Earth Observatory, Columbia University, Palisades, NY 10964-8000

Of practical importance to a wide range of scientific disciplines is the radiocarbon calibration. Radiocarbon ages spanning the last 11,900 years are calibrated to calendar years by making radiocarbon age determinations on tree rings of known age. Over this time interval, fluctuations in the atmospheric ^{14}C were largely produced by changes in the solar magnetic field. For the age interval between 12,000 years and 50,000 yrs BP, radiocarbon ages are calibrated by less accurate methods, such as varved sediments, rapidly accumulating marine sediments, $^{230}\text{Th}/^{234}\text{U}/^{238}\text{U}$ dating of speleothems, and $^{230}\text{Th}/^{234}\text{U}/^{238}\text{U}$ dating of corals. In addition to solar contributions prevalent in the Holocene, carbon cycle variations contribute to atmospheric ^{14}C fluctuations in the pre-Holocene. Combining published radiocarbon calibration data greater than 12,000 yrs. BP results in an unusable calibration data set because offsets and contradictions are the norm among these various data sets. Our contributions to the international radiocarbon calibration effort are the high precision $^{230}\text{Th}/^{234}\text{U}/^{238}\text{U}$ and ^{14}C analyses of a suite of unusually high quality coral samples cored from drowned reefs offshore several islands in the tropical Atlantic and Pacific Oceans. We have overlapped and extended the tree-ring radiocarbon calibration from 11,000 to 50,000 yrs. BP in enough detail to be used as a stand-alone radiocarbon calibration of the highest quality. We have measured a radiocarbon anomaly produced during the Laschamp geomagnetic excursion that confirms the K/Ar date on the Laschamp flow at 47.4 ± 1.9 kyrs BP reported by Hall and York (1978). This age is between 15% and 24% older than recent Laschamp age estimates based on ice core and marine core chronologies. The age offset between uncalibrated radiocarbon years and $^{230}\text{Th}/^{234}\text{U}/^{238}\text{U}$ calendar years exceeds 9200 years during the Laschamp excursion. The radioactive decay of the Laschamp ^{14}C anomaly, compounded by several smaller anomalies, results in the long-term convergence of radiocarbon and calendar years. Conveniently, the large ^{14}C production anomaly produced during the Laschamp excursion "spiked" the carbon reservoirs with sufficient radiocarbon to effectively extend the useful range of radiocarbon dating to eight half-lives.

50-4 9:10 AM Farley, K.A.

APPLICATIONS AND LIMITATIONS OF (U-TH)/HE DATING FOR QUATERNARY GEOCHRONOMETRY

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The recent resurgence of interest in dating by ingrowth of ^4He from U and Th decay has been driven by thermochronometry applications, but a few studies have demonstrated its strengths and weaknesses for "absolute" dating, especially of very young materials. The main attraction of ^4He for this application is that ingrowth in many minerals is rapid relative to blanks and detection limits; e.g., in just 1 Myr the ^4He produced in 1 mg of material with 1 ppm U at secular equilibrium is $>100\times$ typical blank. Furthermore, it is commonly possible to trade-off lower U, Th contents against larger sample size, so even materials with ppb levels of parent nuclides may be datable. However the method suffers from two major limitations: 1) Some materials diffuse He at Earth surface temperatures, including volcanic glass and whole rock, quartz, feldspars, and Mn oxides, while apatite, zircon, titanite, garnet, fluorite, amphibole, pyroxene, and some Fe oxides are thought to be sufficiently retentive to be potential dating targets (though "excess He" may be a problem in some of these minerals). 2) Secular disequilibrium in the U series may cause He production to be time-varying as the intermediate nuclides decay into equilibrium. For volcanic samples the nuclide of concern is ^{230}Th ($t_{1/2}=75$ kyr), while in fluid precipitated samples ^{234}U ($t_{1/2}=247$ kyr) must also be considered. Secular equilibrium is achieved within $\sim 51/2$ of the longest lived daughter in initial disequilibrium, but He concentrations integrate disequilibrium ingrowth and so "remember" it for much longer periods. Methods for determining ages under secular disequilibrium are straightforward if the initial conditions are known or assumed; if they are not known it is possible to obtain precise but potentially inaccurate ages, with the inaccuracy decreasing with time since mineral formation. Examples of He ages of Quaternary apatite, zircon, garnet, fluorite and goethite obtained at Caltech and by other groups will be discussed. Over the range from ~ 1 kyr to ~ 2 Myr, He ages typically are precise to $\pm 5-10\%$. Accuracy ranges from equally good to unacceptably poor depending on age and knowledge of secular equilibrium state.

50-5 9:30 AM verosub, Kenneth L.

RECENT ADVANCES IN THE USE OF PALEOMAGNETISM FOR DATING SEDIMENTS
VEROSUB, Kenneth L., Geology, Univ of California - Davis, One Shields Ave, Davis, CA 95616, verosub@geology.ucdavis.edu

The Earth's magnetic field varies over many different time scales. Over tens of years to hundreds of years, the direction of the field can change by as much as 30 or 40 degrees at mid-latitudes. These changes, known as paleosecular variation, are coherent over distances of at least a few thousand kilometers, and records of paleosecular variation from different sites in the same region can be compared and compiled into a master curve that can then be used to provide a chronology for a new site. In recent years, researchers have used paleomagnetic records from Holocene lacustrine sequences to develop high-quality master curves for several regions of the world. They have also shown that when master curves from lacustrine sequences are compared to paleomagnetic records from nearby marine environments with high deposition rates, the agreement is usually quite remarkable. Thus, the use of master curves of paleosecular variation for the dating of both lacustrine and marine sediments deposited during the past 10,000 years is well-established.

However, the Earth's magnetic field is a vector which has a magnitude as well as a direction. Determining the magnitude (or intensity) of the field is more difficult than determining its direction because the strength of magnetization of a sediment reflects both the intensity of the magnetic field at the time of deposition and the concentration of magnetic material in the sediment. In the past fifteen years, methods have been developed to separate the influence of these two factors, and it is now possible to obtain reliable records of the paleointensity variations of the Earth's magnetic field. These records show that the field varies on time scales on the order of a few thousand to a few tens of thousands of years and that these variations are globally coherent. Moreover, composite records of paleointensity variations now span the last million years. Although these records were developed from and have been applied mainly to marine sediments, the global coherence of the paleointensity signal means that paleointensity dating can also be used for lacustrine sediments deposited during the past 1 million years.

50-6 10:10 AM Roberts, Richard G.

THE REVOLUTIONARY SMALL-SAMPLE PHOTON-STIMULATED LUMINESCENCE DATING METHODS

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Huntley et al. (Nature 313, 105-107, 1985) proposed that the time since grains of quartz and feldspar were last exposed to sunlight could be estimated from their photon-stimulated luminescence (PSL) signals and knowledge of the environmental dose rate. They noted the potential to obtain ages from individual sub-samples (aliquots), but a working single-aliquot protocol was not devised for K-feldspars until 1991, and this was later extended to individual sand-sized grains of K-feldspar. The next breakthrough was made in 1997 with the development of the 'Single-Aliquot Regenerative-dose' (SAR) protocol for single aliquots and individual grains of sand-sized quartz. Since then, several improvements have been made to this protocol, including additional validation tests of protocol performance. Most current 'small sample' studies of sand-sized quartz and K-feldspar use the SAR protocol, which has been extended to silt-sized grains, the 'linear modulation' method of photon excitation, and the red PSL and thermoluminescence (TL) emissions from these minerals (until recently, attention has been focussed on their ultraviolet-blue PSL and TL signals).

With the SAR protocol, inter-aliquot normalisation is not required; any sensitivity changes that occur during reconstruction of the burial dose can be tracked and accounted for; the extent to which samples have been adequately bleached by sunlight before deposition can be assessed; and certain types of post-depositional disturbance can be identified. All of these improve the accuracy and precision of the final dose and age estimates. Also, little raw material is required for single-aliquot or single-grain analysis, thus facilitating dating of small samples and those that contain few quartz or K-feldspar grains. Deposits ranging from modern to 0.5 Ma, perhaps as old as 1 Ma, in age may be dated by PSL techniques, with a typical uncertainty on the age of 5-10%.

In my talk, I shall discuss some of the latest developments in 'small sample' PSL dating, with reference to recent applications in the Earth and archaeological sciences. As well as improvements in the accuracy of the PSL age estimates, I shall describe attempts to push the limits of PSL dating beyond 1 Ma and to investigate processes of sediment mixing. An overview will also be provided of the current limitations to PSL dating.

50-7 10:50 AM Radtke, Ulrich**ESR DATING OF QUATERNARY CORALS FROM BARBADOS - IMPLICATIONS FOR SEA-LEVEL RECONSTRUCTION**

RADTKE, Ulrich, Department of Geography, Univ of Cologne, Albertus-Magnus-Platz, Cologne (Köln), D-50923, Germany, u.radtke@uni-koeln.de and SCHELLMANN, Gerhard, Department of Geography, Univ of Bamberg, Am Kranen 1, Bamberg, D-96047, Germany. The systematic ESR dating of fossil corals was first applied in the 1980s. Since this time, this relatively new dating technique has been improved substantially and ESR dating results now convincingly matched those from the well-established techniques of C-14 and TIMS U-series dating (Radtke et al. 2002; Schellmann et al. 2002). ESR dating of coral sampled from Barbados allows for differentiation between the marine isotopic substages 5e, 5c, and 5a. However, by dating older samples it is only possible to distinguish between the main marine isotopic stages 9, 11, and 13, and 15, most likely due to recrystallization effects. More than 300 new age determinations presented here suggest that, during the last 400 ka, sea level has oscillated more strongly than previously thought. For example, several sub-stages with sea-level between 10 m and 25 m below present sea level are preserved on south Barbados from the last two Interglacial sea-level highstands (5a-1, 5a-2, 5c-1, 5c-2, 5c-3, 7-1). The sea-level fall at the end of the relatively short last and penultimate interglacial transgression maximum (5e-3 and 7-3) is documented by individual reef terraces (5e-1, 5e-2, 7-2, 7-3). Our study enables a revised estimate of the spatial and temporal variation in tectonic uplift rate within west and south Barbados. These new rates are an essential requirement for more precise glacio-eustatic sea-level reconstructions during the Late and Middle Pleistocene from this region. Our findings also provide strong evidence for non-linear crustal uplift during the late Quaternary - an assumption which has been pivotal to most previous studies in the region.

References: U. Radtke, G. Schellmann, A. Scheffers, K. Kelletat and Kromer, B. (2003) ESR and C-14 dating of corals deposited by Holocene tsunami events on Curacao (Netherlands Antilles) (Quat. Sc. Rev., in press). G. Schellmann, U. Radtke, E.-K. Potter, T.M. Esat, M.T. McCulloch and K. Lambeck (2002) Comparing ESR and TIMS U/Th age measurements of oxygen isotope stage 5c and 5a corals from Barbados (10th Intern. Conf. on Luminescence and ESR Dating, Reno, June 24-28, 2002; Abstr., 156)

50-8 11:10 AM Grün, Rainer**DATING HUMAN FOSSILS WITH MINIMUM DAMAGE**

GRÜN, Rainer and EGGINS, Stephen, Research School of Earth Sciences, The Australian National Univ, Canberra, ACT 0200, Australia, Rainer.Grun@anu.edu.au. Dating studies on palaeoanthropological sites are usually carried out on material associated with the human remains, such as the sediment, charcoal or other fauna rather than the human specimen itself. The reason lies in the fact that most dating techniques are destructive and because the hominid remains are too rare to be sacrificed for dating. This indirect dating approach is in many cases not satisfactory, because:

- (i) the human remains are often buried into the sediments and the association with other materials is uncertain (e.g. Border Cave, Skhul, etc.);
- (ii) faunal remains or minerals from the sediment are re-worked from older deposits (see e.g. present discussion of the age of the Homo erectus remains in Indonesia);
- (iii) the hominid specimen was discovered at a time when no careful excavations were carried out and it is impossible to correlate the specimen with other datable material (which applies to a very large percentage of all palaeoanthropological specimen).

Until recently, hominid fossils could only be dated by radiocarbon. This method reaches back to about 40,000 years. As a consequence, all the older fossils could not be analysed and many important questions in our understanding of human evolution could not be addressed.

Human remains are scarce and extremely valuable, therefore any sort of destruction has to be kept to an absolute minimum. This is of particular importance in Australia where any human fossils are sacred. Thus, for the analysis of hominid material it was necessary to develop a more or less non-destructive techniques. This has been accomplished in recent years by the combining ESR and laser ablation ICP-MS analyses of tooth enamel. The examples of Border Cave 5 and the Cave of Hearths are used to illustrate the potential of these methods in palaeoanthropology.

50-9 11:30 AM Zreda, Marek**ADVANCES IN COSMOGENIC DATING OF PALEOSEISMIC EVENTS**

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Historical references are the best sources of data for reconstructing the seismic activity along specific faults. However, historical records are usually much shorter than the time scales of geological processes. Historical records extend several thousand years in China and other regions of the Old World, and only about 500 years in the New World. But the recurrence interval of earthquakes at the same location on a fault can be measured in tens to hundreds of years along highly active faults, to tens or hundreds of thousands of years along less active fault zones. While the lower limit of the recurrence interval is within the range of historical records, the upper limit is certainly not. Thus, archives other than those based on historical information must be utilized for studies of prehistoric seismic activity. Such archives include any deformed geological unit, if the age of the deformation can be determined.

Here, I discuss landforms and features that carry information about prehistoric earthquakes and that can be dated by the accumulation of *in-situ* produced cosmogenic nuclides. Applications of cosmogenic nuclides to dating seismogenic deposits and features are few at this early stage of development, but in addition to already-published accounts, several new and potential applications have been appearing. Two geological settings that have received considerable attention during the last decade are deformed abandoned alluvial fans and bedrock fault scarps. In addition, I will discuss dating of fault scarps developed in sediments, landslides, shorelines and precarious rocks. Finally, I will explore geochronological potential of colluvial wedges and fissures filled with rubble. Three important aspects of cosmogenic dating of paleoseismic record will be discussed: (1) conceptual models of nuclide accumulation in evolving landforms and features; (2) field and laboratory techniques; and (3) the forward and inverse modeling of nuclide accumulation and determination of ages of paleoseismic events.

50-10 11:50 AM Putkonen, Jaakko K.**ACCURACY OF MORaine AGES DETERMINED BY COSMOGENIC BOULDER DATING**

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Analyses of all published cosmogenic exposure ages for moraine boulders show an average age range of 38% between the oldest and youngest boulders from each moraine. This range conflicts with the common assumption that ages of surface boulders are the same as the age of the landform. The wide spread in boulder ages is caused by erosion of the moraine surface and conse-

quent exhumation of fresh boulders. A diffusion model of surface degradation explains the age range and shows that a randomly sampled small set of boulders ($n=3-7$) will always yield a lower age limit for the moraine. The model indicates that for identical dating accuracy, six to seven boulders are needed from old and tall moraines (40,000-100,000 yr, 50-100 m initial height) but only one to four boulders from small moraines (20,000-100,000 yr, 10-20 m). By following these guidelines the oldest obtained boulder age will be 790% of the moraine age (95% probability). This result is only weakly sensitive to a broad range of soil erosion rates. Our analysis of published boulder ages indicates that <3% of all moraine boulders have prior exposure, and 85% of these boulders predate the dated moraine.

SESSION NO. 51, 1:30 PM**Monday, July 28, 2003****Paleoclimate II (Posters)****Reno Hilton Resort and Conference Center, Pavilion****51-1 BTH 1 Kasper Zubillaga, Juan Jose****ENVIRONMENTAL AND STATISTICAL ANALYSES OF GEOCHEMICAL DATA FROM A GULF OF MEXICO CORE**

KASPER ZUBILLAGA, Juan Jose¹, HUERTA DIAZ, Miguel Angel², ORTIZ ZAMORA, Glicinia Valentina³, SALAS DE LEON, David⁴, MONREAL GOMEZ, Adela⁵, SOLER ARRECHALDE, Ana Maria⁶, URRUTIA FUCUGAUCHI, Jaime³, and PALMA, Marchodeo⁷, (1) Geología Marina y Ambiental, Instituto de Ciencias del Mar y Limnología, UNAM, Cd. Universitaria s/n, Coyoacán, México D.F. 04510, Mexico, kasper@icmyl.unam.mx, (2) Geoquímica Ambiental, Instituto de Investigaciones Oceanológicas, Km 103, Apdo Postal 453, Carr. Tijuana-Ensenada, Ensenada B.C, 22830, Mexico, (3) Paleomagnetismo, Instituto de Geofísica, UNAM, Cd. Universitaria, Coyoacán, México D.F. 04510, Mexico, (4) Geología Marina y Ambiental, Instituto de Ciencias del Mar y Limnología, UNAM, Cd. Universitaria s/n, Coyoacán, México D.F. 04510, Mexico, (5) Geología Marina y Ambiental, Instituto de Ciencias del Mar y Limnología, UNAM, Cd. Universitaria s/n Coyoacán, México D.F. 04510, Mexico, (6) Paleomagnetismo, Instituto de Geofísica, UNAM, Cd. Universitaria, Coyoacán, México D.F. 04510, Mexico, (7) El Hombre y su Ambiente, Laboratorio de Ecología y Conservación de la Fauna Silvestre, UAM, DCBS-UAM Xochimilco, Calzada del Hueso 1100, Col. Villa Quietud, México D.F. 04960, México

A sediment core from the Coatzacoalcas River, which discharges in the southeast Gulf of Mexico, was studied to interpret the environmental and statistical significance of geochemical data related to early diagenetic processes. Trace metals (tm=Fe, Pb, Co, Cu, Zn, V) were extracted into two operationally-defined fractions (HCl-tm and pyrite-tm) through which the degree of pyritization [DOP=pyrite-Fe/(pyrite-Fe + HCl-Fe)] and the degree of trace metal pyritization [DTMP-tm=pyrite-tm/(pyrite-tm + HCl-tm)] were calculated as a function of depth. These results were then interpreted for their environmental and geochemical significance. In order to test for significant differences between DOP and DTMP mean values, an univariate two tailed t-test was carried out for each of the trace metals. Visual inspection of the breaker points for the DOP and DTMP values of the vertical profiles was carried out in order to group their shallow and deep values separately. The t-test values were significant for Fe, Pb, Co and Cu in which the null-hypothesis of equal means was rejected. These results suggest that the vertical changes in DOP and DTMP are significant in terms of the biogeochemical processes taking place in the sediments and that the values are not due to random effects in the system. The high values of DOP suggest that Fe is incorporated into the pyrite phase at depth as the most important trace metal due to its kinetic behavior. Furthermore, it was observed that Cu, Co and Pb followed the same DTMP vertical profile pattern despite the fact that Cu and Pb form sulfide minerals faster than Co, which exhibits a kinetic behavior close to that of Fe. This result may suggest that even with different kinetic behaviors, Pb, Co and Cu are incorporated into the pyrite phase with similar patterns at depth. In contrast, Zn tends to form strong soluble complexes, leaving less of this metal available for solid trace metal sulfide formation. V is depleted in the pyrite fraction probably because its incorporation into this mineral phase occur only under very strong reducing conditions, which were not present in our core. Moreover, it can be observed that even though high Fe-DOP levels are reached at depth, the DTMP for most of the rest of the trace metals decreased with depth.

51-2 BTH 2 Eggins, Stephen**THE DISTRIBUTION OF MG IN PLANKTONIC FORAMINIFERA TESTS: IMPLICATIONS FOR MG/CA PALEOSEAWATER THERMOMETRY AND HABITAT MIGRATION**

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The distribution of Mg and other trace elements within planktonic foraminifera tests have been determined using a high resolution, laser ablation ICPMS technique. Using this technique, Mg/Ca ratios can be profiled through test walls of sequentially precipitated chambers that form each test. Simultaneous analysis of Mg and other trace elements (e.g. Mn, Zn, Sr, Ba, Cd, U) and their isotopes, with detection limits to low ng/g levels, is undertaken in <60 seconds. The mass of material consumed by each analysis is ~20-30 ng (cf. typical test mass of ~10-30 µg) and replicate analyses can be made on individual chambers. Mg/Ca ratios can be reproducibly measured within particular chamber wall layers to ±2.5 % and more uniformly distributed Sr/Ca ratios to ±1 %. Studies on key planktonic species used in paleoclimate reconstruction (e.g. *Globigerinoides sacculifer*, *Globigerinoides ruber*, *Neoglobobadrina* sp.) define the capabilities of our technique, highlight the inherent limitations of conventional bulk analysis methods, and provide new insights into biomineralisation processes and habitat migration during adult stages of foraminifera life-cycles. The ability to measure Mg/Ca in shell parts grown under specific seawater conditions, rather than bulk compositions integrated over the life-cycles of multiple whole shells, promises the ability to calibrate more accurate and reliable Mg/Ca thermometers than is currently possible, to assess the variability and the mean of seawater temperature within a deep-sea core sample interval, and to reconstruct changes in the thermocline. The tiny amount of sample consumed further allows for subsequent δ¹⁸O microanalysis of the same shell material, and presents the potential to more reliably reconstruct paleoseawater salinity.

51-3 BTH 3 Shin, Sang-ik

SOUTHERN OCEAN SEA-ICE CONTROL OF THE GLACIAL NORTH ATLANTIC THERMOHALINE CIRCULATION

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The National Center for Atmospheric Research-Community Climate System Model (NCAR-CCSM) is used in a coupled atmosphere-ocean-sea-ice simulation of the Last Glacial Maximum (LGM, around 21,000 years ago) climate. In the tropics, the simulation shows a moderate cooling of 3C over land and 2C in the ocean in zonal average. This cooling is about 1C cooler than the CLIMAP sea surface temperatures but consistent with recent estimates of both land and sea surface temperature changes. Subtropical waters are cooled by 2-2.5C, also in agreement with recent estimates. The simulated oceanic thermohaline circulation (THC) at the LGM is not only shallower but also weaker than the modern with a migration of deep-water formation site in the North Atlantic as suggested by the paleoceanographic evidences. This glacial North Atlantic THC changes are caused by the enhanced Antarctic Bottom Water (AABW) formation and an accompanying increase of oceanic vertical stability in the Atlantic Ocean, which is triggered by sea-ice change and an associated haline density flux increase in the Southern Ocean. From the coupled climate perspective, the Southern Ocean control of the glacial North Atlantic THC is caused by the stronger sea-ice sensitivity to the glacial climate forcing in the Southern Ocean than in the North Atlantic, triggered by the enhanced equatorward sea-ice transport by increased westerlies in the Southern Ocean at the LGM.

51-4 BTH 4 Molnia, Bruce F.

RESPONSE OF U.S. GLACIERS TO POST-LITTLE-ICE-AGE CLIMATE

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Glaciers exist in Alaska (AK) and 9 western contiguous states (WCS). A survey was conducted to determine how these U.S. glaciers are responding to post-Little Ice Age (LIA) climate. In AK, glaciers occur on 11 mountain ranges and 3 island areas; cover ~ 5% of the State (~ 75,000 sq. km); and range in elevation from > 6,000 m to below sea level, and latitude from 55 to 69 degrees N. In the WCS, glaciers exist in 19 mountain ranges and on 8 volcanoes, cover < 0.00001 of the WCS (~ 600 sq. km), and range in elevation from ~ 4,300 m to ~1,250 m, and latitude from 39 to 49 degrees N. Many types of data were used to construct baselines and determine glacier change. These include: published and manuscript descriptions of glaciers; historic and modern maps; aerial, ground, and space photography; airborne and satellite radar; multi-spectral satellite imagery; various types of proxy data; and aerial reconnaissance and field observations by the author. Data available varied for each region and glacier.

In the WCS (Washington, Oregon, California, Montana, Wyoming, Colorado, Idaho, Utah, and Nevada), every area investigated is characterized by significant glacier retreat, thinning, and/or stagnation, especially at lower elevations. At some locations, glaciers have completely disappeared during the 20th century. In places, retreat that started pre-mid-19th century has continued into the 21st century.

In AK, every glacier ending below ~ 1,500 m in the Wrangell Mountains, Alaska Range, Talkeetna Mountains, Ahklun-Wood River Mountains, Kigluak Mountains, Brooks Range, Alexander Archipelago, Aleutian Islands, and on Kodiak Island is retreating, thinning, and/or stagnating. In the Coast Mountains, Saint Elias Mountains, Chugach Mountains, Kenai Mountains, and the Aleutian Range, more than 98% of glaciers ending below ~ 1,500 m are also retreating, thinning, and/or stagnating. However, ~ 15 glaciers are currently advancing. Some advancing glaciers have tidewater termini. Many glaciers have disappeared during the 20th century. In places, retreat is resulting in the number of glaciers increasing, but volume and area decreasing. Glaciers at elevations above ~ 1,500 m show little or no change.

AK's two largest glaciers, Bering and Malaspina, are thinning and retreating, losing several cubic kilometers of ice each year to melting and calving. U.S. glaciers are a major contributor of meltwater to global sea level rise, with > 99% coming from AK.

51-5 BTH 5 Tripathi, Aradhna

A RECONSTRUCTION OF COASTAL TEMPERATURES AND UPWELLING INTENSITY ALONG THE CENTRAL CALIFORNIA COAST OVER THE PAST 4000 YEARS

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Several studies have documented regional changes in climate during the Holocene (11,000 years ago to present) along the Pacific coast. Very little is known about the climate history of central California. Previous studies have shown that the geochemical composition of mollusk shells records the environmental conditions under which they live. We are measuring the $\delta^{18}O$, $\delta^{13}C$, Mg/Ca, and Sr/Ca composition of *Mytilus californianus* (California mussel) shells from Native American middens (shell mounds) at two sites along the central California coast, and from modern sites at several latitudes in the Eastern Pacific. Geochemical data from archeological specimens are compared to data from modern specimens, and used to determine past changes in coastal temperatures and upwelling intensity. These data are used to reconstruct the natural climate variability over the past 4000 years. Preliminary results indicate significant temporal variability in coastal climates.

51-6 BTH 6 Wang, Guo

FEATURES OF BARROW'S TEMPERATURE CHANGE 6000 YEARS AGO

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A temperature record from a lake core reveals that it is warming at average rate of 0.4°C per century generally over the past 400 years at Barrow, but it is cooling from 6800 aBP to 6900 aBP. Maximum entropy spectra analysis shows temperature fluctuation cycles of 33, 40, 29, and about 90 years at Barrow. According to statistics and entropy analysis of monthly mean temperature from Barrow Meteorological Observatory in 1921-1994, there are cycles of 4 months, 6 months, 14 months, 16 months, 3 year, 4 years, 7 years and 10 years in the recent temperature change..

51-7 BTH 7 Newbrey, Michael

A NEW METHOD TO ESTIMATE EARLY HOLOCENE MEAN ANNUAL TEMPERATURE USING GROWTH CHARACTERISTICS OF FOSSIL *PERCA FLAVESCENS* (YELLOW PERCH)

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One of the best preserved Early Holocene fossil assemblages ever reported comes from the 10,000 – 7,500 year-old Seibold site located in the Missouri Coteau, near Buchanan, North Dakota. The first fossils were recovered in 1971 and included spruce needles that were still green, complete skeletons of several types of fish surrounded by oily residues, and insects with gut and internal organs still preserved. The fossil fish recovered include complete specimens of yellow perch, which can provide insight into Early Holocene ambient temperature using our newly developed methodology. Ageable skeletons of fossil yellow perch, *Perca flavescens* (Teleostei: Percidae) were recovered from a lacustrine deposit to contrast the growth patterns between fossil and extant yellow perch, and these growth patterns were used to estimate the mean annual temperature (MAT) of the Early Holocene environment. Scales and vertebrae of yellow perch were aged by counting annuli. The age and total length of yellow perch provided information for a comparative analysis between that of Early Holocene and extant yellow perch. Total length and MAT data for 20 populations of extant yellow perch, ranging in latitude from the Central Manitoba, Canada to South Carolina, USA, were analyzed using linear regression analysis to develop a new MAT index. A preliminary examination of isolated fossil scales shows potential longevity of up to 16 years, a characteristic of slow growing yellow perch from cool climates. Our preliminary results also show that three fossil yellow perch skeletons, ages one to three years, recovered from latitude 47°N had total lengths-at-age values similar to that of contemporary yellow perch from the colder climate of central Manitoba (55°N). Using regression equation parameters and total length information from contemporary yellow perch, a MAT of approximately -0.1°C was calculated for the Early Holocene North Dakota environment. Comparatively, the current ambient MAT of the Seibold site is 4.5°C. Ultimately, these new techniques could be used at other localities containing yellow perch, for example those in Kansas, Minnesota, Oklahoma, and South Dakota and offer a new test for corroboration of palynological, oxygen isotope, and insect mutual climate range analyses for estimating the temperature of Quaternary paleoclimates.

51-8 BTH 8 Scott, Kevin M.

HOLOCENE HISTORY OF MOUNT BAKER VOLCANO, NORTH CASCADES

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Following completion of edifice construction by 11,000 ¹⁴C yrs BP, Mount Baker was the site of multiple Holocene eruptions (mainly hydrovolcanic) and flank collapses. Intensely altered and water-saturated collapses mobilized to clay-rich (cohesive) lahars that traveled as far as the Puget Lowland. All significant collapses were from the SE half of the volcano, the sector between summit azimuths N 30 E and S 50 W. The main Holocene events:

Schriebers Meadow cinder cone formed near the base of the volcano (8,800 ¹⁴C yrs BP), yielding a widespread scoria fall (tephra SC) and a lava flow damming the Baker River valley, followed by flank collapse of the sector of Mount Baker upslope from the cone (8,500 ¹⁴C yrs BP).

The Mazama Park eruptive period (newly dated at 5,600-5,900 ¹⁴C yrs BP) includes collapses and eruptions previously dated throughout a range of 4,300-6,700 ¹⁴C yrs BP. Collapse occurred initially in Park Creek on the east and in the Middle Fork Nooksack River on the southwest, the latter producing the largest Holocene lahar, extending >44 km. Then, a phreatomagmatic eruption produced lithic tephra OP, synchronous with a flank collapse from near modern Sherman Crater—the active 0.5-km-wide vent south of the summit—that produced a lahar traveling >33 km. Finally, a magmatic eruption produced juvenile andesitic tephra BA, extending >34 km north-east. We interpret the events as reflecting a single intrusive cycle, with the Park Creek and Middle Fork collapses resulting from edifice destabilization by the earliest intrusion. Then, after a discrete interval (indicated by erosional stratigraphy), sequential phreatomagmatic and magmatic eruptions occurred, probably triggered directly by unloading by the collapse near Sherman Crater.

The Sherman Crater eruptive period (AD 1843 to present) began with a phreatomagmatic eruption shaping the modern crater and ejecting lithic tephra YP. Collapse (AD 1845-1847) of the east crater rim produced a lahar inundating much of the Baker River valley. Hydrovolcanic activity, including the well-documented tenfold increase in thermal activity in 1975, continues.

In AD 1890-1891, collapse from Lava Divide produced a debris avalanche/lahar extending 10.5 km; in 1927, probable seismogenic collapse of >1.0 km of stagnant ice in the distal Deming Glacier yielded a debris flow extending >10 km.

51-9 BTH 9 Scott, Kevin M.

ISLAND OF FIRE IN A SEA OF ICE—THE GROWTH OF MOUNT BAKER VOLCANO AND THE FRASER GLACIATION IN THE NORTH CASCADES

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Late Pleistocene lava and lithic pyroclastic flows, with synruptive lahars and their alluvial runouts, comprise the youngest deposits of the Mount Baker stratocone. These synruptive assemblages overlie glacial deposits of the Vashon Stage of the Fraser Glaciation. Correlation with the Vashon, beginning before 20,000 ¹⁴C yrs BP, is verified by incorporated clasts of Baker andesite, thus probably excluding any older glaciation (W. Hildreth defines the beginning of the major period of growth of the present cone at ~40,000 yrs based on K-Ar lava ages). The apron deposits around the southern half of the volcano shows that the Cordilleran Ice Sheet (CIS) surrounded the growing volcano, transporting erratics from faraway terranes and multiple directions, including dunite from Twin Sisters Mountain to the southwest.

Edifice growth was completed during the following Everson Interstade, at the time what we call Glacial Lake Baker filled the Baker River valley southeast of the volcano. The Sandy Creek beds are a varved lacustrine sequence—yielding a ¹⁴C age of 12,200±45 yrs BP—transitionally overlying erratic-bearing till like CIS diamicts elsewhere. Thus the CIS remained around the Baker edifice to near that time.

The edifice was entirely complete before an alpine re-advance correlating with the Sumas Stage or Younger Dryas. Soils on the flanks of the volcano yield ages of at least 11,020±180 ¹⁴C yrs BP and include Baker tephra SP, ca. 10,800 ¹⁴C yrs BP. The innermost in a sharply defined complex of terminal moraines in the Middle Fork Nooksack River yields these ¹⁴C ages: log at basal contact with Vashon deposits, 10,600±40 BP; logs within moraine, 10,510±40, 10,520±50, and near top, 10,550±40 BP. The moraines end 4.7 km downstream from the modern Deming Glacier, and only 3.0 km beyond the maximum extent of Neoglacial ice in the Middle Fork.

51-10 BTH 10 Koch, Johannes**HOLOCENE GLACIAL HISTORY NEAR WHISTLER, SOUTHERN COAST MOUNTAINS, BRITISH COLUMBIA**

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In a multiproxy effort to reconstruct the Holocene glacial history of the Green Lake watershed in the southern Coast Mountains, 80 km north of Vancouver, British Columbia, a combination of terrestrial (dendrochronology, lichenometry, radiocarbon) and lacustrine (varve counting, tephrochronological, radiocarbon) dating methods were used. Detrital wood in the forefield of Overlord Glacier yielded radiocarbon ages between 5900 and 6200 ¹⁴C yr BP. The narrow age range suggests that the trees were killed by advancing ice ca. 6000 ¹⁴C yr BP. At Decker Glacier, just north of the watershed, *in situ* stumps, apparently sheared by glacier ice, and one detrital log, all on a cliff high above the present surface of the glacier, yielded ages of 2900 to 3200 ¹⁴C yr BP. The implication is that the glacier was advancing and more extensive than today ca. 3000 ¹⁴C yr BP. Moraines at Overlord Glacier were dated by dendrochronology and lichenometry to around AD 1735, 1835, 1890, and 1920 (all dates include age-height and ecesis corrections). The outermost moraine at Overlord Glacier is older than 500 years and thus indicates either an early Little Ice Age or even earlier advance. In neighbouring watersheds, glaciers yield similar results, thus indicating synchronous Little Ice Age advances and at least two separate but significant glacier advances earlier during the Holocene. The continuous record of lake sedimentation from the Green Lake watershed reveals a general increase in the clastic component of lake sediments from the early Holocene to present. One of the largest increases in clastic sedimentation occurred immediately prior to the deposition of Mazama ash (6800 ¹⁴C yr BP). Green Lake sediments are rhythmically laminated after 3200 cal yr BP. Varves are thickest at ca. 750-500 BC, AD1530, AD1740, AD1850, and between AD1920 and 1945. The last period of thick varves corresponds to a time of rapid ice retreat. We interpret earlier periods of thick varves as times of enhanced sedimentation following moraine-building events. The combined record shows good accordance in the later part of the Holocene and confirms at least two Neoglacial phases coinciding with the 'Tiedeman' advance and the Little Ice Age.

51-11 BTH 11 Reyes, Alberto V.**A TALL TALE OF TILLS: EVIDENCE FOR MULTIPLE HOLOCENE ADVANCES OF LILLOOET GLACIER, SOUTHERN COAST MOUNTAINS**

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Lateral moraine stratigraphy at Lillooet Glacier, a large valley glacier in the southern Coast Mountains, is characterized by stacked tills separated by organic horizons containing *in-situ* paleosols and large wood macrofossils. Natural exposures are locally present where streams flowing from adjacent slopes have eroded through the moraine. Examination of several such gullies revealed two laterally continuous organic horizons and associated lines of detrital wood. More continuous exposures have been created by slopewash and minor gully erosion on the steep proximal slope of the moraine. Up to four organic horizons with abundant woody debris were identified at these exposures. Radiocarbon dating of detrital wood at one exposure suggests that Lillooet Glacier advanced between ca. 1600 and 1100 ¹⁴C yr BP, and again after 440 ¹⁴C yr BP. Forthcoming radiocarbon ages from other gullies, including sites with a complete sequence of four stacked tills separated by continuous organic horizons, should provide additional insight into the Holocene fluctuations of Lillooet Glacier. Dendrochronological techniques are being used to facilitate chronostratigraphic correlation of gully exposures along a ca. 3-km length of the lateral moraine.

51-12 BTH 12 Mathewes, Rolf W.**A PALEOECOLOGICAL RECORD OF CLIMATIC DETERIORATION FROM MIDDLE TO LATE WISCONSINAN TIME ON THE INTERIOR PLATEAU OF BRITISH COLUMBIA, CANADA**

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The Indianpoint section, 90 km southeast of Prince George, presents a >25 ka record of paleoenvironmental changes from non-glacial Middle Wisconsin time to just before Late Wisconsin ice from the Cordilleran Ice Sheet overran the site. Detailed plant and insect macrofossil analyses of a 5-6 m thick fine grained unit reveal that it represents a small lake, based on aquatic plants and insects, and taxa indicative of riparian or shoreline environments. Radiocarbon ages of 33.3 ka (TO-9159) and 46.5 ka (CAMS 93938) were obtained on willow (*Salix*) twigs near the base. The lower 30 cm of the unit is characterized as shrub tundra dominated by willow with some shrub birch (*Betula*), and no macrofossil evidence of conifers. Directly above 30 cm, abundant needles, seeds and seed wings of spruce (*Picea*) indicate that this tree was locally present, probably in small groves. Further analyses of samples from the lower portion of the section will be carried out to clarify the record of forest vegetation. The middle portion of the section indicates tundra with willow and minor birch. In the upper 2.5 m of the section, between 24.5 ka (CAMS 93940) and 20.4 ka (CAMS 93939), the vegetation changes to dry shrub tundra, dominated again by willow with minor birch. Characteristic insects such as the weevil *Vitavitus thulius* and the ground beetles *Trichocellus mannerheimi*, *Pterostichus* (*Cryobius*) *nivalis*, and *Amara alpina* are presently only found in dry tundra habitats. The upper 40-50 cm of the lacustrine unit shows a decrease in the occurrence of willow and represents dry herb tundra. An age of 19.9 ka (AA44045) has been obtained on a willow twig 20-30 cm below where the unit is truncated by a Late Wisconsinan till. More AMS radiocarbon ages and a pollen diagram to complement the macrofossil evidence are in progress.

The lacustrine unit of the Indianpoint section spans >25 ka and records climatic deterioration associated with the growth of the Cordilleran Ice Sheet during the Late Wisconsinan. The increasingly dry and cold conditions indicated by the macrofossil assemblage likely reflect the growth of ice in the Coast Mountains which would reduce the availability of moisture to the Interior Plateau from Pacific air masses.

51-13 BTH 13 Bilderback, Eric L.**TIMING AND PALEOCLIMATIC SIGNIFICANCE OF LATEST PLEISTOCENE AND HOLOCENE CIRQUE GLACIATION IN THE ENCHANTMENT LAKES BASIN, NORTH CASCADES, WA**

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The Enchantments Lakes Basin in the Alpine Lakes Wilderness, WA, preserves two sets of moraines that record distinct post-Wisconsin maximum advances of cirque glaciers in the eastern North Cascades. Cores collected from five lakes adjacent to the moraines preserve detailed records of the timing and extent of the advances. The cores show no evidence for early Holocene advances, in contrast to some other studies in the North Cascades. (e.g., Heine, 1998; Thomas, 1997).

Upstream glacier activity, as indicated by rock-flour production, is recorded in the lake sediments as fluctuations in magnetic susceptibility, organic content, and sediment particle size. Tephra identification, AMS ¹⁴C dating and secular variation recorded by the sediments provide detailed age constraints for the lake cores. The presence of the 475-year-old Mt. St. Helens W₁ tephra within outwash associated with the inner (Brynhiid) moraines indicates that they are Little Ice Age (LIA) equivalent, and that the advance began between ~1100-700 cal yr B.P. The age of the outer (Brisingham) moraines, previously reported as early Holocene (Waitt et al., 1982), are instead latest Pleistocene; basal ¹⁴C dates demonstrate that this advance ended shortly before ~11,300 cal yr BP, suggesting temporal equivalence with the North Atlantic Younger Dryas climatic reversal (12940±260 – 11640±250 cal yr BP; Alley et al., 1993). An early Neoglacial advance, which was less extensive than the subsequent LIA advance, is recorded in the sediment cores and lasted roughly 400 years between ~3300 and ~2900 cal yr BP. Steady-state equilibrium-line altitudes (ELAs) for Brynhiid and Brisingham advances estimated with accumulation-area ratio and balance-ratio methods are distinct but nearly indistinguishable at ~2365 m. Following Leonard (1989), conditions required to form and sustain the Brisingham and Brynhiid paleoglaciers include a summer temperature depression of ~3° C, an increase of ~90 cm water-equivalent in winter precipitation, or, more likely, some intermediate combination of the two. These constraints imply a regional climate that could support only minor advances in the latest Pleistocene, and none in the early Holocene.

51-14 BTH 14 Bovet, Paul Martin**A PALEOENVIRONMENTAL RECORD OF THE LATE PLEISTOCENE AND HOLOCENE INFERRED FROM ORGANIC CARBON ANALYSIS OF GLACIAL LAKES SEDIMENTS IN THE ALBION RANGE, IDAHO**

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Bottom sediments from lakes in the Albion Range of south-central Idaho provide a record of late Pleistocene to Holocene geomorphic and climatic change. During the late Pleistocene, cirque and small valley glaciers occupied valley heads surrounding Cache Pk. in the southern Albion Range and Mt. Harrison in the north. Moraines and stagnation topography formed during ice recession impound small lakes. We cored several of these lakes and analyzed cores from three; Independence Lakes I and II below Cache Pk. and Lake Cleveland below Mt. Harrison. Analysis involved stratigraphic description, identification of tephra layers, measurement of organic carbon content (OC), particle size, and magnetic susceptibility, and macrofossil AMS radiocarbon dating.

The three cores have very similar stratigraphy. Each bottomed in hard sediment that we interpret as glacial till or outwash. This layer is overlain by laminated, organic-deficient, silts, overlain in turn by massive, much more organic-rich, silts and clays. Within the upper organic-rich unit, OC is highest near the base and lower toward the top. The sequence is best dated in the Independence Lake I core, which is radiocarbon dated at 6 levels and contains two dated tephras. In that core an AMS age of 13020±50 ¹⁴C yr. BP from the laminated silts provides a minimum age for deglaciation. The transition from basal silts to the overlying organic sediment began after 12820 ± 12 ¹⁴C yr. BP and was completed by 9925 ± 40 ¹⁴C yr. BP. This change probably reflects the final disappearance of ice from the drainages and/or an abrupt change to warmer conditions, with increased organic productivity and landscape stabilization by vegetation, at the beginning of the Holocene. OC remained very high until sometime after 8330 ± 60 ¹⁴C yr. BP, then dropped significantly before deposition of Mazama Ash ca 6800 ¹⁴C yr. BP. This drop likely marks the end of an early Holocene Allithermal period. Although glaciers did not reform, the change in OC in all three lakes suggests a mid-Holocene transition to cooler and/or wetter conditions, leading to increased periglacial activity and decreased organic productivity. At Lake Cleveland there is evidence of a further small drop in OC near the core top, possibly related to further cooling during the "Little Ice Age". This change is not evident in the Independence Lakes cores.

51-15 BTH 15 Rosenbaum, Joseph G.**THE GLACIAL TO HOLOCENE TRANSITION IN SEDIMENTS FROM BEAR LAKE, UTAH/IDAHO**

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Bear Lake, in northeastern Utah and southern Idaho, lies at an elevation of 1800 m, covers an area of 280 km², and has a maximum depth of 63 m. Throughout most of the Holocene, the Bear River did not flow into Bear Lake and Holocene sediments are comprised largely of endogenic carbonate. Glacial-age sediments, however, are comprised of organic-poor siliciclastic material, much of which was delivered to the lake by the Bear River. AMS ¹⁴C dates were obtained on a variety of materials including pollen concentrates, ostracodes, and total organic carbon. Beginning at some time prior to 32 cal ka, a significant amount of glacial flour derived from the Uinta Mountains was contributed to the siliciclastic sediments. In comparison to other clastic material, the glacial flour is finer-grained, hematite-rich (as determined by magnetic properties), and characterized by high Al relative to Ti. Taking the ¹⁴C-based chronology at face value, the content of glacial flour displays a number of well-defined millennial scale fluctuations before peaking at 25-24 cal ka. This suggests that maximum glacial extent in the Uintas occurred significantly earlier than in many areas. Alternatively, the ¹⁴C ages for this part of the record may be too old. For these glacial flour-rich sediments, all ¹⁴C ages were obtained from pollen concentrates that contained sparse degraded pollen, small pieces of charcoal, and other refractory organic material. Such materials may have been sequestered in the catchment. Younger sediments contain much more abundant, well preserved pollen. From 22 to 17 cal ka content of hematite-rich material from the Uintas declined while the proportion of more magnetite-rich material (probably from the local Bear Lake catchment) increased. Beginning at 17 cal ka, shortly after the catastrophic draining of Lake Bonneville, the Bear River gradually abandoned Bear Lake over a period of about 3,000 years, and clastic sediments were replaced by endogenic carbonate. Draining of Lake Bonneville may have contributed to the loss of the Bear River from Bear Lake by reducing lake-effect precipitation and thereby the volume of Bear River flow.

51-16 BTH 16 Reynolds, Amanda C.

NUTRIENT SOURCING OF NINE PLANT SPECIES IN THE SOUTHWESTERN U.S. USING STRONTIUM ISOTOPES

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The nutrient enrichment anomalies surrounding trees and shrubs in the Southwestern U.S. has long been a source of contention. Patches of increased nutrient concentrations at the base of trees may be due to the lateral import of nutrients by tree roots with a resulting depletion in peripheral areas or due to foliar trapping of nutrient-rich dust followed by incorporation of the throughfall into the underlying soil. If the former were true, the nutrient source for all plants at a particular site would be similar, and so would the ⁸⁷Sr/⁸⁶Sr ratio of all plant species at a given site. If life history and growth form influences the efficiency to trap atmospheric dust, however, nutrient sources and radiogenic isotopes of cellulose could vary among species. Plant reliance on dust inputs can vary depending on surface-to-volume ratio of the foliage, the plant's degree of dependency on soil waters, and the depth of the rooting zone. We suspect that the grasses will be the most dependent on silicate mineral weathering for their nutrient supply, and therefore exhibit ⁸⁷Sr/⁸⁶Sr ratios much more similar to that of bedrock. Trees with dense foliage, on the other hand, should be much more efficient at trapping eolian dust, and therefore should exhibit ⁸⁷Sr/⁸⁶Sr ratios closer to that of atmospheric dust ratios.

We measured ⁸⁷Sr/⁸⁶Sr ratios in cellulose and bedrock to gauge the dependence of trees, grasses, and shrubs on atmospheric dust as a nutrient source for 8 prevalent species of trees, shrubs, and an annual grass (*Pinus ponderosa*, *Pinus edulis*, *Juniperus monosperma*, *Juniperus scopulorum*, *Chrysothamnus nauseosus*, *Fallugia paradoxa*, *Rhus trilobata*, and *Bouteloua gracilis*) at El Malpais National Monument, New Mexico. Sampling sites varied by bedrock type (limestone, sandstone, granite, cinder and basalt) and by age (Quaternary to Precambrian). Local dust ⁸⁷Sr/⁸⁶Sr ratios at El Malpais and surrounding areas are tied by marine carbonates with minor additions from local bedrock. In our study, we found local dust ranges (.7059-.7083) within tree species with minor basalt contributions at sites with basaltic bedrock. Basalt in the area is known to efficiently trap dust within crevices. Such crevices may allow for more chemical contribution by local bedrock. The resulting data demonstrate the ability of Sr isotopes to decipher nutrient source variability within the study site.

51-17 BTH 17 Barton, Bax R.

INTERPOLATED PALAEOTEMPERATURES FOR LATEST PLEISTOCENE TO EARLY HOLOCENE MAMMOTH FINDS FROM WESTERN NORTH AMERICA

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Recent overall acceptance by the archaeological community of the validity of the Monte Verde archaeological assemblage and its early ¹⁴C chronology (Meltzer *et al.* 1997) has led to a new awakening in several lines of late Pleistocene palaeoenvironmental and archeological research in North America. The results from Monte Verde, coupled with a new assessment of the actual record of late Pleistocene megafaunal extinctions in North America, necessitate abandonment of the 'overkill' model as proposed by Martin (1967) and various co-authors. The three inferential legs of the tripod that support the 'overkill' model can now be shown to be either wrong, inconclusive, or lacking in significant supportive evidence. Clearly the Clovis Culture was not the first to arrive in the Americas, and extensive evidence of association between North American megafauna and Clovis predation remains either elusive and/or insignificant (Grayson and Meltzer 2002). Chronologically the extinction 'event' of the model can now be shown to have been composed of multiple extinctions most likely occurring over a period of no less than 10,000 years (Grayson and Meltzer 2003). The void created by the demise of the 'overkill' model only serves to emphasize our general lack of genus/species specific palaeoenvironmental data for extinct North American megafauna species. In short, it has always proven easier to attack the 'overkill' model, and much harder to produce useful data in support or opposition to the various 'climate- and/or environmental-change' extinction models (Graham and Lundelius 1984; Guthrie 1984). This poster presents the results of nascent research into extracting palaeotemperature data for western North American mammoth sites out of the previously published palaeoclimatic model data for this region (Thompson *et al.* 1994). Seventy-four radiocarbon or culturally dated mammoth finds, ranging in date from the Last Glacial Maximum (LGM) to the early Holocene, are assigned tentative palaeotemperature values based on interpolated data drawn from this model, and the significance of these temperatures for mammoth extirpation from North America is noted.

51-18 BTH 18 Wang, Hong

SHORT-TERM VARIATION OF C₃/C₄ PLANTS AND GROWING-SEASON CLIMATE IN CARBON AND OXYGEN ISOTOPES OF CARBONATE ROOTLET CASTS

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Records of terrestrial paleoclimate with annual to decadal resolutions are difficult to assemble. Unlike the marine environment, there is a lack of quantifiable proxies for temperature, humidity, and plant biomass in the terrestrial environment, and implications are often made based on modeling and vague indices rather than accurately measurable parameters. This problem is keen in arid and semiarid regions where pollen records are rare, making the reconstruction of past climate and habitat particularly challenging. One promising approach for determining short-term variations of C₃/C₄ plants and growing-season climate in arid-semiarid regions is to analyze carbon and oxygen isotopic compositions of small carbonate rootlet casts. Micro and macro morphologies of these carbonate rootlet casts reveal that they formed around living and respiring roots. The nucleation center of calcite precipitation is within root epidermal and cortex cell walls. Microorganisms such as fungal hyphae associated with the living plant roots are also seen calcified inside and outside the root cells, suggesting that root respiration provides the primary carbon source. Rootlets have short life spans and root respiration occurs only during growing seasons. Thus, carbon and oxygen isotopic compositions of carbonate rootlet casts should provide evidence for short-term variations in C₃/C₄ plants and growing-season climates. This approach has demonstrated that during the last glaciation, seasonal climate events in terrestrial environments such as monsoonal seasonalities and El Niño/Southern Oscillation abnormal patterns could be imprinted in the carbon and oxygen isotope signatures of carbonate rootlet casts. Furthermore, the distribution of global arid-semiarid soils expanded significantly during the last glaciation and the formation of soil carbonates may have been an important process in the sequestration of atmospheric CO₂. Hence, measuring the thickness and the completeness of rootlet cell walls replaced by micritic calcite crystals may provide valuable information for modeling the contribution of soil carbonates to the atmospheric CO₂ concentration during that time.

51-19 BTH 19 Cole, Kenneth L.

HOLOCENE VEGETATIONAL DISEQUILIBRIUM SUGGESTED BY SLOW DISPERSAL OF LATE-SUCCESSIONAL TREES AND SHRUBS OF WESTERN NORTH AMERICA

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AMS radiocarbon dating of plant macrofossils from packrat (*Neotoma* spp.) middens verifies migrational timing of western North American trees and shrubs such as creosote bush (*Larrea tridentata*) and piñon pines (*Pinus monophylla*, *P. edulis*). These records document their late Wisconsinan ranges and subsequent Holocene migrations into their current ranges. Creosote bush grew in the lower Colorado River Valley during the late Wisconsinan (Isotope Stage 2). Starting around 11,000 yr B.P., it migrated northward and upslope into its present range. By 6000 yr B.P. it had spread upslope to above its current limits in the northern Mojave Desert. Despite evidence of cooling late Holocene climates from isotope and tree-ring proxies, it continued to migrate northward, albeit at a slower rate. Three northerly populations did not arrive at their current limits until around 4000, 2500, and 2000 yr B.P. Its migration lagged well behind other desert thermophiles suggesting that migrational distance played a key role in its rate of dispersal. Single-needle piñon (*Pinus monophylla*) migrated northward from the Mojave Desert into the Great Basin arriving near its current northeastern limit as early as 7000 yr B.P. but more slowly in the western Great Basin where it reached its northwestern limit around 2000 yr B.P. Colorado piñon (*Pinus edulis*) migrated from near its current southern boundary northward, reaching the eastern Grand Canyon as early as 10,600 yr B.P. It is not recorded from central Utah until after 7000 yr B.P. It evidently moved northward slowly, arriving at some northerly and easterly stands only within the last 1000 years. These migrational histories reflect a combination of dispersal limitations and periodic climatic changes. But the long migration times required suggest that the primary factor slowing their response was migrational distance. These results have implications for vegetational effects of the expected climate shifts of the next century. The observed differential migration rates over short upslope distances versus long latitudinal distances, and between early and late successional plant species, suggest that these data may be of greater use in modeling the dynamics of differential vegetational response to future warming than in reconstructing Holocene paleoclimates

51-20 BTH 20 Coats, Larry L.

MIDDLE WISCONSINAN VEGETATION ON THE COLORADO PLATEAU, UTAH AND ARIZONA, USA: EVIDENCE FOR GLACIAL-AGE MONSOONS?

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Packrat (genus *Neotoma*) middens provide paleoecological information for arid regions of southwestern North America. A rich vegetation history for the late Wisconsinan through Holocene times has been reconstructed for the Colorado Plateau of Utah, Arizona, New Mexico, and Colorado, but midden deposits older than 25 ka yr B.P. are rare. Our review of midden records found that only 7% (n=2243) of middens from the Colorado Plateau exceeded 25 ka ¹⁴C yr B.P. in age. We report the results of paleoenvironmental studies using packrat middens collected from the Colorado Plateau in Canyonlands and Grand Canyon National Parks. Fifteen of sixty middens analyzed yielded a middle Wisconsinan age, dating from 27 ka to 46 ka ¹⁴C yr B.P. These are the oldest midden series yet discovered on the Colorado Plateau. The middens from the Grand Canyon contain a substantially mesic assemblage of vegetation for the last 40 ka yrs of the Wisconsinan Glaciation, with some taxa displaced as much as 1200 m vertically downward from their modern distributions. For example fernbush (*Chamaebatiaria millefolium*), rose (*Rosa stellerata*), and big sagebrush (*Artemisia tridentata*) were growing on sun-exposed ledges at 1100 m from ~50 ka to 10 ka ¹⁴C yr B.P. These species occur between 1300 and 1900 m today. In contrast, the oldest of the middens from Canyonlands (~50 ka to 29 ka ¹⁴C yr B.P.) record a xeric assemblage of vegetation, including dwarf mountain-mahogany (*Cercocarpus intricatus*), Mormon tea (*Ephedra torreyana*), and Utah juniper (*Juniperus osteosperma*), a grouping almost indistinguishable from modern plant assemblages. Furthermore, some of these middens contain fossils of Arizona single-needle piñon (*Pinus edulis* var. *fallax*), a species that today is more typical of areas in central Arizona receiving abundant monsoon precipitation. This tree does not occur in Canyonlands today, with the closest populations more than 100 km downstream along the Colorado River. The presence of this species in Canyonlands during the middle Wisconsinan, and the absence of montane species, contrasts sharply with the mesic late Wisconsinan vegetation assemblages documented by our work and in the literature. Our data suggest the existence of an interstadial climate regime, and that a weak monsoonal flow may have been present during summer months that possibly influenced the vegetation as far north as central Utah.

51-21 BTH 21 Baker, R.G.

VEGETATION ON THE EASTERN GREAT PLAINS, NORTH AMERICA, DURING MID-WISCONSINAN TIME—LATE MIS STAGE 3—EARLY MIS STAGE 2

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Little is known about the history of prairies on the central Great Plains. Specific questions involve whether prairies were present during the cool period prior to the last glacial maximum (LGM), and if so, whether they survived in situ or were displaced during the subsequent glacial advances to the north. Pollen and plant macrofossil analyses from several sites on the eastern edge of the central Great Plains, in eastern Nebraska and Kansas and western Iowa, reveal consistent changes in vegetation between ~33,000 and 20,000 ¹⁴C yr B.P. Between 33,000 and about 27,000 ¹⁴C yr B.P., upland vegetation was apparently very open, with prairie species and scattered Picea, Populus, and Betula cf. papyrifera. Woody riparian/wetland taxa included Salix spp., Betula glandulosa, and Myrica gale. These taxa suggest a modern analog might be aspen parkland near the boreal-forest border. A rich wetland and aquatic vegetation was abundant at all sites. A Picea forest rapidly became widespread across midwestern United States beginning about 24,000 ¹⁴C yr B.P., and prairie taxa disappeared. As is commonly the case in Wisconsinan Picea-dominated assemblages, there is little else present but Carex spp. These assemblages suggest an analog in the species-poor boreal forest, and a significant climatic shift toward cooler, moister conditions. Picea forests persisted at some sites until after 20,000 ¹⁴C yr B.P., but in other settings, the persistence of Picea is unknown, because the fossil record ended earlier when loess accumulation began to fill wetlands with silt. The Mid-Wisconsinan parkland was thus displaced, probably southward and westward, from the eastern edge of the central Great Plains as climate cooled during glacial expansion.

51-22 BTH 22 Panyushkina, Irina P.

TREE-RING INVESTIGATION OF THE YOUNGER DRYAS IN THE U.S. UPPER MIDWEST
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 The warming from Late Glacial to Early Holocene was interrupted by an abrupt, cold excursion known as the Younger Dryas (YD) event. There is abundant evidence of this event in Europe, but there is less evidence and clarity of its effects in N. America, even though events in central N. America (melting of the continental ice sheet) may well have been responsible for triggering the YD. In this project, the environmental changes in mid-North America is being investigated over several millennia (ca. 10,000 to 14,000 ¹⁴C-yr BP) during the Late Glacial-Early Holocene transition, including the YD interval. More than 10 sites have been identified from which wood of this interval has been preserved by sedimentation, a few of which contain dead trees in their growth position (stumps). All sites will be sampled (or re-sampled) over the next 2 years, but a large number of pieces of wood have been examined from 3 sites: two from archival collections collected at least a decade ago, and a third site collected in August 2001. Like many of the sites of this age interval in the Midwest, two of the sites consist of spruce trees (the other is hardwood). Tentative tree-ring chronologies have been built from these specimens including from the Wisconsin Two Creeks forest (11,640 ¹⁴C-yr BP) and the Michigan Gribben Basin forest (10,000 ¹⁴C-yr BP). The chronology from the Illinois Lincoln Quarry site is much less certain because trees were not in growth position and a wide range of ¹⁴C ages were measured. This is the first step in systematically constructing the first high-resolution portrait of the Late Glacial/Early Holocene transition in mid-N. America using chronologies of tree-ring widths, ring anomalies/events (such as frost rings), stable isotopes and radiocarbon activity.

51-23 BTH 23 Dean, Walter E.

THE LACUSTRINE CARBON CYCLE AS ILLUMINATED BY THE WATERS AND SEDIMENTS OF TWO HYDROLOGICALLY DISTINCT LAKES IN MINNESOTA, USA

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 The accumulation rates of CaCO₃ and organic carbon (OC) in lake sediments are delicately balanced between production in the epilimnion and destruction in the hypolimnion. The cycling of these two forms of carbon comprises a "carbon pump" that greatly affects the biogeochemical cycles of other elements. To further understand these biogeochemical dynamics, the lakes, streams, and wetlands of the Shingobee River headwater area of northwestern Minnesota have been subjected to intensive hydrologic and biogeochemical studies. Williams Lake, situated close to the highest point in the regional flow system, is hydrologically closed, with no surface inlet or outlet, and ground water and precipitation as the only sources of water. Shingobee Lake, situated at the lowest point in the regional flow system, has the Shingobee River as an inlet and outlet. The surface waters of both lakes are oversaturated, and the bottom waters undersaturated, with respect to CaCO₃ during the summer. The small amount of CaCO₃ that is precipitated in the epilimnion of Williams Lake during the summer is dissolved in the undersaturated hypolimnion and sediments with the result that no CaCO₃ is incorporated into the profundal surface sediments. Because of the high phytoplankton productivity of Shingobee Lake, sufficient CaCO₃ is produced in the epilimnion that large amounts survive the corrosive hypolimnion and sediments. Another consequence of higher phytoplankton productivity in Shingobee Lake is that the hypolimnion becomes oxygen deficient within a month after overturn in both the spring and fall. Because of reducing conditions that develop in the hypolimnion of Shingobee Lake, high concentrations of dissolved Fe and Mn accumulate there during summer stratification. Precipitation of Fe and Mn oxyhydroxides during periods of fall and spring overturn results in concentrations of Fe and Mn in surface sediments that are 7 times and 27 times higher, respectively, than can be explained by contributions of Fe and Mn from detrital aluminosilicates. High concentrations of Fe and Mn do not build up in the hypolimnion of Williams Lake

51-24 BTH 24 Swinehart, James B

MULTIPLE GENERATIONS OF LATE HOLOCENE LINEAR DUNES, NEBRASKA SAND HILLS, USA

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 Extending over 58,000 sq km and presently stabilized by native grassland, the Nebraska Sand Hills have mobilized several times in the Holocene. Limited optically stimulated luminescence dates, mostly from the large-scale transverse dunes, indicate these dunes were actively migrating during one or more periods of aridity between 3-9 ka. Recent optical dating of small-scale dunes, and upland paleosols, combined with radiocarbon dating of aeolian sand beds in interdune peatlands, indicates there were several periods of aridity and dune activity within the last 3 ka. In the central and eastern Sand Hills, these late Holocene aeolian bedforms are primarily linear dunes, 1-3 km long and 15m high, occurring either in discrete dune fields or superimposed on larger transverse dunes. Preliminary optical dates of aeolian sand collected from the superimposed linear dunes suggest that they were formed between 950 and 750 a. This episode of dune activity is coeval with the "megadrought" preserved in aeolian sand sheets in interdune wetlands within the central Sand Hills. However, OSL dates from linear dunes near the southeastern and eastern edge of the Sand Hills, indicate dune activity between 2.5 and 2 ka and 500-600 a. It appears that much of the eastern half of the Sand Hills have seen linear dune mobilization during drought episodes of the past 2.5 ka, however different areas were active at different times and associated wind regimes may not have been the same.

51-25 BTH 25 Arbogast, Alan F.

EARLY HOLOCENE MOBILIZATION OF EOLIAN SAND IN EASTERN LOWER MICHIGAN
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 Dune fields are geomorphically sensitive landforms that are excellent indicators of paleoenvironmental change. Most research on North American dune fields has focused on grassland and desert systems where widespread mobilization of eolian sand occurred in the late Holocene. Forested dunes that occur in glaciated regions, in contrast, have generally received less attention. Nevertheless, research indicates that now forested dunes developed because of 1) deflation of unvegetated deglacial/lacustrine surfaces (e.g., Connecticut, Saskatchewan) during the late Wisconsin; 2) fire during cold/dry intervals in the Holocene (e.g., Quebec); and 3) increased mid-Holocene aridity (e.g., Minnesota). A place that contains a number of forested dune fields is the interior of Michigan. One of the largest interior dune fields is the Saginaw dune field, which covers the Saginaw lowland in Michigan's eastern lower peninsula. This dune field contains mostly parabolic and transverse dunes, largely with northwestern (~ 315°) orientations, that mantle the lacustrine surface created by pro-glacial Lake Saginaw ~ 16,000 cal. yrs B.P. In general, these dunes

are thought to have formed shortly after subaerial exposure of the lake plain. This hypothesis was recently tested through OSL dating of eolian sand and radiocarbon dating of basal peats. Basal radiocarbon dates (2σ) provide maximum-limiting dates ranging between ~ 16,200 and 12,900 cal yrs B.P. OSL dating indicates that widespread mobilization of eolian sand last occurred between ~ 11 and 9 ka. Thus, it appears that the landscape of eastern lower Michigan may have stabilized more slowly following deglaciation than previously thought. A contributing variable may have been the rapid drop in the level of Lake Huron to the Stanley phase in the early Holocene, which may have lowered the regional water table sufficiently to promote mobilization of eolian sand in the interior. Localized reactivation of dunes occurred in the late Holocene, with burial of paleosols occurring at ~ 1,100, 850, 425, and 200 cal yrs B.P.

51-26 BTH 26 Glover, Katherine C.

TRACKING CLIMATE CHANGE IN OHIO THROUGHOUT THE LAST TERMINATION: A NETWORK OF PALEOBASINS DATING TO C. 16,000 ¹⁴C YRS BP

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 Data from the North American Midwest documenting the Last Termination remain scarce, but recent work has identified a network of ~25 closed basin sites throughout Ohio that help fill this data gap. Preliminary analyses, including loss-on-ignition (LOI), magnetic susceptibility, and radiocarbon dating control from 1-3 horizons, show that 1) the basal ages in multiple sites range from 14,660 ±83 to 16,400 ±170 ¹⁴C yrs BP and 2) these sites track both local conditions and regional climatic forcing. The sites within this network fall into four spatially controlled areas. The first cluster, located on the southern half of a north-south trending interlobate area in west-central Ohio, contains site 0201 – this is currently the most studied paleobasin of the network. The record therein shows a sudden increase in organic and algal productivity at 13,390 ±280 ¹⁴C yrs BP after deposition of a thick (~3 m) sequence of loess. Local biota flourish due to an apparent warming event at this time, marking the largest environmental shift record in this sector. The second cluster lies in the till plains of western Ohio, where wind-blown silt contributes to sedimentation rates so high that most paleobasins are filled prior to c. 13,000 ¹⁴C yrs BP. The third cluster is located in the northwest portion of the interlobate complex. These sites are generally younger than other areas and lack both the thick loess package and strong warming indications. The fourth cluster is in the uplands of northeastern Ohio, where loess input ceases c. 12,740 ±100 ¹⁴C yrs BP but the timing of punctuated LOI increases range from c. 11,350 to 12,740 ±100 ¹⁴C yrs BP between local sites. This reconnaissance work shows that the onset of deglaciation and ice sheet recession occurred before 16,400 ±170 ¹⁴C yrs BP at the southwestern portion of the network, and rapidly progressed northward. Subsequently, high eolian sedimentation prevailed in a sparsely vegetated, periglacial terrain. Most sites then transitioned into shallow lakes or bogs and completely infilled by early Holocene. Our current dating resolution and variant proxy curves for these sites do not yet show a single event at all sites, but rather increases in biological activity appear to have crossed local thresholds. Thus, the timing and nature of Last Termination warming remains open in these regional records.

51-28 BTH 28 Haas, Jean Nicolas

THE CHANGING FLORA OF THE FERNBANK INTERGLACIAL SITE NEAR ITHACA, NEW YORK, USA

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 The Fernbank Interglacial section (42°33'00"N, 76°37'12"W) by Lake Cayuga, near Ithaca, New York, is a rare North American interglacial locality, presumably Sangamonian and early Wisconsinan (ca. 130,000-115,000 years BP). It is therefore of special interest for the reconstruction of climate, flora and vegetation, especially because of abundant pollen and plant macrofossils. Pollen zones indicate deciduous forest preceded boreal forest. Transfer functions applied to the pollen spectra indicate mean July temperature ranged from 23°C to 18.0°C; the modern temperature is 20.3°C. Abundant seeds of thermophilic water plants (such as *Najas flexilis*) during the hypsithermal point to drier conditions and possibly to 1-2°C higher summer temperature than today. Special plant fossils such as *Physoecarpus opulifolius* (Ninebark), *Eupatorium maculatum* (Joe-Pye Weed), *Rubus allegheniensis* (Allegheny Blackberry), *Euphorbia vermiculata* (Vermiculate Spurge) and *Rorippa islandica* (Islandic Water-cress) allow insights into the local, dry- and wetland herb vegetation and phytodiversity. In addition, a huge charcoal input shows that major fire events must have occurred during the terminal Sangamonian and beginning Wisconsinan. Single charcoal particles analysis reveals that pine stands (e.g. *Pinus strobus/Pinus resinosa*) burned down, and this sheds a first light on the climate-related fire history of the North American Continent ca. 118'000 years ago.

51-29 BTH 29 Donders, T.H.

A PALYNOLOGICAL APPROACH TO RECONSTRUCT PAST EL NIÑO-VARIABILITY; FIRST RESULTS FROM A SUB-TROPICAL FLORIDA WETLAND

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 South-Florida wetland vegetation patterns are determined by hydroperiod and water depth which in turn depend on precipitation levels. Changes in these parameters immediately result in the adjustment of local plant communities. Hence, shifts in vegetation through time most likely represent changes in local water availability. Over 50% of the winter precipitation in Florida depends on the strength of the El Niño Southern Oscillation (ENSO). Past vegetation changes, reconstructed by means of pollenanalysis, reflect past wetland hydrology. Analysis of well-dated peat sections on high temporal resolution may thus provide valuable clues about past El Niño-variability, magnitude and persistence.

Evaluating the extent of vegetation response to known variations in hydrology, allows calibration and quantification of naturally occurring vegetation changes. Peat profiles from a mixed cypress swamp in Fakahatchee Strand, Florida (U.S.A.) have been examined for pollen and spores. The high resolution records reveal several dry periods, the latest of which can be attributed to wetland drainage starting in 1930 (AMS radiocarbon-dated). An earlier dry phase, approximately between 1750 and 1850 AD, is of the same magnitude as the recorded change caused by human activities in the 20th century. An even larger vegetation change is apparent in the deepest part of the profile, where present-day cypress forest was preceded by wet prairie-fringe vegetation indicating substantially lower water tables and shorter hydroperiods. Additionally, within this dry period spells of high *Salix* abundance occur indicating short wet phases.

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Pollen analysis in fast-accumulating Florida peat sediments provide a sensitive tool for reconstructing past hydrologic conditions. Spatial patterns of South Florida vegetation, surface pollen assemblages and water regime are well studied and provide a solid basis for interpretation of past vegetation changes. Further dating (now in progress) will establish the exact timing and duration of past dry phases and their relation to climatic global events (e.g. Little Ice Age), comparison with other proxies will provide clues about phases of altered ENSO persistence and magnitude.

51-30 BTH 30 Mörner, Nils-Axel

ENSO EVENTS, EARTH'S ROTATION AND OCEAN SURFACE CIRCULATION

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The El Niño/ENSO events have turned out to represent a very important process in the Earth's geodynamic system. From a geological point of view, it has been proposed that there also exist similar signals lasting for decades up to a century or so, viz. "super-ENSO" events. The driving forces should be an interchange of angular momentum between the solid Earth and the hydrosphere (in a feedback coupling) recorded in the East-West displacement of equatorial water masses and the related variability (beat) of the Gulf Stream, the Kuroshio Current, the Humboldt Current, etc. and its paleoclimatic-paleoenvironmental effects on the bordering coasts and land masses. Sea level changes in direct anti-correlation are, for example, recorded between Peru and East Africa, and between Europe and Connecticut. The idea has been successfully tested by instrumental records for the last 300 years in Europe. Variations in the Earth's rotation correlate with the variability of the Gulf Stream system recorded in regional sea level and paleoclimate. During the Spörer, Maunder and Dalton Sunspot Minima, Earth experienced a general speeding-up due to the decreased Solar Wind out-put and its retarding effect on Earth rotation. During these periods, cold Arctic water was pulled down along the European coasts all the way to central Portugal, hence experiencing a drastic cooling or "Little Ice Age" of the bordering land areas. At the same time, the hot Gulf Stream water was concentrated to Gibraltar and northwest African region, which hence experienced a simultaneous warming or "Little Interglacial". The ocean surface circulation (also a very large heat store) is the first hydrosphere layer to respond to changes in Earth's rate of rotation. Besides thermo-haline forces, rotation is proposed as a prime factor for driving changes in ocean circulation (e.g. www.pog.su.se/sea; GeoJournal, 37.4, 1995, 419-430).

51-31 BTH 31 Curry, Robert R.

THE PARDEE — CHAMBERLIN ERRATIC: A QUATERNARY ENIGMA

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A ±15 km glacially polished and transported erratic was recovered from the surface of a high shoreline beach ridge of glacial Lake Missoula in Missoula, Montana, USA. The boulder surface has compression features and glacial meltwater polish typical of englacial erratics with a long or multi-cycle transport history. It may have been carried by the primary ice stream in the Rocky Mountain Trench from eastern British Columbia into northern Idaho or northwestern Montana to calve off in a large enough iceberg to be transported by wind 100 or more km southeastward to be stranded on a high ice-dammed lake shoreline.

The lithology of the erratic appears to resemble impact regolith breccias that are believed to be of lunar origin. The matrix of the breccia is a fine-grained red quartz and plagioclase(?) arkosic metasilt and the sharply angular matrix-supported breccia clasts are white and dark grey quartzite(?). No sedimentary structure is evident. No petrographic or chemical analysis has been done. The full remarkable transport story is yet to be deduced from the boulder's surface features. All clasts appear highly shocked. Oxidation and/or reduction patterns similar to some Mid-Proterozoic Belt Supergroup quartzites that exist in the possible glacial source areas would even permit origin hypotheses that allowed remobilization of a meteorite or adjacent deposits that fell during Precambrian time. The matrix-support of the breccia resembles a fall-back impact deposit like those at Sudbury, Ontario and like those classed as lunar impact deposits.

Enough meteorite fragments have been collected in Antarctica and the Arabian Peninsula in the last 20 years to establish a group of characteristics that identify lunar impact ejecta. Although this erratic was found in the 1970's, it has been necessary to wait until today to present this object for peer criticism and review. Glacial or ice-rafted transport is certain. The rest of the story is yet to be deduced using richly creative multiple working hypotheses. This poster session presents the erratic itself and its geologic context. It is named in honor of Joseph Pardee who was willing to present himself to peer ridicule with the hypothesis of a giant ice-dammed lake, and to T. C. Chamberlin who presented Quaternary and planetary scientists with tools for evaluating controversial theories.

SESSION NO. 52, 4:30 PM

Monday, July 28, 2003

Plenary Session

Reno Hilton Resort and Conference Center, Reno Ballroom

52-1 4:30 PM Singhvi, Ashok K.

TERRESTRIAL AND OCEANIC RECORD OF THE PAST CLIMATES OF THE INDIAN SUB-CONTINENT: A SYNTHESIS

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A diverse range of landforms, ranging from the Desert to alluvial plains, the tectonically active Himalaya and its glaciers, to the Arabian Sea and the Bay of Bengal, make the Indian subcontinent an ideal locale to understand Quaternary processes and climates. A large variety of archives have been used to understand the climate and a common link between the proxy records from various archives is the pre-eminent role of the monsoon. However, a large spatial and temporal variability in monsoon performance exists. These include e.g. the upwelling in the western Arabian Sea vs. the impact of fresh water inputs in the eastern Arabian Sea, regions with summer-dominated and winter-dominated monsoons and spatial heterogeneity in the rainfall intensity. The archives used for

paleoclimate reconstructions range from tree rings and cave speleothems to alluvial sediments of humid central India, the desert and the semi-arid southern India, the loess and lacustrine deposits of Kashmir, etc. So far, a major lacuna in paleoclimatic reconstruction has been the absence of reliable radiocarbon chronology due to the lack of species-specific accelerator mass spectrometric radiocarbon ages and to the questionable reliability of bulk radiocarbon ages. Within the terrestrial records, this void is now being filled with the extensive use of Optical ages.

In this contribution, an effort will be made to synthesize the available paleoclimatic records in time slice mode and discuss their relationship/implications on paleo-monsoon reconstruction. Despite the large-scale heterogeneity in the monsoon performance and different response times/climatic thresholds of different geomorphic surfaces, the available records clearly show a more arid climate during isotopic stages 4 and 2 and at 5-4ka, 2ka and at 0.4-0.2ka and more humid climate during isotopic stage 3 and 1, and during the mid Holocene and the medieval warming. A 1500-year periodicity during the Holocene is also seen. The oceanic records show trends similar to the terrestrial records and provide additional inputs on the monsoon reconstruction. However, areas of discordance between the land and oceanic records do exist, the most important being the oceanic record of strengthening of monsoon in the recent century vs. the terrestrial and instrumental records of static monsoon conditions during the same period.

52-2 5:10 PM Street-Perrott, F. Alayne

THE LION OR THE UNICORN? DO WE NEED TO INVOKE VARIATIONS IN ATMOSPHERIC CO₂ IN ORDER TO EXPLAIN LATE QUATERNARY CHANGES IN THE TROPICAL LAND BIOSPHERE?

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During the Last Glacial Maximum (LGM), the atmospheric partial pressure of CO₂ decreased to a physiologically-limiting level of 190 - 200 microatm, rising to its preindustrial level of 270 - 280 microatm by the beginning of the Holocene. There is no modern analogue, even at high altitudes, for the reduced CO₂/O₂ ratio that prevailed at the LGM. Experiments in growth chambers suggest that it would have increased photosynthesis and decreased water-use efficiency in C₃ trees, shrubs and herbs; thus providing a competitive advantage to C₄ plants, notably graminoids, and CAM cacti and succulents, which are drought-adapted and possess carbon-concentrating mechanisms that inhibit photorespiration. Although the Earth's orbital configuration was similar to today, other ice-age boundary conditions such as lower sea-surface temperatures were associated with widespread cooling and regional precipitation changes over tropical land areas. In contrast, during the early to mid-Holocene, increased (decreased) climatic seasonality in the Northern (Southern) Hemisphere should have resulted in an enhanced inter-hemispheric gradient in summer-monsoon precipitation, at a time when air temperatures and CO₂ were close to their preindustrial levels. This paper will review the case for significant changes in the terrestrial carbon cycle in Africa and the tropical Americas during the Late Quaternary, focussing particularly on evidence derived from stable carbon isotopes and fossil grass cuticles. Significant increases in the proportion of C₄ biomass at the LGM were restricted to sites at which the effects of lower atmospheric CO₂ were enhanced by decreased precipitation. Furthermore, the C₄/C₃ ratio increased during the early to mid-Holocene in areas subject to drought or to an enhanced proportion of summer rainfall. These findings suggest that regional climate has been more important as a control on the past distribution of C₃ and C₄ plants than atmospheric CO₂, although the latter may have been responsible for some of the puzzling features of the palaeoecological record, such as the occurrence of no-analogue plant assemblages and altered vegetation-canopy structure.

Huang, Y, Street-Perrott, F.A. et al. 2001. Climate change as the dominant control on glacial-interglacial variations in C₃ and C₄ plant abundance. Science 293, 1647-1651.

SESSION NO. 53, 1:30 PM

Monday, July 28, 2003

S4. Long Continental Records (Posters)

Reno Hilton Resort and Conference Center, Pavilion

53-1 BTH 32 Guo, Zhengtang

EVOLUTION OF ASIAN DESERTIFICATION SINCE 22 MYR AGO INFERRED FROM EOLIAN DEPOSITS IN CHINA

GUO, Zhengtang¹, RUDDIMAN, William F.², HAO, Qingzhen³, WU, Haibin⁴, QIAO, Yansong³, ZHU, Rixiang³, PENG, Shuzhen³, WEI, Jianjing³, AN, Zhisheng¹, and LIU, Tungsheng³. (1) Institute of Earth Environment, Chinese Academy of Sciences, Xi'an, 710075, China, ztguo@95777.com, (2) Univ Virginia, Clark Hall, Charlottesville, VA 22903-3188, (3) Institute of Geology and Geophysics, Chinese Academy of Sciences, P.O. Box 9825, Beijing, 100029, China, (4) Institute of Earth Environ, Chinese Academy of Sciences, Xi'an, 710075, China

In northern China, the loess-soil sequence of the last 2.6 Myr, the Hipparion Red-Earth of eolian origin and the recently reported Miocene loess-soil sequences provide a near continuous continental record of Asian desertification history for the past 22 Myr. The onset of loess deposition by 22 Myr ago indicates the existence of sizeable deserts in the interior of Asia and of a energetic winter monsoon by that time. The alternations of loess and soils indicate cyclical changes in the intensity of winter and summer monsoons. The Himalayan-Tibetan complex was extended enough and sufficiently elevated by 22 Myr ago to cause desert formation and to produce winds strong enough to carry eolian particles. Loess accumulation rate during the Miocene was much lower than for Quaternary, suggesting moderate levels of aridity and winter monsoon strength. Higher accumulation rates are observed at 15-13 Myr and 8-7 Myr, which may represent temporary instabilities of climate or land-surface conditions in the source region.

Desert lands and winter monsoon must have been constantly maintained since then, as evidenced by the Hipparion Red-Earth and Quaternary loess-soil sequences. The inland aridity was stronger from ~6.2 to ~5 Ma BP and weaker from ~5 to ~3.6 Ma BP. Two major drying steps are observed at ~3.6 and ~2.6 Ma BP, respectively. The enhanced aridity at ~3.6 Ma BP is synchronous with a suggested uplift of portions of the Tibetan Plateau. The general aridification history is also highly consistent with the ongoing high-latitude cooling and the consequent expansion of Arctic sea-ice/ice sheets since 6.2 Myr BP. These suggest that both Tibetan uplift and ice-building processes in the northern hemisphere were two prominent driving forces behind the long-term desertification in the interior of Asia.

53-2 BTH 33 Itzstein-Davey, Freea Jade**A FINE RESOLUTION PLIOCENE VEGETATION STUDY: YALLALIE, SOUTH-WESTERN AUSTRALIA**

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The Pliocene was a transitional period terminating the Tertiary and prelude to the Quaternary and was characterised by major plate-tectonic motions that opened or closed gateways, thereby triggering major climatic events (Wright 2001). The palaeoenvironmental setting of Australia in the Pliocene is incomplete. However, recent study of a 110 m section of lake sediment of Pliocene age from Yallalie, south-western Australia, documents a high quality laminated lake sequence (Dodson and Ramrath 2001). Numerous sections of the core contain fine laminations, assumed to be possible annual sedimentation layers. This study examines forty two samples from 7.91 cm of laminated sediment from 133.64 to 133.72 m, representing approximately 82 years around 3 million years ago.

Samples are dominated by *Allocasuarina/Casuarina* and Myrtaceae, primarily *Eucalyptus*, pollen. Restionaceae pollen is also abundant. Other consistently occurring pollen types include Araucariaceae, Cyperaceae, *Dodonaea*, Euphorbiaceae, Poaceae, Restionaceae and Rutaceae types. *Nothofagus*, *Dacrydium* and *Podocarpus* types were also noted, as was Gyrosteromaceae. Proteaceae taxa include *Banksia/Dryandra* type, *Grevillea*, *Petrophileand Xylomelum*. This investigation supports that the Pliocene vegetation in south-western Australia contained a mix of diverse contemporary species and the more ancient wetter rainforest species, supporting that the climate was wetter and at least as warm as today. Biodiversity was as high as then, or even higher, than today. Continuous presence of charcoal throughout the examined sediment section of the core also indicates that fire was an important component of the environment in the region around Yallalie (Atahan 2002).

References

- Atahan P (2002) Mid-Pliocene fire recurrence at Palaeolake Yallalie. Honours Thesis, Department of Geography, The University of Western Australia.
- Dodson JR, Ramrath A (2001) An Upper Pliocene lacustrine environmental record from south-western Australia - preliminary results. *Palaeogeography, Palaeoclimatology, Palaeoecology* **167**, 309-320.
- Wright JD (2001) Climate change: The Indonesian valve. *Nature* **411**, 142-143.

53-3 BTH 34 Takemura, Keiji**LAKE BIWA SEDIMENTS IN JAPAN: RECORDERS OF GLOBAL PALEOENVIRONMENT AND ISLAND ARC TECTONIC SINCE PLEISTOCENE**

TAKEMURA, Keiji¹, HAYASHIDA, Akira², NAKAGAWA, Takeshi³, KITAGAWA, Hiroyuki⁴, YASUDA, Yoshinori⁵, MEYERS, Philip A.⁶, and HORIE, Shoji¹, (1) Institute for Geothermal Sciences, Kyoto Univ, Noguchibarū, Beppu, 874-0903, Japan, takemura@bep.vgs.kyoto-u.ac.jp, (2) Science and Engineering Research Institute, Doshisha Univ, Kyotanabe, Japan, (3) Institute for Geothermal Sciences, Faculty of Sci, Kyoto Univ, Noguchibarū, Beppu, 874-0903, Japan, (4) Graduate School of Environmental Studies, Nagoya Univ, Furo-cho, Chikusa-ku, Nagoya, 464-8601, Japan, (5) Int'l Risch Ctr for Japanese Studies, 3-2 Oeyama-cho, Goryo, Nishikyo-ku, Kyoto, 610-1192, Japan, (6) Univ Michigan - Ann Arbor, 425 E University Ave, Ann Arbor, MI 48109-1063

Lake Biwa is the largest freshwater lake in Japan, measuring 22.6 km side by 68 km long and having a maximum depth of 104 m. The lake has a long history from the early Pliocene based on the geological survey and paleogeographical study of lake sediments around Lake Biwa (Kobiwako Group). The sediments revealed the paleoenvironmental change and tectonic events at the convergent margin of the Eurasian plate since early Pliocene times. Deep drillings for paleolimnological studies were carried out in 1970's and 1980's. These studies showed that the present Lake Biwa Basin bears a sedimentary sequence of about 900 m thickness, which were deposited in lacustrine or fluvial environments in the Pliocene and the Quaternary. The upper most unit is a continuous and massive sequence of lacustrine clay of 250m thick intercalating more than 50 layers of volcanic ashes. The tephrochronological and paleoclimatological data suggest that the 250 m clay unit has been deposited from the last 430 kyrs and is correlated to major glacial-interglacial cycles. We will show the summary of the result from drilling studies in Lake Biwa. Pioneer studies on the long sediment core from Lake Biwa revealed that the fluctuations of climatic signals were successively correlated to the Milankovitch cycles. However, the upper part of long core was highly disturbed because of relatively poor coring techniques. In 1990's, 15 to 20 m long piston cores were obtained from three sites in Lake basin, and analytical studies at higher-resolution have been carried out. These studies suggested that the Lake Biwa sediments record climatic fluctuations at millennial to century order, which can be correlated to the Heinrich events or Dansgaard-Øeschger cycles. The paleolimnological setting of Lake Biwa offers outstanding advantages for high-resolution study of the East Asian monsoon climate of the Late Quaternary.

53-4 BTH 35 Thamó-Bozsó, Edit**CHANGES IN QUATERNARY FLUVIAL TRANSPORT DIRECTIONS TO MID-HUNGARIAN PLAIN, BASED ON STATISTICAL ANALYSIS OF DETRITAL HEAVY MINERAL COMPOSITION OF SANDS**

THAMÓ-BOZSÓ, Edit¹, LAJOS, Ó. Kovács², and KERCSMÁR, Zsolt¹, (1) Basin Analysis, Geological Institute of Hungary, Stefánia 14, Budapest, 1143, Hungary, bozso@mafi.hu, (2) Information Centre, Hungarian Geological Survey, Stefánia 14, Budapest, 1143, Hungary

Quaternary fluvial sediments in the central part of the Hungarian Plain (Pannonian Basin) have been studied in 10 cored boreholes. The 50-690 m thick sediment successions consist of sand, silt and clay, transported here from different directions. Recently the Tisza River and its tributaries bring pyroxene, hornblende, epidote, chlorite or garnet rich sediments from NE, NNE and SE directions into the studied area, from the Apuseni Mountains and the NE-Carpathians, while Danube River brings here sediments with high garnet content from NW direction, mainly from the Alps and from the W-Carpathians.

The evaluated mineralogical data derive from earlier examinations by polarising microscope of the 0.1-0.2 mm fraction of 590 sand samples from the boreholes and from recent river sediments of the Hungarian Plain. Based on the similarities between the detrital heavy mineralogical composition of samples derived from recent river sediments and from boreholes, revealed by Cluster Analysis and Principal Component Analysis (PCA), we can reconstruct the paleo-fluvial transport directions and provenance, as the geological and geographical constraints of the region have been similar during the Quaternary. With these methods in most cases we could distinguish the sediments of the Paleo-Tisza River and its tributaries, from the sediments of the Paleo-Danube River. The suggested separation has some uncertainties when sediments of different rivers have similar heavy mineral suites, although the geological settings of the catchments of these two main rivers are quite different.

Changes in fluvial transport directions and river pattern during the Quaternary reflect tectonic changes: the uplift of the surrounding mountains and different part of the Hungarian Plain, and local subsidence of certain areas.

This research was supported by the Hungarian National Scientific Research Fund (OTKA T-32956).

53-5 BTH 36 Juhász, Györgyi**STRATIGRAPHIC ARCHITECTURE AND SEQUENCE STRATIGRAPHY OF LONG-TERM FLUVIAL RECORDS IN A CONTINENTAL INTERIOR BASIN, E HUNGARY**

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The study area is located in the eastern part of the Pannonian Basin system which is Europe's largest continental interior basin. The thickness of the alluvial sedimentary complex exceeds 400 m. The present study is based mainly on subsurface facies analysis and the interpretation of well-logs of some 60 water-prospecting wells. In the course of the investigations traditional sedimentological interpretation was combined with sequence stratigraphic considerations. Different alluvial facies types as well as facies associations showing characteristic stacking pattern on the logs were recognized in the Quaternary succession. They were formed in channel belts, proximal and distal floodplain, floodbasin or wetland and on the distal part of an alluvial fan, respectively. Basin-scale facies mapping of the overall Quaternary sedimentary succession led to the recognition of the main channel belts.

The recognized facies associations show a characteristic vertical pattern in a successive order forming individual 40-100 m thick large-scale fluvial cycles. The basal member is made up of multistorey channel fill beds cut into the underlying floodplain deposits. This is overlain by an alternating sandy - muddy succession of channel fill and floodplain deposits forming the intermediate member. The upper member is comprised of silty-clayey floodplain deposits locally with very thin isolated silty-sandy bodies. The above mentioned 3 members represent a fining upward sedimentary cycle and they were interpreted as low, increasing and high accumulation space deposits, respectively, (i.e. LST, TST and HST in sequence stratigraphic terms). As the basal member generally lies above a regional erosional surface allocyclic controls can be assumed. In parts of the basin the cycle is not complete.

In a regional scale six cycles were differentiated above each other. Although these cycles were allocyclic it is an open question if they were tectonically or climatically driven. The fact, however, that six of them have been identified suggests that they represent the large-scale 400 ka Milankovic cycles during the Quaternary.

53-6 BTH 37 Vidic, Natasa J.**MULTIPROXY EVIDENCE FOR LONG-TERM AND MID-PLEISTOCENE CHANGES IN MONSOON DYNAMICS ON THE CHINESE LOESS PLATEAU**

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We have assembled a multiproxy database for the Chinese loess section at Jiaodao, Shaanxi Province, China (50 km N of Luochuan), that provides new insight into the dynamics of the summer and winter monsoons over the past 2.6 Ma. The database includes information about environmental magnetic properties, pedogenic and total iron concentrations, color indices (rubification and melanization), particle size distribution, and carbonate content. Several paleoclimate proxies, especially soil color index rubification, show a gradual long-term decrease in temperature accompanied with a gradual increase in winter monsoon strength from 2.6 Ma to present, similar to the long-term increase in oxygen isotope values seen in the marine record. In addition, following the mid-Pleistocene climate rearrangement (in loess/paleosol layers younger than 0.65 Ma), some proxies, such as magnetic properties and depth of decalcification, indicate a significant increase in summer monsoon precipitation during soil-forming (interglacial) periods while other proxies, such as particle size, show an increase in winter monsoon strength during depositional (glacial) episodes. This evidence from our continuous multiproxy database from the 170-m thick loess/paleosol section near Jiaodao contributes significantly to the understanding of long term changes in Asian monsoon dynamics of the past 2.6 Ma.

53-7 BTH 38 Oches, Eric A.**LINKING THE LOESS - PALEOSOL RECORD OF PLEISTOCENE CLIMATE IN SERBIA WITH THE EXPANDING CENTRAL EUROPEAN AMINOSTRATIGRAPHY**

OCHES, Eric A.¹, MARKOVIC, Slobodan B.², MCCOY, William D.³, STEVENS, Thomas³, GAUDENYI, Tivodar², JOVANOVIC, Mladjen², and WALTHER, Richard¹, (1) Department of Geology, Univ of South Florida, 4202 E. Fowler Ave. - SCA528, Tampa, FL 33620, oches@chuma1.cas.usf.edu, (2) Quaternary Research Center, Institute of Geography, Univ of Trg Dositeja, Obradovica 3, 21000 Novi Sad, Yugoslavia, (3) Department of Geosciences, Univ of Massachusetts, Amherst, MA 01003-5820

Numerous loess-paleosol sections have been investigated along Fruska Gora in Vojvodina, Serbia, and a detailed paleoclimate record for the mid to late Pleistocene is emerging for south-central Europe. In order to test regional stratigraphic correlations and correlate with loess sequences studied elsewhere in central Europe, we sampled fossil gastropod shells from loess units and measured D/L amino acid ratios in an effort to expand our evolving European aminostratigraphy into the Serbian loess region. Stari Slankamen, the longest continuous section that we have sampled, includes eight interglacial paleosols and intervening loess units recording alternating warm-moist and cool-dry climate oscillations. We also sampled loess-paleosol sections at Ruma, Petrovaradin, Irig, Miseluk, Kula, and Titel.

Gastropods sampled include the genera *Helicopsis*, *Trichia*, *Pupilla*, and *Succinea*. Using reverse-phase liquid chromatography, we measured D/L ratios in 10 amino acids. Our analysis and interpretations focus on D/L aspartic acid, glutamic acid, valine, phenylalanine, and allisoleucine/isoleucine ratios (alle/ile). The range of racemization rates exhibited by these amino acids allows us to optimize resolution for different time periods. According to the present chronostratigraphic model, loess L1 and paleosol S1 were formed during glacial cycle B, corresponding with marine oxygen-isotope stages (MIS) 2-5. Horizons within L2 and S2 correspond with glacial cycle C and MIS 6 and 7, respectively. S2 is a double paleosol and is correlated with the Hungarian BD paleosol pair on the basis of racemization data. Loess and paleosol units L3 and S3 correlate with glacial cycle D and MIS 8 and 9, respectively. Older units in the sequence are similarly correlated with the Hungarian aminostratigraphy, although few outcrops are available for sampling and comparing data from stratigraphically lower units.

Present-day ground temperatures in loess of Hungary and Serbia show a significant increase in temperature from the northwest to the southeast. Mean annual temperature at one-meter depth rises from 10.5 °C near Budapest to 13.5 °C in parts of Vojvodina. This increase in temperature explains the more rapid rate of racemization and the higher D/L ratios in loess of Vojvodina relative to the equivalent age loess units in Hungary.

53-8 BTH 39 Dlussky, Konstantin G.

NEW DATA FROM LOESSES AND PALEOSOLS OF THE US MIDWEST

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Loess/paleosol series of the US Midwest provide long-term proxy records of Quaternary sedimentation, climate and environments south of the glacial limits of North America. Three key sections were investigated at Wittsburg Quarry (Arkansas), Missouri Valley (Iowa) and Eustis Ash Pit (Nebraska) by geochemical, paleomagnetic and micromorphological analyses. Below the surface soil at each section, four loesses are present. They are separated by three well-developed paleosols.

The Crowley's Ridge loess is the oldest loess unit at the sections under study. At Wittsburg, it lies on Pliocene gravel, at Eustis it immediately overlies the Lava Creek B ash layer, and at Missouri Valley it lies directly on the Pre-Illinoian till surface. A well-developed paleosol modifies this loess at all three sections. This paleosol has not previously been reported in western Iowa or eastern Arkansas. At all three sites, it is immediately overlain by the Sangamon paleosol which itself represents pedologically-altered Loveland loess. This means that the Loveland loess is much thinner than previously suggested. The Sangamon paleosol is well developed and readily correlated between Wittsburg and Missouri Valley, but is probably partly eroded at Eustis. It has luvisolic properties but with much more clayey pedogenic texture than modern luvisols, and has no clear eluvial horizon. The overlying Roxana loess at Wittsburg and its equivalents at Eustis and Missouri Valley are mostly altered by soil formation. At Wittsburg and Missouri Valley, this soil is called the Farmdale paleosol. On the basis of its pedogenic features it correlates to the Gilman Canyon Formation paleosol at Eustis. This soil has chernozemic properties at all three sections, but at Wittsburg it is less developed. At all three sections, this soil has ancient krotovinas, hence the gley features observed must be interpreted as post-burial changes. In the upper part of all the sections, the thickest Peoria loess is developed and shows the properties most typical of loess. From the Peoria loess to the Loveland loess, the correlations proposed are well corroborated by numerous published TL and ¹⁴C dates. Below the Loveland loess, only a few TL dates are available. Mass-specific magnetic susceptibility and its frequency-dependence correlate well with lithology and have maxima at the top of each paleosol.

53-9 BTH 40 Mueller, Ulrich

THE INFLUENCE OF THE NORTH ATLANTIC CURRENT ON EUROPEAN ENVIRONMENTS DURING THE LAST INTERGLACIAL

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To examine the influence of the North Atlantic circulation on European environments a correlation of last interglacial marine and terrestrial records was undertaken by an event-stratigraphic approach.

The major cold event after the last interglacial, i.e. C24, is clearly expressed in both marine and terrestrial records. In SST records this event is documented by the major peak abundance of IRD and *N. pachyderma* sinistral at the end of substage 5d. In terrestrial pollen records C24 is identified by the peak abundance of steppic taxa during the Herring stadial. The impact of the major cold event previous to the interglacial, i.e. Heinrich 11, is expressed in marine records by the peak abundance of IRD at the transition from MIS 6 to 5. In terrestrial pollen records the effect of H11 is recognized by peak abundance of steppic taxa right before the start of reforestation. Depths interpreted as showing the impact of C24, are assigned an age of 107 ka and depths which show the impact of H11 are assigned to 128 ka. Ages after Shackleton et al. (2002) are based on marine core MD95 2042. Events in the interval between C 24 and H 11 were tentatively dated on the assumption of uniform deposition rate.

The results show during the interglacial between 115 and 126 ka, the warming influence of the North Atlantic current (NAC) extended as far as 70°N to the Nordic Sea. For this period European pollen records indicate that the polar timberline was at ca. 69°N in Scandinavia and the northern boundary of thermophilous deciduous dominated woods at ca. 61°N. A major shift took place about 115 ka, which is labeled C26. The marine records show that the warming influence of the NAC did not extend to the Nordic Sea but still influenced sites in the subpolar North Atlantic. The response of European vegetation was an immediate southward push of the polar timberline to latitudes of northern Germany at ca. 53°N and the boundary of thermophilous deciduous dominated woods to ca. 48°N. These results show that European environments respond directly to changes in North Atlantic circulation.

53-10 BTH 41 Kleber, Arno

A SOLUTION TO THE DEVILS HOLE PARADOX

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The Milankovic hypothesis is an important paradigm of modern Quaternary Sciences. However, it appears defeated in parts by oxygen isotopes obtained from well-dated travertine deposited at Devils Hole, Nevada, which indicate the onset of the warming at the end of several cold phases occurred significantly before warming may have been triggered by northern latitude insolation increase according to Milankovic hypothesis. This would imply reactions of the climate system pre-dated their own causes.

Comparison of air pressure patterns during pleni- and late glacials over South-Western North America to modern ones during certain, rare climate events yields evidence that then fractionation of oxygen isotopes on their way to Devils Hole may have been significantly different from average conditions during the Quaternary, with the difference entirely explaining the observed departures of the Devils Hole record from other records supporting Milankovic hypothesis.

53-11 BTH 42 Bavec, Milos

LATE QUATERNARY SEDIMENTARY SEQUENCE IN THE JULIAN ALPS - A POTENTIAL FOR OBTAINING A 40 KA PALEOCLIMATIC RECORD IN THE ALPINE - MEDITERRANEAN REGION OF NW SLOVENIA

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A sequence of late Quaternary lacustrine sediments - at least 197 m thick - has been discovered in the Alpine region of NW Slovenia in the area opened to the climatic influence of the Mediterranean. The sediments were deposited in paraglacial environment as proven by extensive mapping, drilling, sedimentological analyses and absolute dating. Clast fabric and other sedimentological properties of the diamicts have shown that the later were deposited as mass-flow deposits and not as glacial tills as previously interpreted. OSL, TL and radiocarbon dating have been applied to estimate the

deposition age of diamicts and fluvial deposits that relate spatially to the lacustrine sequence. Ages between 200±43 ka b.p. to present were determined. Absolute age has been estimated for the upper 34 m of the lacustrine sequence. Its age spans from 12790±85 radiocarbon years b.p. at the depth of 34 m to 5885±60 radiocarbon years b.p. at the very top of the sequence, yielding calculated sedimentation rate of 5 mm of compacted sediment per year. A simple extrapolation of age vs. depth shows that continuous sedimentation in the lake might have covered the period as long as 40,000 years. Such a record with possible climatic implication is unique in the area of the SE Alps and we believe that the interest exists in the broader scientific community for further investigations of the record. We are therefore looking for international cooperation that would enable us to extract the sediment core in-whole and investigate its paleoclimatic implications.

53-12 BTH 43 Grachev, M.A.

A LONG RECORD OF PALEOCLIMATES FROM NORTH MONGOLIA: SEDIMENTS OF LAKE KHUBSUGUL

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Lake Khubsugul (North Mongolia) fills a depression in the Baikal Rift Zone. Unlike its sister Lake Baikal, it is almost saturated with CaCO₃, because its major loss of water is by evaporation (80%). The outlet is a small Egerin River. Atmospheric precipitation is 10-50 mm in winter, 300 mm in summer. Moisture is mostly delivered by cyclones born in the North Atlantic. The lake is at the far extent of their tracks, and hence its sediments are of special interest for paleoclimatology.

Recent studies have shown that Lake Khubsugul in the Last Glaciation had no outlet, was almost desiccated, and has been only filled to its present outlet in the Holocene. Signs of recent paleo-deltas at ca. 200 m below the present water surface were found by seismic profiling. A few gravity cores were studied, and one dated by ¹⁴C AMS to 12 ky BP. Sediment accumulation rate in the Holocene was 4 cm/ky. The sediment of this time is a diatomite (80 mln frustules/g). Prior to the Bolling, diatoms were either absent or non-preserved. Ostracods were highly abundant. Carbonates and at times gypsum (proxy of brackish water) precipitated to the bottom. Sediments of the Upper Pleistocene, compared to those of the Holocene, are enriched in Ca, Sr, Mg, C_{inorg} and show lower concentrations of Sc, Ni, Y, U, W, and REEs (all extractable with weak nitric acid). Transition from the Upper Pleistocene to the Holocene resulted in an increase of organic matter from < 1 to > 6 %, and of BiSi from 1 to 20%. Abrupt climate oscillations associated with Bolling-Allerød - Younger Dryas are clearly revealed by these and other proxies. Moreover, the proxies reveal a short-term arid episode centered between 6 and 5 ky BP, contemporary with the desertification of Sahara.

In March of 2003, a 50 m drilling core from Lake Khubsugul was obtained. The core contains a record of paleoclimates of the last few hundred thousand years. The first results of its studies will be reported.

SESSION NO. 54, 1:30 PM

Monday, July 28, 2003

S16. The Late Quaternary Glaciation of Tibet and the Bordering Mountains: Implications for Understanding and Reconstructing the Evolution of the Mountains, Deserts, Hydrology, Vegetation and Early Humans in Central Asia (Posters)**Reno Hilton Resort and Conference Center, Pavilion****54-1 BTH 47** Oberholzer, Peter

THE INFLUENCE OF THE MONSOON ON PALEOGLACIATIONS ON THE TIBETAN PLATEAU

BERHOLZER, Peter¹, SCHAEFER, Joerg M.², SCHLUECHTER, Christian³, ZHAO, Zhizhong⁴, IVY-OCHS, Susan⁵, KUBIK, Peter W.⁵, BAUR, Heinrich¹, and WIELER, Rainer¹, (1) Institute for Isotope Geology and Mineral Resources, ETH, Zurich, 8092, Switzerland, oberholzer@erdw.ethz.ch, (2) Lamont-Doherty Earth Observatory, Route 9 W, Geochemistry Room 61, Palisades, NY 10964, (3) Institut für Geol. Sciences, Baltzerstrasse 1-3, Berne, 3012, Switzerland, (4) Chinese Academy of Geological Sciences, Institute of Geomechanics, Beijing, China, (5) Paul Scherrer Institute c/o Institute of Particle Physics, HPH H30, ETH Hoenggerberg, Zurich, CH-8093, Switzerland

The Tibetan Plateau has a strong potential to influence the Earth's climate on a regional to hemispheric scale because of its high elevation at a low geographic latitude and with a large area. The glacial deposits of the Tibetan Plateau reflect not only climate signals originating in the North Atlantic region, but also changes in the intensity of the Indian monsoon, the main moisture source of the area. It is not clear, though, what the nature of the forcing mechanisms of glaciations on the plateau is. Due to the scarcity of datable material, the establishment of absolute chronologies is very difficult. Available data from different parts of the plateau and the Himalaya mountains are not consistent with each other and difficult to relate to glacial chronologies in other parts of the earth. This situation has improved recently with the advent of surface exposure dating (SED) using in-situ terrestrial cosmogenic nuclides. We investigated a set of large terminal moraines in Nyalam County, near a 4300 metres high mountain pass between Tibet and Nepal, with SED. The study aimed at shedding light on the relative importance of North Atlantic and monsoonal climate signals. The climate in this region today is dominated by the monsoon as the wet air masses cross the Himalaya on their way from India to the Tibetan Plateau. Hence, the mountain glaciers in this area respond to variations of the summer monsoon intensity. The moraines are located about 15 km in front of the present-day glaciers. For dating the moraines we used the in-situ produced cosmogenic nuclides Be-10 and Ne-21. To control the non-cosmogenic signal, we analysed the shielded bottom of a sample alongside with its exposed surface wherever possible. First results indicate deposition of the Nyalam moraines at around 60 ka BP, i.e. during early Marine Isotope Stage 3, a time of enhanced summer monsoon, and an interglaciation in the North Atlantic record. This implies that increased precipitation from a strong summer monsoon triggered glacier advances in the Himalaya during interglacial times. A smaller succession of moraines, about 5 km upvalley from the first, is about to be dated. It is expected to yield information about the behaviour of the glaciers during times of northern hemisphere cooling. The data will be available at the conference.

54-2 BTH 48 Sheinkman, Vladimir**QUATERNARY GLACIATION AND ITS INFLUENCE ON ENVIRONMENT IN THE HIGH MOUNTAINS OF CENTRAL SIBERIA**

SHEINKMAN, Vladimir, Department of Dynamic Geology, Tomsk State Univ, Lenin av., 36, Tomsk 634050 Russia, sheinkma@bgumail.bgu.ac.il.

High mountain ridges surround Siberia from the south and east and form a continuous belt reaching from Altay to Yakutia. The ridges are characterized by a comparable height and cold continental climatic conditions. The mean annual temperatures gradually drop along the belt from -3°C in West Altay to -17°C in northeastern Yakutia. Such a difference is comparable to the temperature change during the Pleistocene Cooling, when climatic continentality promoted the spreading of permafrost under arid conditions ('cryoaridization'). Thus the range of climatic differences today is comparable to the range of climatic changes between glacial and interglacial conditions. We used these characteristics for environmental reconstruction.

The environments along the belt differ in their degree of interaction of glaciers and cryogenic ice. Both of them characterize the certain type of glaciation by their proportion. Deep-reaching permafrost occurred along the belt throughout the Quaternary. Permafrost cannot occur when there is high precipitation. A drop in temperature would have triggered glacier growth under these conditions. An increase in precipitation, which would have also caused an increase in glaciation, we leave out in such a situation.

At present only southwestern end of the mountain belt receives more than 1000 mm of annual precipitation, whereas other ridges receive 500-700 mm, declining to 100-200 mm in the intramontane basins. Therefore the largest modern glaciers are found in Altay, whereas the maximum volumes of cryogenic ice occur in the coldest parts of Yakutia. As the Pleistocene cryoaridization progressed, the difference has been smoothed. The temperature effect became dominant and the largest Quaternary glaciers occurred in the mountains of Yakutia. However, glaciation was restricted to valley glaciers, because the limited moisture supply did not allow the formation of ice sheets. At the certain stage of the glaciation another form of surface ice, so-called icings, could turn into perennial features comparable to glaciers both with regard to ice volume and as landscape-forming agents.

54-3 BTH 49 Yi, Chaolu**QUATERNARY GLACIATION IN MUSHITAGE MOUNTAIN, NORTHWESTERN BORDER OF TIBET PLATEAU**

YI, Chaolu, Department of Geography, Nanjing Univ, Hankou Road 22, Nanjing 210093 China, clyi@nju.edu.cn.

Mushitage, with the highest peak over 7500m, is located in the western border of Tibetan Plateau. The presence of Quaternary glaciation was reported by Cui Zhijiu (1960). But the times and periods of the past glaciations were largely unknown. We observed series of the end moraines and lateral moraines in the field in the summer of 2002. Samples were collected and dated, using the techniques of electron spinning resonance (ESR) and accelerating mass spectrometry (AMS). The results show that the four periods of ancient glaciations were present since the Last Glaciation.

54-4 BTH 50 Munroe, Jeffrey S.**PAST AND PRESENT GLACIER EXTENT IN THE TANGGULA SHAN OF THE QINGHAI-TIBETAN PLATEAU, CHINA**

MUNROE, Jeffrey S., Geology Department, Middlebury College, Bicentennial Hall, Middlebury, VT 05753, jmunroe@middlebury.edu, COLGAN, Patrick M., Geology Department, Northeastern Univ, 14 Holmes Hall, Boston, MA 02115, and ZHOU, Shangzhe, Geography Department, Southern China Normal Univ, Guangzhou, China. The Tanggula Shan, situated astride the border between the provinces of Qinghai and Tibet in western China, provide an excellent location in which to study the interaction of continental and monsoonal air masses, and their effects on past and present glacier extent. The area around Tanggula Pass contains numerous end moraines that can be grouped into four phases of glaciation on the basis of topographic and surface weathering characteristics. The oldest of these, either the Tanggula or Jazhazangbu phase, is represented by extensive areas of hummocky topography, extending to elevations below 5050 m asl, and 16 to 25 km from modern glacier margins. These moraines define the margins of sizeable piedmont glaciers that drained a large ice cap that covered most of the Tanggula Shan. The Basicuo phase is represented by moraines located 5 to 9 km from the modern glacier margins between elevations of 5050 and 5150 m asl. The surfaces of these moraines are highly weathered, and the only extant boulders are composed of highly resistant sedimentary and igneous lithologies. During the Basicuo phase the Tanggula Shan were partially inundated by several discrete ice fields. The Longiazai phase is represented by small, poorly preserved moraines located less than 5 km from modern ice margins at elevations above 5150 m asl. Ice at this time was restricted to valleys and minor ice fields. Finally, end moraines located less than 1 km from the margins of modern glaciers likely record the extent of a small Neoglacial advance.

Modern glaciers cover ~300 km² in the mapping area. An analysis of the modern equilibrium line altitude (ELA) using a toe-headwall altitude ratio (THAR) of 0.4 indicates an ELA between 5450 and 5600 m asl. Estimates of the paleo-ELA during the oldest glacial phase suggest an ELA lowering of only ~100 m, reflecting the control of the uniform plateau surface (~5000 m asl) on the elevation of glacier termini. Mean summer temperatures at the modern ELA are ~2° C and mean summer water accumulation is ~350 mm. These conditions are more arid than those found at the equilibrium lines of other modern glaciers, indicating that the mass balance of the Tanggula Shan glaciers is negative. Comparison of glacier margins in satellite images from 1964, 1976, 1989, and 2001 confirms that glaciers have retreated >100 meters over the last 40 years.

54-5 BTH 51 Abramowski, Uwe**GLACIATION HISTORY OF THE PAMIR AND ADJACENT MOUNTAINS RECONSTRUCTED BY BE-10 SURFACE EXPOSURE DATING OF ERRATIC BOULDERS**

ABRAMOWSKI, Uwe¹, ZECH, Roland¹, SEEBACH, Dominik¹, BERGAU, Arne¹, GLASER, Bruno¹, KUBIK, Peter W.², and ZECH, Wolfgang¹, (1) Institute of Soil Sci and Soil Geography, University of Bayreuth, Bayreuth, D-95440, Germany, uwe.abramowski@uni-bayreuth.de, (2) Paul Scherrer Institute c/o Institute of Particle Physics, HEP H30, ETH Hoenggerberg, Zurich, CH-8093, Switzerland

In an attempt to reconstruct the late Quaternary glaciation history of Central Asia, we have sampled erratic boulders from different moraine stages in the Southern Alichur Range and in the areas of Lake Yashilkul and Ailuitek Pass, Pamir, Tadshikistan, as well as in the Alay Range, Kyrgyzstan, for surface exposure dating using in-situ cosmogenic Be-10. Our results show that remnants of an extensive plateau glaciation in the southeast of the Pamir date to before the MIS 4 and probably are of middle Pleistocene age. During the late Pleistocene, glaciers in the Pamir were restricted to the valleys and left distinct high lateral as well as arcuate terminal moraines, which in the Pamir frequently show a hummocky relief, locally called "tschukur". Exposure ages from the more extensive of these "tschukur" moraines show a wide scatter ranging from the end of MIS 4 to the end of MIS 2, showing that they have been actively degrading, especially by melt-

ing out and sublimation of buried ice and permafrost, for all this time. A MIS 3-4 moraine in the Koku valley of the Alay Range, which is situated below the permafrost limit, shows no such scatter in boulder ages and no "tschukur" relief. At Lake Yashilkul, a single lateral moraine outside the "tschukur" moraine dates to the beginning of MIS 4, when glaciation in this area was at its late Pleistocene maximum. Behind the "tschukur" lobes in the Pamir, there frequently lies a succession of recessional moraines, which lead back to a more pronounced, but less extensive stage dating to the MIS 2. During the MIS 2, glaciation in all studied valleys was less extensive than during MIS 3-4, extending at most a few km from the cirque headwalls. Older moraines frequently show clear symptoms of degradation and relief activity. This is reflected in the distribution of the boulder surface ages. This distribution in most cases is not random, but ages younger than the deposition age tend to cluster around times of younger glacier advances in the same valley. This supports the idea that times of glacier advances are also times of relief instability in the surrounding periglacial area.

54-6 BTH 52 Lin, Qiuyan

PALEOCLIMATIC CHANGE AND NEOTECTONIC MOVEMENT IN THE TIBETAN PLATEAU
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From studies on the distribution and geometric characteristic of lake; the correlation between lake belts and tectonic zones, and migration and shrinking of lakes, we obtain the following conclusion:

The neotectonic movement in the plateau is a great and violent nonformative whole uplifting tilted to the northeast. There is some internally differential relative movement in this process. The main trend of migration is to the northeast. However, local trends to the northwest, southeast or NWW direction exist. These local trends and their strength are related to the huge fold systems and strike-slip fault belt. Quaternary active faults in the plateau, especially those strike in the direction of NW, NE and North, are the most recent and active ones. They are of high seismic risk. Large earthquakes mainly occur at the intersection of these faults and the east-west main fault belts. The whole uplifting and interior differential movement in the Tibetan plateau is the result of sliding between layers in the lithosphere as well as the surface deformation caused by the collision between Indian plate and Europe-Asian plate.

The lake geometry is restricted neotectonism. This study indicates that some lakes geometry has been interacted more by the paleoclimate than by the neotectonism. On the other hand, the lake migration reflects the direction and strength of neotectonism. However, shrinking or enlarging of lake has been caused by the paleoclimate. We analysed the change of lake and found it contained many elements. The paleoclimate and the neotectonism had been affirmed by two main facts.

54-7 BTH 53 Wang, Weiguo**A HOLOCENE CLIMATIC RECORD IN GUN NUUR, NORTHERN MONGOLIA**

WANG, Weiguo¹, FENG, Zhaodong¹, MA, Yuzhen², and LEE, Xinqing³, (1) Department of Geography, Lanzhou University, Lanzhou, 730000, China, wangwg@hotmail.com, (2) National Laboratory of Western China's Environmental Systems and Department of Geographical Sciences, Lanzhou Univ, Department of Geographical Sciences, Lanzhou University, Lanzhou 730000, China, Lanzhou, 730000, China, (3) Department of Geography, Lanzhou Univ, Lanzhou, 730000, China

To retrieve regional records for depicting the global Holocene climatic changes, we successfully drilled 7.45 m lake core at Gun Nuur in the Northern Mongolian Plateau. Based on a reasonably constrained chronology and strikingly contrasted strata, we conducted a multi-proxy analysis of the core (e.g., magnetic parameters, pollen assemblages, total organic carbon and organic carbon isotope). The data show that the climate was still in the glacial mode (cold and dry) before 10,500 cal yr B.P. in the Northern Mongolian Plateau. The post-glacial warming occurred from 8,700 to 8,700 cal yr B.P. The climate was characterized by becoming warmer and dry from 8,700 to 6,500 cal yr B.P. After an about 1,500-year wet and cool climate between 6,500 and 5,000 cal yr B.P., the second half of the elapsed portion of the Holocene has been characterized by wetter and cooler climate than the first half with three relatively warm and dry spells: 5000-4000 cal yr B.P., 3500-3200 cal yr B.P. and 2500-1900 cal yr B.P. These major climatic fluctuations recorded in the lake Gun Nuur appear in-phase with those recovered in northern China. The magnetic records also show that climate changed abruptly at about 1600, 2900, 4500, 5900 and 8200 cal yr B.P., approximately echoing those abrupt events recorded in North Atlantic.

54-8 BTH 54 Mooney, Scott David**Holocene Fire History in the Sydney Basin, NSW, Australia: The Climate, Humans & Fire Nexus**

MOONEY, Scott David and BLACK, Manu, School of Biological, Earth & Environmental Sciences, Univ of New South Wales, Sydney, 2052, Australia, s.mooney@unsw.edu.au. There are several contentious issues regarding the history of fire in the humid environments of south-eastern Australia. This includes claims that the manipulation of fire by Aboriginal people resulted in significant vegetation change. Bowman (1998 in New Phytol.), for example, noted that palaeoecological studies do not objectively shed light on these issues, largely because of uncertainties associated with previous charcoal analyses.

This study presents the results from several studies located in the Sydney Basin where the 'Oregon sieving method' and image analysis of charcoal has been undertaken with the aim of untangling any inter-relationships between climate, humans and fire.

Results from the last ~25 ka at Gooches Crater (~33°28'S, 150°16'E), are particularly highlighted. This site has revealed an initial increase in charcoal at 12.6 cal. ka BP, which agrees with archaeological evidence of people in the region. Charcoal is then elevated, but with major oscillations (notably, one is coeval with the European Younger Dryas), until a period of low charcoal between 8.9 and 5.5 cal. ka BP. This is followed by a relatively abrupt increase in charcoal at 5.5 cal. ka BP, after which charcoal accumulation remains high.

This mid-Holocene increase in charcoal may reflect the increased anthropogenic use of fire, as it is coincident with an intensification of Aboriginal populations described in archaeological sequences. Alternatively, the increase in fire activity may reflect climatic forcing directly, and/or human responses to any climate change. The increase in fire, for example, may reflect the crossing of a critical threshold as ENSO strengthened through the Holocene (eg. Moy et al., 2002 in Nature). The change at 5.5 cal. ka BP is also coeval with the end of the African Humid Period (eg. deMenocal et al., 2001 in Quat. Sci. Rev.). Ongoing palynological work is aimed at separating these hypotheses, however the nexus between climate, humans and fire potentially represents a complex interaction.

54-9 BTH 55 Zhou, Weijian

VARIABILITY OF HOLOCENE CLIMATIC EVENTS RECORDED IN PEAT SEDIMENTS FROM THE TIBETAN PLATEAU

ZHOU, Weijian¹, HEAD, John², JULL, A.J.T.³, BURR, G.³, and LU, Xuefeng¹, (1) State Key Lab of Loess and Quaternary Geology, Institute of Earth Environ, Chinese Academy of Sciences, No.10 Fenghui South Road, Hi-Tech Zone, P.O. Box 17, Xian, 710075, China, weijian@loess.llg.ac.cn, (2) School of Geosciences, Faculty of Science, Univ of Wollongong, Wollongong, NSW 2522, Australia, (3) NSF-Arizona AMS facility, Univ of Arizona, 1118 East Fourth St, Tucson, AZ 85721

North Atlantic deep sea sediment records indicate that the Holocene climate has been punctuated by abrupt shifts with a cyclicity close to 1500 yr, forming part of a millennial scale climate cycle operating independently of the glacial-interglacial cycle¹. Recent examination of a peat bog profile along the Tibetan Plateau has involved high resolution sampling (15-30 yr) and sensitive proxies together with reliable 14C AMS dating. Among other sharp fluctuations, we have recognized a series of cold, dry Holocene events and correlated well with ice rafting events recorded in North Atlantic Ocean sediment cores¹ and sedimentary sequences from the Arabian Sea. Spectral analysis of our data indicates high frequency climate variation with a predominant cyclicity of 1460 yr. This high-to mid-to low latitude relationship can only occur through an ocean-atmosphere coupling mechanism^{2,3}. Hence the role of the Tibetan Plateau as a conduit for both high and low latitude climate variations needs to be examined more closely.

References:

1. Bond, G., Showers, W., Cheseby, M., et al., A pervasive millennial-scale cycle in North Atlantic Holocene and glacial climates. *Science*, 280, 1257-1265 (1997).
2. Zhou, W. J., Head, M. J., Lu, X. F., et al., Teleconnection of climatic events between east Asia and polar, high latitude areas during the last deglaciation. *Palaeogeog. Palaeoclim. Palaeoecol.*, 152, 163-172 (1999).
3. Zhou, W. J. et al. Terrestrial evidence for a spatial structure of tropical-polar interconnections during the Younger Dryas Episode. *Earth and Planetary Science Letters* 191, 231-239 (2001).

54-10 BTH 56 Meyer, Michael

THE GLACIAL CHRONOLOGY OF EASTERN LUNANA (NW BHUTAN-HIMALAYA)

MEYER, Michael¹, HÄUSLER, Hermann², LEBER, Diethard², and WANGDA, Dorji³, (1) Institute of Geology and Paleontology, Univ of Innsbruck, Innrain 52, Innsbruck, 6020, Austria, michael.meyer@uibk.ac.at, (2) Department of Geological Sciences, Univ of Vienna, Vienna, Austria, (3) Department of Geology and Mines, Thimphu, Bhutan Lunana, a heavily glaciated area in the northwest of Bhutan, acted as accumulation area for Pleistocene ice-stream nets and is the source area for recurrent glacial lake outburst floods during Holocene and recent times. The Quaternary sediments and glacial geomorphology have been examined in detail. Here we present a first glacial chronology for Eastern Lunana, constrained by radiocarbon age dating. Remnant sequences of Pleistocene lateral moraines and kame terraces can be traced downvalley and contain datable organic material. Using these ice-marginal deposits, a glacier advance of approximately 35 km can be reconstructed for the local LGM. A younger loess-covered moraine complex at an altitude of 4100 m (Thanza Stage) indicates a glacier advance of 4 km, with an approximate Equilibrium Line Altitude depression of 300 m (relative to the recent situation). This contains datable buried paleosols as witnesses of warm periods. The ages of the Neoglacial moraines were constrained using dendrochronology and radiocarbon age dating. The main valleys of NW Bhutan are open to the south and are situated just out of the rain-shadow produced by the Shillong Plateau. Thus the Indian summer monsoon can directly transport moisture to high altitudes, feeding glaciers in Lunana. The recent "Glacier Elevation Index" (as approximation of the Equilibrium Line Altitude) was calculated at 5300 m, some 250 m lower than in the southwestern Everest region, which probably reflects the more humid climatic conditions in NW Bhutan. According to our meteorological data, 80 to 90 % of the total annual precipitation (500 – 700 mm/yr) falls during March to October, which is strongly influencing the mass balance of Lunana's glaciers. We assume that these glaciers, which are entirely summer accumulation-type glaciers, as well as their Quaternary sediments, reflect recent and paleo-monsoon dynamics, thus making Lunana a suitable place for testing whether the glaciers in the Bhutan-Himalaya region fluctuated synchronously with other northern hemisphere ice volumes or not.

54-11 BTH 57 Goddu, Srinivasa Rao

MULTIVARIATE STATISTICS AND TIME SERIES ANALYSIS OF LACUSTRINE SEDIMENTS DURING PLEISTOCENE AT SOUTHERN MARGIN OF TIBETAN PLATEAU

GODDU, Srinivasa Rao¹, HU, Shouyun², APPEL, Erwin³, and WANG, Sumin², (1) Geophysics, Institut für Geowissenschaften, Universität Tübingen, Sigwartstrasse 10, Tübingen, 72076, Germany, srinivasa.rao@uni-tuebingen.de, (2) Nanjing Institute of Geography & Limnology, Nanjing, Nanjing, 210008, China, (3) Geophysics, Institut für Geowissenschaften, Universität Tübingen, Sigwartstrasse 10, Tübingen, 72076, Germany The dramatic rise of the Tibetan plateau during the Pliocene has strongly controlled the global monsoon system. Lacustrine sediments of long living lakes at the southern fringe of the Tibetan plateau are good archives for palaeoenvironmental changes. We deal with three such lacustrine sections i.e. Kashmir basin (Kashmir, India), Katmandu basin (Central Nepal) and Heqing basin (Yunnan, China). A 168 m-drill core of lacustrine sediments is recovered from the Heqing basin, Yunnan province, western China. Magnetic and nonmagnetic parameters were measured with an average interval of 10 cm. Carbon-14 dating at the top of the core and magnetostratigraphy (Blake event, BM boundary) show that the core spans the last ~1Ma. Magnetic mineralogy is dominated by magnetite. Lithology and grain size analysis show that the core is quite homogeneous throughout. Results of Fourier analysis of susceptibility (χ) and carbonate content show clear cyclicities. Wavelet analysis supports the results of Fourier analysis. A phase lag between parameters (χ) and carbonate is observed. Different sliding windows show the change of the power spectrum and amplitudes all along the core. The results can be interpreted in terms of palaeoclimatic changes (e.g. topmost 50m behave differently than the lower part) and can be also used to improve the age frame by calibrating the spectra to Milankovitch cycles. Fuzzy cluster analysis of magnetic parameters, carbonate content and pollen shows a periodic grouping with division of the section into three different parts.

54-12 BTH 58 Takada, M.

LANDFORM EVOLUTION AND LATE QUATERNARY ENVIRONMENTAL CHANGES AROUND LAKE PUMUYOM CO IN THE SOUTHERN PART OF THE TIBETAN PLATEAU

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There have been heated debates on the relationship between environmental changes in Tibet and the global climate change during the Glacial-Interglacial cycle. However there are still many uncertainties on the timing and extent of Quaternary glaciations for most areas on the plateau. In this study, we have investigated landform and unconsolidated materials around Lake Pumoyom Co (altitude: 5010 m, E90°30', N28°32') to clarify environmental changes in the southern part of the Tibetan Plateau during Late Quaternary. Around the lake there exist several moraines, which can be classified into three groups. The innermost terminal moraines are located about tens to hundred meters apart from the front of present glaciers. Being unweathered and non-vegetated, they seem to have been formed quite recently such as during the Little Ice Age. The middle terminal moraines are little vegetated and hardly weathered. The outermost terminal moraines are not much weathered but covered with grass, and gradually change into the highest outwash terraces. Moreover the outwash terraces gradually merge into the highest river terraces along the outlet of the lake. The relative height between the highest river terrace surface and the present river bed along the outlet is about 10 meters. In the vicinity of the northern shore there exists the lowest divide of the lake basin, the altitude of which is about 10 meters higher than that of the present lake surface. One wind-gap or paleo-channel was identified there. These Observations suggest that the water level of the lake was once about 10 meters higher than the present one. Based on the relationship between the outwash terraces and other river terraces, the period of the higher water level seems to have coincided with that of an advance of neighbouring glaciers. Indeed an older moraine from one tributary valley glacier is found to have once blocked the lower course of the outlet. Therefore the period of high lake level seems to have been mainly due to damming up of the outlet. A 14C age (16,000±70 yBP) from loess deposits which cover older glacial diamicton and several OSL ages from the highest river terrace deposits indicate that the age of the period was almost around the Last Glacial Maximum (LGM). It is concluded that the extent of glaciers in and around the study area was limited and Lake Pumoyom Co was present during the LGM.

54-13 BTH 59 Montgomery, David R.

ANCIENT LAKES UPSTREAM OF THE TSANGPO RIVER GORGE AT NAMCHE BARWA, EASTERN TIBET

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Lacustrine and fluvial terraces along a major tributary to the Yarlong Tsangpo River upstream from Namche Barwa at the eastern end of the Himalaya indicate that Holocene glaciers repeatedly advanced far enough to dam the Yarlong Tsangpo. An upper set of lacustrine terraces, together with fluvial terraces graded to them, define the extent of a lake roughly 200 km long and 500 m deep, impounding an estimated 152 km³ of water. A lower set of terraces record a smaller lake that extended almost 100 km upstream from the entrance to the gorge, that was almost 200 m deep, and which impounded about 15 km³ of water. Radiocarbon dating of woody debris and charcoal from lake sediments from the higher lake terraces yield ages of 8860±40 and 9870±50 14C yr B.P. Dates from the lower terrace yield ages of 1220±40 and 1640±50 14C yr B.P. Field observations of moraine deposits on both sides of the Yarlong Tsangpo immediately upstream of the entrance to the gorge suggest that advances by a glacier from the flank of Namche Barwa repeatedly dammed the Yarlong Tsangpo. Rupturing of the ice dams would have released giant outburst floods down the gorge of the Yarlong Tsangpo. Although the estimated peak discharge for failure of the larger lake dam was 200,000 m³ s⁻¹, the estimated maximum stream power during the Yarlong Tsangpo floods was comparable to that of the Pleistocene Missoula floods in Washington state (USA). Therefore, it seems likely that substantial downcutting and valley-side erosion during the late Quaternary occurred during these floods, with important implications from models seeking to link mountain uplift, climate, and upper mantle rheology. The timing of the lake forming events is of interest because of these tectonic models, and because of the light they shed on the glacial history of southeastern Asia.

54-14 BTH 60 Gillespie, Alan

CLIMATIC INTERPRETATION FROM MOUNTAIN GLACIATIONS IN CENTRAL ASIA

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Glaciers advance or retreat in response to changes in precipitation, summer temperatures, insolation and cloudiness. Therefore, the extent of ancient glaciers in Central Asia can be used to understand some aspects of its paleoclimate. The timing of the local maximum advances and their equilibrium-line altitudes exhibit strong spatial structure. We recognize three main zones of glaciers in Central Asia: 1) a western zone, from the Karakoram north to the Kyrgyz Tien Shan, and east to central Tibet; 2) a northern zone, from the Xinjiang Tien Shan to central Mongolia, and north to southern Siberia; and 3) eastern Tibet. In zone 1, the maximum glacial advances occurred early in the ice-age cycle (~110-14 ka) as determined by ¹⁰Be dating: ~110-90, 63-45, and 30 ka. "Last Glacial Maximum" (~20 ka) glaciers were little larger than modern glaciers. In zone 2, the LGM glaciers were as large or larger than the older glaciers. In zone 3, Holocene glaciers were nearly as large as the Pleistocene glaciers. We interpret these patterns in terms of the climatic factors affecting glacier growth.

These regional variations in glacial history must reflect regional differences in the evolution of the controlling climate factors. Owing to the location of Central Asia, the climate there is relatively straightforward, and represents a continental 'end member' of the system. (Modern precipitation is mainly from spring and fall low-pressure systems guided by the jet stream. Strong thermal high-pressure cells over Siberia during the winter limit the number of storms in the winter months. Summertime temperatures are largely radiatively determined, and the extreme orography of the region plays an important role in shielding the area from the monsoons). Despite its simplicity, the interannual and decadal climate variability there has received scant attention. Using the relevant regional climate indicators for glaciers (e.g., positive degree days, annual precipitation), we employ composite analysis of atmospheric reanalysis data to explore how circulation regimes in the current climate give rise to regional variability. Using these results and the available suite of global climate model simulations for glacial climates, we aim to construct self-consistent climate scenarios which can be reconciled with the glacial history of the region.

54-15 BTH 61 Wang, Yiming**MID TO LATE HOLOCENE VEGETATION AND PALEOCLIMATE EVOLUTION OF LAKE DOOD BASIN, NORTHERN MONGOLIA, BASED ON PALYNOLOGICAL DATA**

WANG, Yiming and FOWELL, Sarah, Geology and Geophysics, Univ of Alaska Fairbanks, PO Box 755780, Fairbanks, AK 99775-5780, ftyw@uaf.edu

Lake Dood is a fresh water oligotrophic lake located on the floor of the extensional Darhad Basin, one of two extensional basins that occupy the southern tip of the Baikal Rift Zone in northernmost Mongolia. This basin lies within the transition zone between forest-steppe ecosystems to the south and boreal forest to the north. The vegetation and paleoclimate change can be reconstructed by using palynological data. Our core covers approximately last 6,000 years. In this study, we propose a Normalized Difference Steppe/Forest Index (NDSFI), based on the ratio of the difference between forest-steppe vegetation pollen to arboreal forest pollen to their total pollen concentration, this index is thought to be a proxy for changes in moisture availability and temperature. Typical forest-steppe taxa include *Larix*, *Artemisia* and *Chenopodiaceae* and those of boreal forest are the taxa of *Picea*, *Pinus*, *Larix* and *Betula*. Greater boreal forest pollen concentrations are indicative of humid climate conditions, on another hand, greater steppe concentrations correlate with relatively arid climate conditions. Pollen from this core indicates there are 8 major shifts between forest steppe and boreal forest vegetation. This compares well with other cores from Lake Dood. The vegetation shift suggests that changes in atmospheric circulation and temperature are driven by solar insolation.

SESSION NO. 55, 1:30 PM**Monday, July 28, 2003****S18. Warm Times/Cold Times: Holocene Climate Variability in the North Atlantic Region (Posters)****Reno Hilton Resort and Conference Center, Pavilion****55-1 BTH 128 Jessen, Catherine****ABRUPT CLIMATIC CHANGE IN SWEDEN CENTRED ON 3,750 CAL. YEARS BP: EXPLORING ENVIRONMENTAL RESPONSES AND THEIR RELATIONSHIP TO ATMOSPHERIC CO₂**

JESSEN, Catherine, RUNDGREN, Mats, and HAMMARLUND, Dan, Department of Geology, Quaternary Geology, Lund University, Tornavägen 13, Lund, SE-223 63, Sweden, Catherine.Jessen@geol.lu.se

Many proxy records from the northeast Atlantic region register an abrupt response to climatic change shortly after 4000 years ago, generally marking the beginning of Late Holocene increased instability. Among these is a stable carbon and oxygen isotope record from Lake Igelsjön, south central Sweden showing a distinct change to a 'wetter/cooler' climate.

New cores have been extracted from Lake Igelsjön and a multi-proxy approach applied at high-resolution (ca. 20-25 years) to examine the character and timing of the different proxy responses. Lake sediment chemistry data, magnetic parameters and pollen assemblages have been investigated and compared using a chronology based on high-resolution AMS radiocarbon dates. In addition, by applying the inverse relationship of atmospheric CO₂ concentration and the stomatal index of leaf fragments at the same high-resolution, a quantified record of global CO₂ has been obtained.

The results show a distinct reduction in lake productivity beginning at 3,880 cal. years BP and centred on 3,750 cal BP. Lake productivity was generally low for a period of 160 years with only a short-term recovery (ca. 140 years) before further fluctuations occur. Beginning at precisely the same time, the local/regional vegetation reconstruction shows a clear response for 360 years. The decline occurred over a period of only 60 years and possibly due to climatically induced alterations in human land-use. The preliminary stomatal index (SI) reconstruction of atmospheric CO₂ concentrations show a possible reduction for a period of 280 years beginning at 3,740 cal years BP, i.e. 140 years after the start of the vegetation and lake production responses. This could not therefore be considered the forcing behind this climate change.

The concurrent, independent response of different environmental proxies beginning at 3,880 cal. years BP from Lake Igelsjön, along with evidence from other Scandinavian sites, suggests that the climatic change affecting this region occurred rapidly and impacted sensitive environments for at least 150 years.

55-2 BTH 129 Caseldine, Chris**BIOLOGICAL PROXIES FOR HOLOCENE CLIMATE CHANGE IN ICELAND – PATTERNS AND ISSUES**

CASELDINE, Chris, LANGDON, Peter, and HOLMES, Naomi, Geography, Univ of Exeter, Amory Building, Rennes Drive, Exeter, EX44RJ, United Kingdom, C.J.Caseldine@exeter.ac.uk

Terrestrial records of Holocene climate reconstruction in Iceland have relied heavily on past glacial evidence to produce sequences of climatic change, although palynological data based in particular on oscillations in tree birches (temperature) and sedges reflecting expanding wetlands (precipitation/temperature) have been used to expand and refine the palaeoclimatological record. New pollen data from Northern Iceland are used to examine patterns of vegetation change between 9600 14C yr BP and 6000 14C yr BP and are compared to evidence for tree-line change, glacial and offshore evidence. Further comparison with published chironomid-based temperature reconstruction from NW Iceland is made to introduce some of the wider issues concerning the interpretation of such data, especially the problems on non-agreement between records and the identification of climatic signals within data sets influenced by local and regional factors such as migration and soil development. Contrast are also drawn between pollen and chironomid data from very recent sediments covering the last few centuries when climate is known to have oscillated significantly, probably between temperatures characteristic of both the warmest and coldest of the last 10,000 years.

55-3 BTH 130 van Hoof, Thomas B**COUPLING BETWEEN ATMOSPHERIC CO₂ AND TEMPERATURE DURING THE LAST MILLENNIUM**

VAN HOOFF, Thomas B, KÜRSCHNER, Wolfram M, WAGNER, Friederike, and VISSCHER, Henk, Botanical Palaeoecology, Utrecht Univ, Budapestlaan 4, Utrecht, Netherlands, t.b.vanhoof@bio.uu.nl

The Little Ice Age of the Last Millennium is the most recent cool phase in a series of Holocene climate oscillations. Following the Medieval Climatic Optimum, a marked shift to a more colder time began in the 1200s. The climate was coldest between 1600 AD and 1850 AD. Fluctuations in the

pre-industrial CO₂ record from Antarctic ice cores suggest a causal link between the Little Ice Age climate deterioration and atmospheric CO₂ concentration. However, comparison of ice-derived CO₂ data and temperature records is hampered by generally low time-resolution of the CO₂ measurements in ice cores. By applying the inverse relation between numbers of leaf stomata and atmospheric CO₂ concentrations, high-resolution stomatal frequency analysis of buried tree leaves provides a more accurate method for detecting CO₂ changes. To corroborate the concept of a coupling between CO₂ and natural climate variability of the Last Millennium, we studied oak (*Quercus robur*) leaves from sediment cores of an organic-rich oxbow-lake infill of the river Roer (SE Netherlands). This infill consists of 4 meters laminated organic rich clays. 14C dating of the profile suggests the presence of an undisturbed oak leaf record from 1000 AD to 1560 AD. Stomatal frequency analysis of these leaves provide us with a CO₂ reconstruction for this period on a decadal resolution. This reconstruction suggests shifts in atmospheric CO₂ considerably larger than previously recorded in ice-core records. There is every indication that the reconstructed CO₂ trends show good temporal correlation with many proxy records of temperature changes. Ongoing research is focusing upon fine-tuning the time framework for the leaf-based CO₂ reconstructions from the Roer site and extending the CO₂ curve into the second half of the Last Millennium. Therefore, new sites in Denmark are being incorporated in our research.

55-4 BTH 131 Schulte, Lothar**FLUVIAL ENVIRONMENTS AND CLIMATE VARIABILITY IN THE SWISS ALPS: EVIDENCE FROM THE ALLUVIAL FAN OF THE LÜTSCHINE RIVER (JUNGFRAU MASSIF)**

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Fluvial environments respond to changes in climate, physiographic conditions and human activity. Natural paleofloods result from excessive rainfall intensity and frequency, snowmelt, glacier melt, precipitation combined with frozen soils etc. Holocene global-scale changes in the atmosphere can decisively influence these factors. Furthermore, high mountain areas are characterized by the presence of glacial and periglacial processes, increased slope instability and higher precipitation. The Alps, in particular, separate the humid Atlantic temperate zone from the Mediterranean and are sensitive to extreme rainfall and flood events.

The studies on Holocene river dynamics of Central Europe focused over the last decades on river systems located in the lowlands and low mountain ranges (e.g. Rhine, Danube, Weser, Wisloka valley etc.). In addition to the climate dependence, most of these publications refer to the correlation between glacial variations of the Alps and the river dynamics. However, surprisingly little attention was spent on the alpine fluvial systems, which should be more closely related to the glacier history.

This study addresses the fluvial dynamics of the alluvial fan of the alpine Lüttschine River at the northern fringe of the Jungfrau massif focusing on the last 4400 years. The fluvial paleoenvironments were reconstructed by morphological mapping, sedimentological studies of geological sections and drillings, historical maps and documents, geochemistry and pollen analysis. The chronostratigraphy of the deposition processes were established using 14C-dating techniques, historical data and pottery fragments.

The correlation between the Lüttschine river system and the Isola delta in the Upper Engadin, the glacier variations of the West Alps and the lower Grindelwald glacier in particular, as well as the vegetation history of the Alps indicate that fluvial accumulation and erosion processes increased during the cooler Holocene climate events such as the Early Subatlantic Ice Advance (Göschel I period), Early Medieval Ice Advance (Göschel II period) and the Little Ice Age. In contrast, fluvial dynamics during the Roman and Medieval Climate Optimum were less significant and peat formation occurred. The pollen data record the first local human impact since the first century (Roman period).

55-5 BTH 132 Bradley, Raymond S.**HIGH RESOLUTION STUDIES OF LAKE SEDIMENTS FROM THE LOFOTEN ISLANDS, NW NORWAY**

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We hypothesise that the Lofoten islands are sensitive to changes in ocean currents (fluctuations of the North Atlantic Drift) and to circulation shifts associated with different modes of the North Atlantic circulation. At present, the outer islands are bathed in waters that reach +11°C in summer (+5-6°C in winter) in spite of their high latitude location within the Arctic Circle. Changes in the strength and/or position of this warm water tongue will drastically affect the Lofoten environment. The islands have many deep, fresh water lakes and peat bogs with Holocene records; lake sediment cores and peat sections were recovered to provide a detailed record of late Holocene environmental changes in the region. To provide the best possible chronological control, a major effort has been made to develop a tephrostratigraphy for the region. As no tephra work had been done in this area before, several peat profiles were selected to develop a local tephra stratigraphy before applying this to more complex lake sediments. Two peat profiles have been analysed and show one of the best historical tephra sequences outside of Iceland itself. A good range of historical tephra has been identified, including among others, tephra from AD 1875 (Askja), AD 1510 (Hekla), AD 1362 (Oræfajökull), AD 1158 (Hekla) and AD 1104 (Hekla) eruptions and also the big eruption of Hekla in 2310 BC. The AD 1158 and 2310 BC tephra have already been used to provide chronological control in our pilot cores from lacustrine and brackish water sediments. These layers can be used to correlate with core to core and lake basin to lake basin. Furthermore, we will also be able to correlate with other work along the Atlantic seaboard of Europe at key dates such as the 2310 BC (Hekla 4). Using these chronostratigraphic markers, sediments from low elevations lakes in the Lofoten Islands have been analysed at high resolution, providing a detailed & chronologically well-controlled record of late Holocene environmental changes in the region.

55-6 BTH 133 Allen, Judy R.M.**HOLOCENE CLIMATE VARIABILITY IN NORTHERN FINNMARK**

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Palaeoenvironmental records along a west to east transect of lake sites across the northernmost peninsulas of Finnmark, north Norway, have been investigated for evidence of Holocene climate variations. All the sites investigated lie outside (north of) the Scandinavian Younger Dryas ice limit.

The hypothesis we seek to test is that Holocene climatic variability seen in these records is related to variations in the strength, and northward and eastward penetration, of the Norwegian current, a distal arm of the Gulf Stream which brings warm water into the Barents Sea.

Over Gunnarsfjorden (71° 02' 18" N, 28° 10' 6.6" E; 78m above sea level), is a small lake on the east coast of Nordkinnhalvoya which was core in late winter 2000. High temporal resolution (100yr) palynological analyses of the 2.3m of organic sediments recovered from this lake show evidence of post-glacial environmental variations since at least 12,500 calibrated years BP (10,580 14C BP). A second site 2km west of Over Gunnarsfjorden, Ned Trollhetta (71° 02' 28" N, 28° 06' 56" E), lies at 167m asl; a basal AMS radiocarbon date from this lake indicates that sediment accumulation started earlier - about 15,000 calibrated years BP (12,665 14C BP); outline pollen analyses indicate significant development of early late-glacial vegetation.

Detailed analyses of the Holocene record at Over Gunnarsfjorden suggest that there have been episodes of more and less temperate climates throughout this interval. Similar environmental variations are also seen in the Holocene pollen records from two further sites which were cored in late winter 2001, Liten Eap'pesjav'ri on Mageroya to the west and Over Kobbkrokvatnet on Varanger to the east.

These field sites lie to the north of the "Risvik" and "Outer Porsanger" moraine complexes of Finnmark. Prior to this study the ages of these moraines has not been known, despite their potential for constraining the deglacial history of the Barents Sea and Fennoscandian ice Sheets. The new AMS chronology proposed here supports a model of early (ca 15,000 calibrated years BP) deglaciation of the Finnmark peninsulas. This is in broad agreement with rapid deglaciation of the Barents Sea Ice Sheet suggested by recently collected marine sedimentary records.

55-7 BTH 134 Geirsdóttir, Áslaug

HOLOCENE CLIMATE VARIABILITY IN NW ICELAND DERIVED FROM FJORD AND LACUSTRINE SEDIMENT CORES

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Evidence from fjord and lake cores in NW Iceland is used to delineate environmental change during the Holocene. The study area is affected by the southward flowing East Greenland Current of Polar Water origin, and the warmer northward flowing Atlantic Water of the Irminger Current. The fluctuating position of the boundary between these two opposing currents greatly affects the ocean physical and chemical characteristics in the region, including sea surface temperature, salinity and sea ice extent. Changes in the extent and duration of sea ice NW of Iceland has direct impact on land temperatures, as demonstrated by instrumental records and historical accounts. We therefore believe that both marine and terrestrial archives should record changes in the flux of Polar versus Atlantic water.

Marker tephra layers and AMS 14C dates on macrofossils and bulk sediment allow for correlation between marine and lacustrine stratigraphies. Marine sediment cores document rapid ice retreat from the maximum glacier extent on the shelf, starting around 15 ka. Stepwise readvances or halts in the ice recession are recorded in the fjords ~14 ka, ~12 ka and ~11 ka. Less minerogenic sediment and higher total carbon (TC%) in the lake cores reveal the disappearance of ice from the lake basins just before 10.5 ka. Apparent consistency in magnetic susceptibility (MS) and carbonate/TC% occurs between fjord and lake cores over the last ~10 kyr. Both archives record relatively stable conditions from 9.5 ka to 5.5 ka, although a minimum in carbonate/TC% with a correlative maximum in MS is seen in both records around 8.2 ka. Our proxy records register increased instability around 5.5 ka, probably indicating the onset of Neoglaciation, with a distinct low in fjord and lake productivity after ~3.5 ka. A fresh input of ice rafted debris in one of the fjord cores that receives sediment from the extant ice cap Drangajokull documents the expansion of the glacier during the Little Ice Age.

55-8 BTH 135 Long, Antony

HOLOCENE EVOLUTION OF DISKO BUGT, WEST GREENLAND

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The wide ice-free margin of the west coast of Greenland (between 150 and 200km wide) supports a rich array of glacial landforms. Numerous radiocarbon dates, mostly on molluscs contained in raised glacio-marine deposits, provide a chronology of advance and retreat of the Greenland ice sheet since the last glacial maximum. A prominent element of this deglacial history is the widespread 'Fjord Stage' moraine. This is dated to c. 9.3ka cal. BP and formed in response to either a short lived climatic deterioration or because of topographic controls on ice sheet retreat. In this paper we use data derived from offshore gravity cores to explore the correlation between terrestrial models of deglaciation and the oceanographic record of environmental change in Disko Bugt.

Foraminiferal and sedimentological data show a clear oceanographic change dated 9.4 – 8.9 ka cal BP which is similar in age to the 'Fjord Stage'. This event is marked by a switch from colder water foraminifera to a warmer assemblage, more similar to the present day, which may relate to the incursion of the relatively warm and saline West Greenland Current into Disko Bugt. The switch to warmer conditions at the time when the terrestrial evidence points to climate cooling is contradictory. Our work suggests that the 'Fjord Stage' in Disko Bugt occurred later than previously thought (as also suggested by new relative sea-level data collected from the south of the bay). Under this scenario, the oceanographic evidence we report most probably records the influx of warmer water following the retreat of the ice sheet to the eastern shores of Disko Bugt during the early Holocene.

55-9 BTH 136 Miller, Gifford H.

HOLOCENE GLACIATION AND CLIMATE HISTORY OF BAFFIN ISLAND, ARCTIC CANADA

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The Holocene evolution of climate and glaciation has been reconstructed from a variety of proxies preserved in lake and raised-marine sedimentary archives, and from dated moraines and related ice-recessional features. Cosmogenic exposure dating of glaciated surfaces and erratic blocks, coupled with diagnostic changes in the physical and magnetic properties of sediment in glacier-dominated lacustrine systems, document Laurentide Ice Sheet (LIS) recession of ice from the glacial maximum beginning ~13 ka, with rapid ice retreat until ~10 ka (some outlet glaciers retreated as much as 1000 km in 500 yr). A major readvance of the LIS and mountain glaciers occurred ~9.6 ka (Cockburn Substage). At least one minor but widespread readvance occurred just before 8.0 ka, possibly related to the 8.2 ka event. Local glaciers were behind their present margin

before 7 ka, and in some instances much earlier, although the retreating LIS continued to slowly retract to the present day Barnes Ice Cap through the Holocene; Pleistocene ice in the lower levels demonstrates the LIS has yet to completely disappear. The onset of Neoglaciation is well dated to 5.5 ka, with intensification after 2.5 ka. The expansion of local glaciers during the Little Ice Age represents the most extensive advance since 7 ka. Local hilltop ice caps on the plateau of north-central Baffin Island began their most recent expansion 500 years ago. Over the past century melting has reduced their coverage to <5% of their former area. Lakes not covered by the LIS at the LGM remained frozen throughout the year. By 14 ka increasing summer warmth produced moats around some southern lakes, aquatic moss were established, but pollen is exclusively from south of the LIS. By about 12 ka most lakes outside the ice margins thawed. Pollen at this time was dominated by grass, indicating relatively dry, cold summers. Terrestrial and marine conditions as least as warm as present were established by 9 ka. Organic matter accumulation in lake sediment peaked earlier in the south (11 to 9 ka) than in the north (9.5 to 6 ka). Most lakes exhibit a strong increase in minerogenic sediment in the late Holocene, suggesting cooler summers and disruption of vegetation in their catchments. Stronger-than-present penetration of Atlantic water along the east coast of Baffin Island began ~9.5 ka and persisted until ~4 ka.

55-10 BTH 137 Charman, Dan J.

HOLOCENE PALAEO-WATER TABLE RECONSTRUCTIONS FROM BRITAIN AND NORTH ATLANTIC CLIMATE VARIABILITY

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Variability in the North Atlantic is presumed to be one of the main drivers of long term terrestrial climate change in mid-latitude oceanic Europe. However, there have been rather few attempts to make these links explicitly by compiling terrestrial records and comparing them with oceanic and ice core records. One key source of terrestrial data over the mid-late Holocene for Britain is peat surface wetness records. Peat surface wetness changes reflect variability between periods of relatively warm/dry to cool/wet conditions, although the precise relationship of surface wetness with precipitation and temperature is still unclear. Here we compile a series of records of palaeo-water table depth based on testate amoebae analysis from peatlands in northern Britain to identify key phases of climate change. On the basis of comparisons between high-resolution surface wetness records with instrumental climate data, these are interpreted as primarily reflecting changes in summer precipitation. We hypothesize that the long term changes in peatland palaeo-water table depth reflect low frequency variability in the dominant position and strength of zonal circulation during the summer months.

55-11 BTH 138 McConnell, Joseph R.

NET ACCUMULATION ON THE GREENLAND ICE SHEET LINKED TO NORTHERN HEMISPHERE SEA ICE EXTENT

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Eleven ice cores were collected from 1995 to 1999 at widely distributed locations on the Greenland ice sheet and used to reconstruct historical annual net accumulation over recent centuries. Each core was analyzed with high depth resolution for a number seasonally varying chemical species and isotopes, providing near zero uncertainty in dating the annual accumulation records. These records demonstrate that net accumulation is highly variable, with dominant periods of temporal variability different for different regions of the ice sheet. To examine the relationship between hemispheric scale sea ice extent and net accumulation in different regions of the Greenland ice sheet, we compared net annual accumulation at each ice core site with principal components derived from anomalies in northern hemisphere sea ice extent over the past century. Results show that variations in accumulation in specific regions of the ice sheet closely match large-scale variations in sea ice extent. For example, decreases in net accumulation in southeast Greenland coincide with increases in sea ice extent in the Greenland and Barents Seas and decreases in sea ice extent in Davis Strait and the Chukchi and Beaufort Seas. Meanwhile, increases in net accumulation in southwest Greenland correlate with decreases in sea ice extent in the Davis and Denmark Straits and the Greenland Sea but increased sea ice extent in the Barent and Laptev Seas. Accumulation near the summit of the Greenland ice sheet where the GISP2 and GRIP bedrock cores were drilled is relatively insensitive to large-scale sea ice extent. The observed strong relationships in variability of net accumulation and hemispheric scale sea ice extent suggest that an array of appropriately located century to millennial scale ice cores in Greenland offers the possibility of reconstructing proxies of annual sea ice extent to place the modern record in long term perspective.

55-12 BTH 139 Shopov, Yavor Y.

QUANTITATIVE ANNUAL SPELEOTHEM RECORDS OF TEMPERATURE, PRECIPITATION AND SOLAR INSOLATION IN THE PAST-

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We studied luminescence of speleothems from Cold Water cave, Iowa, US and Rats Nest cave, Alberta, Canada. A reconstruction of the past annual precipitation rates for the last 280 years for Kananaskis country, Alberta, Canada has been obtained from speleothem annual growth rates. In dependence on the soil surface exposition we measure either solar sensitive or temperature sensitive paleoluminescence speleothem records: - In case of Cold Water cave, Iowa, US we obtained high correlation coefficient of 0.9 between the luminescence record and Solar Luminosity Sunspot index and reconstructed sunspot numbers since 1000 AD with a precision within the experimental error of our measurements; - in case of Rats Nest cave, Alberta, Canada we measured correlation coefficient of 0.67 between luminescence intensity and air temperature record for the last 100 years and reconstructed annual air temperatures for last 280 years at the cave site with estimated error of 0.35 deg.C, while the error of the direct measurements is 0.1 deg.C.

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55-13 BTH 140 Andrews, John T.

STABLE ISOTOPIC DERIVED VARIATIONS IN BOTTOM WATER TEMPERATURES OFF VESTFIRDIR, NW ICELAND: AN INDICATOR OF CHANGES IN ATLANTIC WATER OVER THE LAST 6000 CAL YRS

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A mixing line for Iceland waters has been developed through an analysis of bottom water $\delta^{18}\text{O}$ SMOW and the water values for $\delta^{18}\text{O}$ SMOW on land. This relationship is used to estimate temperatures from the $\delta^{18}\text{OVPDB}$ determinations on benthic foraminifera from cores collected around Vestfirðir, NW Iceland. Bottom grabs and CTD casts provided data on foraminiferal distributions and their association with environmental gradients. Samples from recent sediments were also used to derive $\delta^{18}\text{OVPDB}$ values for the polar planktonic foraminifera, *N. pachyderma* s. and two species of benthic foraminifera, namely *Cibicides lobatulus* (epifaunal species) and *Melonis barleeanus* (infaunal species). Empirical relationships between water temperature, salinity, and the $\delta^{18}\text{O}$ values indicated that in these waters, most of the variance in the $\delta^{18}\text{O}$ is associated with temperature. Application of the normal equation for the calculation of $\delta^{18}\text{OVPDB}$ for equilibrium calcite to the Siglunes 50-yr hydrographic series, which showed an abrupt change from Atlantic to Arctic waters in 1969 associated with the Great Salinity Anomaly, confirmed the overwhelming importance of temperature in explaining variations in $\delta^{18}\text{OVPDB}$ ($r=0.98$ for $\delta^{18}\text{O}$ and $^{\circ}\text{C}$ versus $r=0.66$ for $\delta^{18}\text{O}$ and ‰). The strong ($r=0.78$) positive, and potentially offsetting, relationship between temperature and salinity over this interval of time is not sufficient to produce a "flat" $\delta^{18}\text{O}$ series. Application to down core $\delta^{18}\text{O}$ data was made taking into account the "vital effect" and with a selection of salinity values. Bottom water temperature estimates from B997-328, -329, -330, and -341 indicate that the coldest interval in the last 5 cal ka BP was during the 18-16thC when bottom waters are estimated to have decreased to between 3 and 4 $^{\circ}\text{C}$ compared to between 5.5 and 7 $^{\circ}\text{C}$ during the maximum of the last 5 cal ka B.P. which occurred between 1.5 and 1 cal ka B.P. An attempt is made to ascribe error limits to the temperature estimates.

55-14 BTH 141 Kristjansdottir, Greta B.

TEPHRAS IN CORE MD99-2269, NW-ICELAND SHELF: A STRATIGRAPHIC TOOL FOR ESTIMATING CHANGES IN RESERVOIR AGE OF SEAWATER

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An abundance of traceable and dated tephra-markers from Icelandic volcanoes offer a unique opportunity for land-sea correlations and determination of reservoir age of seawater around Iceland. An offset of tephra-markers from an established radiocarbon-based age model can be interpreted as a change in reservoir age of the water. The objective of this study is to examine Holocene changes in reservoir age of seawater on the NW-Iceland shelf.

Tephra-markers and adjacent radiocarbon ages from core MD99-2269, a 2533 cm core from Reykjafjardarall, NW-Iceland shelf (365 m water-depth), are analyzed. The MD99-2269 site is situated under fluctuating influence of the warm Irminger Current from the south and the cold East Iceland Current from the north. Previous AMS radiocarbon dates indicate a remarkable linear sedimentation rate of 5 yrs/cm from present back to 12,278 +/- 518 cal BP.

Distribution maps of several Holocene tephras, particularly rhyolitic tephras from the Icelandic volcano Hekla, indicate a distribution of airborne tephra (< 0.5-1 cm layer thickness) over the MD99-2269 site. However, only the Saksunarvatn tephra (9,000 14C BP or 10,180 +/- 60 cal BP) is visible in the core. We have located several tephra-markers by grain counting in the >150 µm size fraction. The samples were split until they could evenly cover a counting tray, then 1 cm² squares were randomly selected for counting until at least 300 grains were counted. Mud clumps and fecal pellets were counted, but not included in the total count of 300 grains. The counted grains were classified into: 1) fresh dark-colored tephra, 2) fresh light-colored tephra, 3) other lithics, 4) biogenic material, and 5) other material. The first two categories were intended to identify peaks in fresh tephra grains, which presumably coincide with primary tephra layers. The fresh tephra was differentiated from the reworked tephra mainly on the basis of having sharp, clean edges whereas the reworked tephra has duller edges. The fresh tephra also tends to look shiny under the microscope compared to the matter, reworked tephra. Samples from selected tephra peaks were geochemically analyzed at the Nordic Volcanological Institute in Iceland and the University of Colorado. Radiocarbon ages were obtained from the University of Arizona.

55-15 BTH 142 Wastegård, Stefan

TEPHROCHRONOLOGY AND EARLY HOLOCENE ENVIRONMENTAL CHANGES ON THE FAROE ISLANDS, NORTH ATLANTIC

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The Faroe Islands are situated in a uniquely sensitive part of the North Atlantic Ocean for registering Late Quaternary climatic changes. In warmer periods, when generally strong, or northward-displaced, circulation occurs in the atmosphere and ocean, the Faroe Islands lie continually in the main arm of the North Atlantic Drift. In colder periods, when this Drift weakens or its main branch takes a more southerly position, a tongue of polar water from the East Iceland branch of the East Greenland Current approaches the Faroe Islands from the northwest. One of the main aims of this research is to construct a complete Holocene tephrachronology for the Faroe Islands so that the marine record of climate development could be precisely compared with that from the terrestrial data. It also forms an important link between the existing tephrachronological frameworks on the British Isles, Germany and Scandinavia and the volcanic source areas on Iceland. The results from the tephra analyses so far indicate that tephra from the Hekla volcano dominates, with Hekla-4 (c. 4200 cal yr. BP) and Hekla-Selsund (c. 3750 cal yr. BP) as the most prominent horizons. Several basaltic horizons have been recorded in addition to the widespread Saksunarvatn tephra (10,240 cal yr. BP), including the Landnám tephra (c. 870s AD), the Hov tephra (c. 5900 cal yr. BP) and the Mjávotn tephra (c. 6300 cal yr. BP). Three silicic horizons from the Katla volcano are reported for the first time outside Iceland. Two of these are tentatively correlated with the SILK-A1 (c. 5900 cal yr. BP) and SILK-A7 layers (c. 7100 cal yr. BP), respectively. The third tephra is dated to c. 8000 cal yr. BP and has a geochemistry virtually identical to the Vedde Ash (c. 12,000 cal yr. BP) and IA2 tephra from the Rockall Trough (c. 13,500-13,000 cal yr. BP). Palaeoecological analyses record a significant vegetation perturbation between c. 10,380 cal. yr. BP and the deposition of the Saksunarvatn ash suggesting a marked change in climatic conditions. The initially dry continental conditions, which favoured *Betula nana*, *Salix*, *Juniperus* and *Ericaceae* but not *Gramineae* or *Cyperaceae*, were rapidly replaced by a cooler, moister climate. This gave rise to increased erosion and a reduction in lake trophic status. The correspondence between our data and earlier work of Jóhansen (1982) indicates that this is a widespread event.

SESSION NO. 56, 1:30 PM

Monday, July 28, 2003

S30. New Developments in Quaternary Numeric Dating Methods (Posters)

Reno Hilton Resort and Conference Center, Pavilion

56-1 BTH 143 Duller, Geoff A.T.

OPTICALLY STIMULATED LUMINESCENCE DATING USING SINGLE MINERAL GRAINS: POTENTIAL AND CHALLENGES

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Luminescence measurements of geological sediments allow the date of the last exposure of mineral grains to be calculated, and has been applied in the age range from a few decades to over 100 ka. The method has proven especially suitable for aeolian sediments where exposure to daylight prior to deposition is very likely. Conventional luminescence measurements involve analysis of sub-samples consisting of many hundreds or thousands of mineral grains and assumes that all of the grains have been exposed to sufficient daylight at the time of deposition to reset the luminescence signal to a low level. However, for many types of Quaternary sediment, it is difficult to be confident that this assumption will be met and this makes them problematic for luminescence dating. If the sediment contains some grains that were exposed to insufficient daylight to remove their signal then the age calculated will be too old. Such sediments are common, especially in glacio-fluvial, colluvial and to a lesser degree fluvial settings. Many of these sediments consist of complex mixtures of grains, some of which were exposed to daylight at the time of deposition, and some which were not.

Recent technological developments have made it easier to measure the luminescence signal from individual sand-sized (100-300 µm diameter) grains of quartz. In theory this single grain approach makes it possible to explicitly assess whether all the grains within a sample have the same apparent age. This would give greater confidence in the ages obtained. Equally, where a mixture of grains is present, some of which were exposed to daylight at deposition and others which were not, it should be possible to select only those fully-exposed grains. However, it is now clear that micro-dosimetry problems during measurement and numerical modelling of the distributions obtained are complex, and these provide major challenges for this single grain method. Results of single grain measurements on aeolian, glacio-fluvial and fluvial samples from Australia, Scotland and South Africa are shown, illustrating the potential of this approach.

56-2 BTH 144 Lepper, Kenneth

SINGLE-GRAIN OSL DATING OF MISSISSIPPI RIVER TIE CHANNEL DEPOSITS

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Aside from historical records (e.g. maps, aerial photos), which are often limited in their coverage and discontinuous in time, there are few viable geochronometric techniques for the study of fluvial processes that have occurred within the last century. Recent equipment advances have made it possible to determine optically stimulated luminescence (OSL) ages from individual sand-size sediment grains and have facilitated the rapid and convenient collection of the quantities of OSL data required for meaningful statistical analysis. Parallel advances in objective analytical methodologies are drastically improving the accuracy of OSL dating, particularly for youthful fluvial sediments. In this investigation we have used single-grain OSL to date sediments deposited by an unaltered tie channel in the lower Mississippi River floodplain approximately 40 miles north of Baton Rouge LA.

Floodplain tie channels link lowland rivers to floodplain lakes, commonly oxbow lakes. This "tie" allows the exchange of water, sediment, nutrients, contaminants and biota between rivers and floodplains. While common throughout the world, documentation of tie channel dynamics and evolution is almost entirely lacking in the geological literature. Single-grain OSL geochronology allowed us to examine the rate of advancement of tie channel deposits into the "Raccourci-Old River" oxbow lake and infer vertical accretion rates along the banks of the channel itself.

This presentation will focus on the experimental and analytical methods utilized, thereby emphasizing the latest advances in OSL dating. All sediments in this study were deposited after A.D. 1850, so the results demonstrate the applicability of single-grain OSL dating to youthful sediments and highlight the potential of the technique to provide temporal constraints for recent sediment transport studies.

56-3 BTH 145 Armitage, Simon J.

OPTICAL DATING OF MARINE SEDIMENT FROM ODP CORE 658B - AN INTERCOMPARISON WITH PRE-EXISTING AMS ¹⁴C CHRONOLOGY

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This study presents the results of an intercomparison of ages produced for marine sediments from Ocean Drilling Program (ODP) Site 658, using optical dating and previously published AMS ¹⁴C (deMenocal et al., 2000). This is the first large-scale, systematic application of optical dating to marine sediment, and demonstrates that the technique has considerable potential for the age estimation of otherwise undatable deep-sea material.

ODP Site 658 is located off Cap Blanc, Mauritania. It has a high sedimentation rate (18 cm/ka), due to high regional surface productivity and large inputs of windblown Africa dust (the material dated in this study). The Pleistocene-Holocene sections of core 658C are well dated (18 AMS ¹⁴C ages to 23 Cal. ka BP). As Core 658C has been extensively studied and core material exhausted, samples for optical dating were obtained from the neighbouring core 658B. Age/depth correlation between the two cores was made using oxygen isotope stratigraphy and carbonate content.

Optical dating techniques measure the total ionising radiation dose that a mineral grain has received since its last exposure to sunlight (i.e. during burial). This figure is divided by the environmental dose rate, giving the burial period for that sample. The environmental dose rate is mainly derived from the decay of radioisotopes in the sediment (K, U and Th). In terrestrial sediments, the uranium and thorium decay chains can be assumed to be in equilibrium. In the marine realm this assumption is not valid, and unsupported Uranium decay series exist on deposition.

Consequently, the environmental dose rate changes with sample age. This problem was circumvented by quantifying U and Th decay series disequilibrium, using an MC-ICP-MS. The evolution of the environmental dose rate during burial was modelled, and ages for each sample calculated.

The ^{14}C and optical dating ages are generally in good agreement, indicating that the latter technique can provide robust chronologies for marine sediments. Optical dating has been successfully applied to terrestrial sediments ranging in age from 0-200 ka, and hence should provide a valuable geochronological tool for marine sediments extending well beyond the time range of ^{14}C dating, and dating marine sediments that contain no dateable carbon.

56-4 BTH 146 Shlukov, A.

CRITICISM OF TRADITIONAL TL-OSL DATING

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TL-OSL dating is based on dosimetric property of some natural minerals, mainly quartz and feldspars. We have raised the question for many times regarding the competency of traditional technique of a dating which we consider to apply the artificial irradiation of samples to receive the natural absorbed dose.

The technique of artificial calibration has been borrowed from a TL dosimetry used in nuclear power engineering in conditions of high dose-rates. Specificity of TL-OSL dating is usage of artificial irradiation to model natural processes in a laboratory. So a natural background radiation with typical dose-rate 10-20 mkr/hour is being replaced by an artificial irradiation with a dose-rate up to 10-100 r/sec. Consequently the dose-rate changes by 7-9 orders. Such artificial calibration is competent only in case if a dosimeter has absolutely equal characteristics in such contrast conditions. However nobody and never has proved, that quartz or feldspars have the similar property.

It is well known from the theory of a luminescence, that such opportunity takes place only in case, if electrons-holes kinetics in crystal structure has the so-called first order. Such property was accepted in TL-OSL dating as a postulate. However, the kinetics of first order is realized usually in fast processes, at which excess energy holds in a crystal starting from a fraction of seconds (scintillation, fluorescence) to several months as maximum (TL dosimeters). This energy is being held during hundreds of millenniums in the geochronometry that is practically impossible at the first order. The second order kinetics take place usually in this case.

We observed experimentally all distinctive attributes of the second order kinetics in natural quartz. The final and full proof of the second order had been received in special experiment. Our results were reported last year at 10-th International Conference LED-2002. However this report was rejected from the Conference's Proceedings. Nevertheless, this rejection cannot serve as the proof of the first order of the kinetics.

56-5 BTH 147 Robinson, Sarah E.

COSMOGENIC NUCLIDES APPLIED TO DESERT PIEDMONT: A TECHNIQUE TO DETERMINE NUMERIC AGES FOR CROSS PIEDMONT CORRELATION

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Understanding the chronology and magnitude of Basin and Range piedmont deposits is important for unraveling the relative influences of tectonics, climate and local environmental conditions during their deposition and in addressing regional landscape development questions. Cosmogenic radio nuclides (CRNs) can improve on the existing relative chronologies by providing numeric ages for specific deposits, but application of this technique to piedmont deposits is challenging as they require explicit treatment of all three variables in the system: age, local erosion rate and inherited nuclides from previous exposure. New data analysis techniques were developed to determine the age and local erosion rate (allowing inheritance to vary for each sample) of two piedmont deposits in the White Tank Mountains, AZ using ^{26}Al and ^{10}Be CRN depth profiles. The amounts of isotope measured in each sample were modeled as the sum of the spallation, negative muon, and fast muon production pathways, and inheritance. Inheritance was calculated both as two individual variables representing the inherited amount of ^{26}Al and ^{10}Be and in terms of a single variable representing the source area erosion rate. For each sample, all combinations of erosion rate, age and inheritance that produced amounts of isotope within the error range of the sample were identified. These suites of possible solutions for samples within the same deposit were then intersected to identify the most probable age and erosion rate for that piedmont deposit. The most probable solutions are three packages of sediment in the older deposit (1.2 Ma, 2.0 Ma and 2.7 Ma) and two packages of sediment in the younger deposit (0.7 Ma and 1-1.5 Ma). The CRN analysis not only provided numeric ages of deposits that allow for cross-piedmont correlation, but also suggested sedimentary contacts not seen in the field providing a more robust geomorphic understanding of the unit relationships.

56-6 BTH 148 Perg, Lesley A.

COSMOGENIC NUCLIDES: NEW USES AS SEDIMENT TRACERS AND IN DEVELOPING SEDIMENT BUDGETS

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Terrestrial cosmogenic nuclide (TCN) concentrations provide a measure of near-surface residence time, and have been used to document surface exposure ages and erosion rates. Using TCNs as a sediment tracer is a promising new application. Here we provide an overview of tracing sediment with TCNs, including determining sediment provenance, tracing sediment through linked geomorphic systems, and balancing long-term sediment budgets, with examples from two landscapes. We also develop the theoretical framework for the general case of balancing the TCN budget in sedimentary systems, including erosion and deposition events in poorly-mixed systems.

The high W. Alps landscape includes broad U-shaped valleys, steep hillslopes, and valley glaciers. Sediment traps indicate a long-term erosion rate of about 0.12 m / k.y. during the Holocene. If landscape denudation were uniform, the spallation TCN component in the subaerially eroding hillslopes should approach steady state in about 5-6 k.y., with a concentration of about 200,000 atoms ^{10}Be / g qtz. The measured concentration in subglacial outwash is a tenth of this, less than 20,000 atoms ^{10}Be / g qtz. River concentrations are similar to the subglacial sediment concentrations, suggesting that the sediment provenance is largely glacial. Given the likely storage of TCNs on slowly eroding hillslopes, we would expect a pulse of high concentration sediment at the onset of large-scale ice sheet glacial advance.

The active margin at Santa Cruz, California is characterized by broad flat marine terraces, steep fluvial basins, and narrow discontinuous beaches. TCNs are used to examine rates of sediment production in basins, to determine the duration of sediment storage on marine terraces, and to constrain fluvial and cliff-derived sediment inputs to the littoral cell. The TCN-derived fluvial erosion rates in the five largest basins are typically around 0.2 mm / yr, with concentrations of ~20,000 atoms ^{10}Be / g qtz. The duration of sediment storage on the lowest terrace is about 65 ka, with an average concentrations of about 200,000 atoms ^{10}Be / g qtz. The measured pattern of

beach TCN concentrations can be reproduced by a spatially uniform, long-term cliff-backwearing rate of ~10 cm / yr, punctuated by fluvial inputs from the various basin sizes.

56-7 BTH 149 Barrows, Timothy T.

DIRECT DATING OF FOSSIL MEGAFaUNA USING COSMOGENIC CL-36

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The age of fossilized skeletal remains is usually determined by association with radiocarbon dates, luminescence dating of the encasing sediments, or uranium-series dating of bracketing speleothems. However, in all of these cases the age of the bones can be very different, even if reworking is not a factor. Direct dating has proven difficult, because bones tend to exchange isotopically with the environment and therefore not act as closed systems. In this paper we describe a new approach to directly dating tooth enamel using the cosmogenic isotope ^{36}Cl . This radionuclide is produced from a nuclear reaction with argon in the atmosphere, where it is dissolved into rain, and delivered to the Earth's surface. The isotope is incorporated into hydroxyapatite during tooth formation and provides a decay clock with a half-life of 301,000 years. For initial dating trials, we chose the exceptionally well-preserved and independently dated fossil remains at the Naracoorte World Heritage area. We defined the modern $^{36}\text{Cl}/\text{Cl}$ ratio in the environment using widespread, large, grazing kangaroos (*Macropus giganteus* or *M. fuliginosus*). Because of the close proximity of the site to the ocean, the modern $^{36}\text{Cl}/\text{Cl}$ is very low due to dilution by sea salt. In the caves there is some background ^{36}Cl production due to neutron production resultant from the decay of uranium and thorium in the sediments, and a minor contribution from muons penetrating the roof. Using a novel stepped-dissolution method, we were able to remove post-depositional contamination, minimize sample size and greatly reduce isobaric interference from collagen sulfur. The background-corrected fossil $^{36}\text{Cl}/\text{Cl}$ ratio in Victoria Fossil Cave gives an age of ~270,000 years, consistent with existing U/Th ages on bracketing speleothems. In Cathedral Cave the ratio gives a background-corrected age of ~430,000 years, older than existing U/Th ages.

56-8 BTH 150 Zreda, Marek

CAN COSMIC-RAY NUCLEON MEASUREMENTS BE USED TO SCALE PRODUCTION RATES OF COSMOGENIC NUCLIDES?

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Before cosmogenic dating methods can be applied with confidence, we must understand the spatial variability of nuclide production rates on the earth's surface. Direct measurements of cosmic-ray fluxes have commonly been used to ascertain the spatial variability of production rates, but the relation between spatial variations of cosmic-ray neutron intensity and production rates of in-situ cosmogenic nuclides remains unclear. We address this problem by comparing neutron measurements with measurements of cosmogenic isotopes over a large range of altitudes. We conducted airborne and ground-based neutron monitor measurements at Bangalore, India ($R_C=17.2$ GV). Our measured attenuation lengths of 147 ± 2 (altitudes 0-2300 m) and 156 ± 1 g cm $^{-2}$ (2,300-5,300 m) are consistent with previous neutron monitor measurements. These results allow for the extension of the neutron scaling model of Desilets and Zreda (2003, Earth and Planetary Science Letters 206, 21-42) to 17.2 GV, which is nearly the highest cutoff rigidity in the current geomagnetic field. To compare our new neutron scaling model with cosmogenic nuclide production rates, we measured an altitude profile of ^{36}Cl inventories in lava flows on Mauna Kea, Hawaii ($R_C=12.8$ GV). The attenuation length of 139 ± 9 g cm $^{-2}$ is consistent with the value of 142 ± 1 g cm $^{-2}$ calculated from our neutron-monitor scaling model. The agreement between neutron and nuclide attenuation lengths suggests that scaling functions derived from modern measurements of neutron intensity can be extended to isotopic systems and to geological time.

56-9 BTH 151 Eggins, Stephen

OPEN SYSTEM U-SERIES DATING OF MARINE MOLLUSC SHELLS

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Marine terraces and shoreline deposits preserve a rich record of sea-level change in response to past climates and tectonic processes. Since Kaufman et al. (1971) demonstrated U-series dating of mollusc shells to be notoriously unreliable because fossil material was subject to open-system behaviour (uptake or loss) of uranium, accurate and independent dating of events beyond radiocarbon limits has been limited largely to U-series dating of marine deposits that contain corals. Subsequently reported U-concentrations and $^{234}\text{U}/^{238}\text{U}$ ratio distributions in fossil shells indicate differing rates of post mortem uranium-uptake in different shell parts and species, and account for different uranium concentrations and closed-system U-series ages obtained from different mollusc species at single localities. However, rather than taking into account this open system behaviour, most mollusc dating studies have pursued closed-system U-series dating of those shell parts that appear to accumulate their uranium shortly after burial (early U-uptake). Furthermore, where inconsistent or a range of dates are encountered, these are typically attributed to unresolved open-system uranium behaviour or the reworking of shells from older units. This approach is clearly of limited value because it can neither be used to obtain independent age estimates nor be applied to many sites. We have taken a new open-system approach to U-series dating of mollusc shells, that employs laser ablation ICP-MS to profile uranium and U-series isotope distributions within fossil shells. These high spatial resolution profiles provide the basis for constraining the uranium-uptake history and accurate U-series dating of fossil shells using physically meaningful open-system models. To date, we have focused on the distribution of uranium and U-series isotopes in fossil (MIS 5e and Holocene) and modern shells of the bivalve *Anadara trapezia*. Fossil shells are observed to accumulate significant uranium (up to 10 ppm) in the outer shell layer and to develop U-concentration and U-series isotope ratio profiles that are consistent with model predictions. Accurate $^{234}\text{U}/^{238}\text{U}$ and $^{230}\text{Th}/^{234}\text{U}$ activity ratios can be profiled in situ on samples that contain as little as 0.5 ppm uranium.

56-10 BTH 152 Durand, Nicolas L.**PROGRESS IN URANIUM SERIES DATING OF IMPURE CARBONATES BY THE TIMS TECHNIQUE: METHODOLOGY AND RESULTS FROM THREE SITES IN SEMI-ARID PENINSULAR INDIA**

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The potential of calcrite for understanding Quaternary climate change is well established, but developing a precise analytical method that can assist in constraining the stages and timescales of calcrite evolution has been a persistent problem. In this contribution, we examine how U-series dating by thermal ionization mass spectrometry (TIMS) can allow analytically precise dating of impure carbonate (calcrite). This method has been applied to calcrite occurrences developed on Precambrian metamorphic rocks and calcareous Quaternary deposits in semi-arid South India. The study consists in dating (1) identical laminar cappings at different locations (regional stratigraphic approach), and (2) calcrite profiles at various sites along a toposequence (geomorphic approach). The importance of acquiring a clear understanding of the calcrite microfabrics before micro-sampling the most homogeneous carbonate phases for radiometric analysis is emphasized.

U/Th analyses were based on the isochron method (Rosholt-type diagram) to correct the initial amount of ^{230}Th based on the abundance of ^{232}Th . The few coeval subsamples required for a sample isochron age determination were obtained by the Total-Sample Dissolution method. We found the proportion of insoluble residue to be relatively high (4.7-15.99% wt) and for any given sample, the measured $^{230}\text{Th}/^{234}\text{U}$ ratios from the different subsamples could differ quite significantly. Two factors may explain this: (1) if the sample behaved as a closed chemical system, the observed variations in $^{230}\text{Th}/^{234}\text{U}$ ratios can be related to the variable amount of detrital material. In that context, it remains possible to distinguish the $^{230}\text{Th}/^{234}\text{U}$ and $^{234}\text{U}/^{238}\text{U}$ ratios within the pure carbonate phase. (2) If the sample was subjected to internal U remobilization, it is important to understand, based on mathematical models, how radioelement migration occurred and affected the age, and whether biological activity is involved. In the first case, U/Th results give a range of late Pleistocene ages, except for calcrite developed on limestone parent-rock in SE Tamil Nadu for which the period of validity of the U/Th dating method is exceeded (> 350 ka). In NW Tamil Nadu, laminar calcrite cappings were formed during the last glacial period under dry and windy climatic conditions than today.

56-11 BTH 153 Thompson, William G.**AN OPEN-SYSTEM MODEL FOR U-SERIES AGE DETERMINATIONS OF FOSSIL CORALS**
THOMPSON, William G.¹, SPIEGELMAN, Marc W.¹, GOLDSTEIN, Steven L.¹, and SPEED, Robert C.², (1) Lamont-Doherty Earth Observatory, Columbia Univ, Palisades, NY 10964-8000, billt@ldeo.columbia.edu, (2) Department of Earth System Science, Univ of California, Irvine, CA 92657

The source of excess ^{234}U in fossil corals and its relationship to U-series age determinations has been an outstanding problem in geochronology for more than 20 years. With increasing numbers of U-series isotope measurements in corals, and significant improvements in analytical precision through mass spectrometry, it is increasingly apparent that a substantial fraction of observed isotope ratios cannot be reasonably explained by closed-system decay. Moreover, observations of a positive correlation between $^{234}\text{U}/^{238}\text{U}$ and $^{230}\text{Th}/^{238}\text{U}$ ratios in corals from the same terrace are difficult to explain. However, the decay of dissolved uranium and alpha-recoil mobilization of uranium daughters produce particle-reactive ^{234}Th and ^{230}Th , whose coupled addition could simultaneously increase coral $^{234}\text{U}/^{238}\text{U}$ and $^{230}\text{Th}/^{238}\text{U}$. Here we present a quantitative model, based on decay-dependent redistribution of ^{234}Th and ^{230}Th , permitting calculation of open-system coral ages. Isotopic arrays of Barbados corals, and corals from terraces around the world, are consistent with model predictions suggesting the open-system model is generally applicable. Corals whose extreme isotopic compositions are impossible to produce by closed-system decay are also consistent with the limited range of isotopic compositions predicted by our model. For corals from a single terrace, ^{234}Th and ^{230}Th redistribution appears to be a source of significant systematic conventional age error, even for corals with slightly elevated ^{234}U . However, open-system ages are consistent, even for corals with extremely elevated ^{234}U . For the youngest three Barbados terraces, mean open-system terrace ages are consistent with mean conventional terrace ages calculated from pristine samples. If the most accurate conventional ages are from corals whose initial $^{234}\text{U}/^{238}\text{U}$ is identical to modern seawater, then the open-system model will improve the accuracy of coral U-series age determinations and dramatically increase the number of reliable ages.

56-12 BTH 154 Reimer, Paula J.**RADIOCARBON CALIBRATION AND COMPARISONS: A PREVIEW OF COMING ATTRACTIONS**
REIMER, Paula J.¹, FRIEDRICH, Michael², HUGHEN, Konrad A.³, KROMER, Bernd⁴, MCCORMAC, Gerry⁵, and REMMELE, Sabine⁶, (1) Center for Accelerator Mass Spectrometry, Lawrence Livermore National Laboratory, Livermore, CA 94550, pjreimer@llnl.gov, (2) Institute of Botany (210), Univ of Hohenheim, Garbenstrasse 30, Stuttgart, D-70593, Germany, (3) Woods Hole Oceanographic Institution, Department of Marine Chemistry & Geochemistry, Woods Hole, MA 02543, (4) Institute for Environmental Physics, Heidelberg Academy of Sciences, INF 229, Heidelberg, D-69120, Germany, (5) School of Archaeology and Palaeoecology, Queen's Univ Belfast, Belfast, BT7 1NN, United Kingdom

Many Quaternary studies depend on radiocarbon calibration for comparison between paleorecords based on ^{14}C ages and those based on other timescales. It is therefore essential to have a standard radiocarbon calibration datasets for such intercomparisons to be valid, rather than using an ad hoc mixture of ^{14}C datasets without proper consideration of potential errors in timescale or carbon reservoir corrections. The IntCal04 Radiocarbon Calibration/Comparison Working Group has put together a set of criteria for assuring datasets are sufficiently robust in both the cal ages and the radiocarbon ages and that the uncertainties are quantified (Reimer et al., 2002).

Refinements and additions to IntCal98 should result in a calibration dataset back to ca. 30 ka BP, which will be presented for ratification at the 19th International Radiocarbon Conference in Wellington, New Zealand. In addition, the IntCal04 Group is working towards a recommendation for comparing ^{14}C based chronologies beyond 30 ka BP where few absolutely dated records exist and there is wide discrepancy among them. We will highlight the differences between IntCal98 and the proposed IntCal04 dataset with example radiocarbon calibrations for some important climatic events.

Reimer, P.J., Hughen, K.A., Guilderson, T.P., McCormac, F.G., Baillie, M.G.L., Bard, E., Barratt, P., Beck, J.W., Brown, D.M., Buck, C.E., Damon, P.E., Friedrich, M., Kromer, B., Ramsey, C.B., Reimer, R.W., Remmele, S., Southon, J.R., Stuiver, M., and van der Plicht, J. 2002. Preliminary Report of the First Workshop of the IntCal04 Radiocarbon Calibration/Comparison Working Group. Radiocarbon 44, (in press).

56-13 BTH 155 Shopov, Yavor Y.**A NEW METHOD FOR IMPROVED DATING OF SEDIMENTAL PALEOCLIMATIC RECORDS USING EVOLUTIVE SPECTRAL ANALYSIS OF ORBITAL VARIATIONS**

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Spectral time series analysis of luminescent records in speleothems shows that it contains cycles of variations of orbital elements and many shorter solar cycles. Luminescence of organic matter in speleothems depends on solar visible and infrared radiation so it can be used as a proxy index of Solar Insolation (SI). The theoretical calculations of Milankovitch cycles determined that the variations of precession are with period of 23 and 19 ka, and obliquity with period of 41 ka. The most intensive solar insolation cycle is with duration of 11.5 ka. Orbital cycles have duration stable in time. So their pseudo- variations derived by evolutive spectral analysis of sediment records are in fact due only to variations of the sedimentation rate of the sediment. The ratio between the real and pseudo- duration of the orbital cycles gives the sedimentation rate deviation from the mean sedimentation rate of the dated sequence of the sediment. We used it to establish "solid" time scale of sediment records.

Financial support from the INQUA Executive Committee

56-14 BTH 156 Amoroso, Lee**DEVELOPMENT OF A CALIBRATED CARBONATE RIND CHRONOSEQUENCE**

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Determining surficial deposit ages is necessary to estimate rates of tectonic and geomorphic processes. An important use of surface-age determinations is in earthquake hazard assessment. Reconnaissance surveys produce slip rate estimates using semi-quantitative methods to estimate surface age. The slip rate values estimated using these methods typically span an order of magnitude or more. A better method of surface age determination may result in more robust estimates of seismic hazard. While many methods have been developed that yield numerical ages of alluvial deposits and bedrock; they are expensive and many have a long turn-around time. Carbonate rind chronosequence may be a better tool for reconnaissance seismic assessments.

Carbonate rind measurements have previously been used to construct an age-constrained soil chronosequence in the Lost River Valley, Idaho. I am expanding on this idea by developing a calibration data set to make numerical age estimates of Quaternary deposits in the Mojave Desert portion of the Basin and Range. The method involves measuring carbonate rind thickness profiles beneath surfaces with numerical ages (found in the literature) to produce a calibrated carbonate rind chronosequence. The calibration points are selected for good geographic coverage of the areas where soil carbonate is present in the Mojave Desert. With the calibration, the maximum measured rind thickness (averaged over 20 cm) in a soil profile would yield a numerical age range estimate. This approach has been tested in a paleoseismic investigation of the Hurricane fault in northern Arizona. The carbonate rind chronosequence was calibrated using surfaces dated using ^3He cosmogenic isotope geochronology. The age of ruptured Quaternary surfaces were estimated using the calibrated chronosequence; the slip rate of the fault was determined using the age and vertical surface displacement. Diverse methods used during the paleoseismic study - including fault trenching, morphologic dating of the fault scarp, as well as the carbonate-rind chronosequence all produced similar slip rates suggesting that this is a viable method in surface age estimation.

SESSION NO. 57, 1:30 PM**Monday, July 28, 2003****T8. Long Terrestrial Late Cenozoic Records in West Central Yukon and Adjacent Areas of Alaska (Posters)****Reno Hilton Resort and Conference Center, Pavilion****57-1 BTH 44 Jackson, Lionel E.****A 2.5 MA CHRONOLOGY OF REGIONAL GLACIATION IN WEST-CENTRAL YUKON, CANADA BASED ON RADIOMETRIC AND PALEOMAGNETIC DATING OF VOLCANIC ROCKS**

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Since the Late Pliocene, the Yukon Plateaus of west-central Yukon Territory, Canada, have experienced periodic fissure eruptions of valley-filling mafic lavas and eruption of small volcanoes (Selkirk Volcanic Group). Ar-Ar and fission track dating as well as paleomagnetic investigations of these volcanic rocks and interstratified sediments chronologically bracket at least three regional glaciations from the Late Pliocene through the Early Pleistocene. The ancestral valley of Rosebud Creek (63° 15' N, 137° 18' W) contains a magnetically normal basalt flow Ar-Ar dated at 2.69 +/- 0.04 Ma. The valley was buried by thick ice-terminus drift deposited during the most extensive and likely the oldest regional glaciation. Regional geomorphic evidence suggests that this glaciation reversed the ancestral Yukon River. The Yukon River assumed its present course by 1.83 +/- 0.3 Ma when a magnetically reversed basaltic flow was erupted near Fort Selkirk (62° 45' N, 137° 25' W). The next Early Pleistocene regional glaciation (Fort Selkirk Glaciation (FSG)) is documented by a till near Fort Selkirk. The till is bracketed in time by Ar-Ar ages on overlying and underlying basalt flows and overlying fission-track-dated tephra. These limit FSG to one of the cold peaks that occurred between oxygen isotope stages (OIS) 64 and 50 inclusive (ca 1.8 to 1.5 Ma). A subsequent regional glaciation left striations and erratics on magnetically reversed alkaline olivine basalt flows dated at 1.47 +/- 0.05 Ma. This glaciation predated the eruption of a magnetically normal complex of valley-filling olivine basalt flows and pillow basalts that dammed the Yukon River near Fort Selkirk 311 +/- 30 ka. The complex is overlain in part by outwash from an ice sheet that formed during Reid Glaciation. Limiting ages determined on tephra overlying Reid drift along with the Ar-Ar age determined on the underlying volcanic rocks date Reid Glaciation to OIS 8. No deposits from OIS 6 ice sheets have been found in Yukon. The OIS 2 (McConnell Glaciation) ice sheet terminated east of Selkirk Volcanics.

SESSION NO. 57

57-2 BTH 45 Rotheisler, Peter N.

A RECORD OF LATE QUATERNARY ENVIRONMENTAL CHANGE: STRATIGRAPHY, PALEOECOLOGY, AND TEPHROCHRONOLOGY FROM MARIPOSA CREEK, YUKON TERRITORY, CANADA

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Late Quaternary stratigraphy, tephra, pollen, plant macrofossils, and insect fossils were studied from a placer mine site along Mariposa Creek in west-central Yukon. Stratigraphy from the eastern placer pit face (Wall A) appears relatively unaffected by cryoturbation and erosional events suggesting a continuous record of environmental change dating back ~ 60 ka. Samples of possible early-Middle Wisconsinian-age (ca. 45 000 to 60 000 B.P.) from Organic Unit 1 indicate an open forest-shrub/tundra environment that was slightly colder and drier than present. Floral and faunal remains from Organic unit 1 correlate well with other probable early-Middle Wisconsinian (Boutellier interval) sites, most notably the Foraker Slump site in Alaska. Preliminary analysis indicates the presence of a previously unidentified type II tephra within Organic Unit 1, tentatively named Mariposa Creek tephra. Overlying Organic Unit 1 is a ~1m thick unit of weathered colluvium cut by an ice-wedge pseudomorph. This colluvium unit may represent severe conditions of the late Wisconsinian. Organic Unit 2 is Holocene with two distinct peat beds occurring near the bottom and top of the unit. Paleoecology of the upper peat (~2850 B.P.) suggests a mature spruce forest analogous to the modern ecological setting. Early Holocene samples from the lower peat bed suggest the presence of an open forest-shrub/tundra environment that was at least as cold and dry as the environment represented in Organic Unit 1.

57-3 BTH 46 Sanborn, Paul T.

PALEOSOLS IN PLIOCENE TO PLEISTOCENE SEQUENCES OF PREGLACIAL AND GLACIAL SEDIMENTS, TINTINA TRENCH, YUKON TERRITORY, CANADA

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Paleosols in long sequences of Pliocene and Pleistocene preglacial and glacial sediments were studied at two sites, East Fifteen Mile River (EFR) and Rock Creek (RC), in the Tintina Trench near Dawson, Yukon Territory. Four buried paleosols at EFR display morphological features of modern Luvisols and Gleysols (Canadian System of Soil Classification), approximately equivalent to Alfisols and Aquic suborders (U.S. Soil Taxonomy). Features suggestive of pedogenesis in the EFR paleosols include accumulation of illuvial clay as conspicuous cutans, and coarse Fe-rich mottles. Crystalline Fe-oxide concentrations range from 1.5 to 2.5% in most horizons, except in the oldest paleosol, formed in preglacial sands, where values exceed 3.0%. Amorphous extractable Al concentrations are usually below 0.1%. At RC, two buried soils display weak structural development suggestive of clay illuviation, with levels of extractable Fe and Al similar to those at EFR. Clay mineral suites in the buried paleosols are dominated by varying proportions of smectite, mica, and kaolinite of probable detrital origin. The surface soil at RC has morphological, mineralogical, and chemical properties equivalent to the Wounded Moose soil found on early Pleistocene outwash deposits elsewhere in the Klondike region. These paleosols appear to consist of B horizons displaying relatively weak gradients in morphological and chemical differentiation with depth. Features suggestive of cryoturbation and periglacial processes appear absent in the buried paleosols at both sites. Paleoenvironmental interpretation is complicated by uncertainty over the degree of truncation of these soil profiles, the possibility of post-burial alteration, and the unknown duration of pedogenesis prior to burial.

SESSION NO. 58, 1:30 PM

Monday, July 28, 2003

T16. Late Quaternary Landscape Evolution and Palaeoclimates in Arid and Semiarid Regions of Central and East Asia (Posters)

Reno Hilton Resort and Conference Center, Pavilion

58-1 BTH 62 Finkel, Robert C.

NATURE AND RATES OF LANDSCAPE EVOLUTION IN A HYPER-ARID INTERMONTANE BASIN, QADAM, NORTHERN TIBET

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The Qadam Basin in northern Tibet is a large intermontane depression dominated by a hyper-arid climate. Alluvial fans, pediment surfaces, shorelines and a thick succession of sediments within the basin coupled with moraines and associated landforms in the adjacent high mountains record a complex history of Late Quaternary paleoenvironmental change and landscape evolution. The Qadam basin, one of the largest hyper-arid intermontane basins on Earth, is a natural laboratory to examine the nature of intermontane basin evolution within a continent-continent collision zone. Furthermore, it provides an opportunity to relate the timing of landscape evolution in a hyper-arid environment to climatic change and associated glacial and hydrological changes. Critical sites along the southern and northwestern margins of the Qadam Basin provide evidence of a strong link between times of climatic amelioration, deglaciation, lake desiccation and alluvial fan sedimentation. From these observations we believe that the major landscape changes took place very rapidly over short intervals of time during periods of climatic instability. To test this hypothesis, we have undertaken remote sensing, field mapping, geomorphological and sedimentological analysis, and numerical dating of Late Quaternary landforms within the Qadam basin. In particular, we have undertaken an extensive program of cosmogenic radionuclide (CRN) surface exposure dating to define the ages of Late Quaternary landforms. This is allowing us to test our hypothesis that the timing of formation of landforms is synchronous with times of climatic instability.

58-2 BTH 63 An, Zhisheng

STRATIGRAPHIC EVIDENCE OF EPISODIC GULLYING ON THE CHINESE LOESS PLATEAU
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Buried gullies are exposed along the margin of a loess tableland in road excavations near Tongchuan on the Loess Plateau of central China. They lie with in a thick loess/paleosol succession that spans at least the last 780,000 years. Constraining ages for gully cutting and filling are provided by the ages of loess and soil units cut by and capping the paleogullies. Gully cutting is initiated during the onset of interglacial conditions and ceases as the gullies begin to fill with colluvium and air-borne dust during the transition from interglacial to glacial conditions. The episodic cutting and filling of gullies implies a basic astronomical (orbital) control of gully evolution involving cyclic changes in dominant summer and winter monsoon climates, surface hydrology, and vegetation cover.

58-3 BTH 64 Liu, Tungsheng

SPATIAL AND TEMPORAL PATTERNS OF QUATERNARY DUNE ACTIVITY IN THE ARID AND SEMIARID CHINA

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Episodic dune formations during the Quaternary were found in many deserts of China. Generally, desert evolutions on the orbital time scales were the response to the astronomical forcing, characterized by expanded deserts during glacial maxima. However, due to the close link between Chinese deserts and the adjacent high mountains (High Asia), the high mountain processes (e.g., glacial grinding, frost weathering, rock denudation) have also played an important role in controlling desert evolution through its effects on sand and silt production. The most striking tectonic control of desert expansion occurred at 1.1 and 0.9 Ma ago, and these tectonic control desert evolutions had durations longer than the Milankovitch cyclicity thus imposed on the glacial-interglacial climatic changes induced desert evolutions. Spatial scale studies on desert evolution indicate that the last two extreme scenarios of a glacial maximum and a Holocene climatic optimum marked extreme ecosystems in China. The deserts margin changed mainly in its longitudinal range due to changes in east Asia monsoonal circulations, and it shifted from 125°E of the last glacial maximum to 105°E of the climatic optimum. Historical desertification in the semiarid China is not a response to climate drought but largely associated with the human impacts (mainly over-cultivation) since about 2300 years ago. Over-cultivation combined with the high wind energy leads to the quick deflation of the 'protection layer' of the Holocene sandy loam soil and ultimately results in the reworking of the underlying LGM sands. Our view of the importance of land use-use practice suggests that, in the fragile ecological system, where a great quantity of sand is available for reworking and high wind energy is concentrated, any unreasonable human activities will greatly accelerate the sand reworking processes. Episodic conversion of nomadic livestock systems to cropping during historical time is the main reason for the reworking processes of relict dunes in the Mu Us Desert and other semiarid regions in China.

58-4 BTH 65 Feng, Zhaodong

COMPOSITIONAL STUDY OF THE LAST INTERGLACIAL PALEOSOL S1 LOESS MINERALS FROM CHINESE LOESS PLATEAU USING SYNCHROTRON X-RAY DIFFRACTION (XRD) AND SYNCHROTRON X-RAY ABSORPTION NEAR EDGE STRUCTURE (XANES)

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This study focuses on the paleosol S1 formed during the last interglacial (approximately from 125,000 to 75,000 years before present) in the Chinese Loess Plateau in an attempt to microscopically examine the mineralogical, chemical compositions, and redox state of iron-bearing phases. These microscopic properties will help us answer essential questions regarding the last interglacial climatic conditions under which the paleosol S1 was developed in the Chinese Loess Plateau. Understanding the S1 soil-forming processes and the processes-related East Asian Monsoon is critical to both improving the soil-related climatic proxies and providing regional information in reconstructing the global interglacial paleoclimate. In this study, we analyzed S1 samples from different geographic and bioclimatic zones with the hope that the geographic differentiation and bioclimatic dependency of the last interglacial paleosol S1 can be traced using synchrotron microbeam x-ray diffraction (XRD) and Synchrotron x-ray absorption near edge spectroscopy (XANES). We will present the results of the loess internal structure and mineral composition in a micrometer-length scale.

58-5 BTH 66 Feng, Zhaodong

THE S1 PALEOSOL ENVIRONMENTAL RECORD INTERPRETED THROUGH SOIL DEVELOPMENT AND WEATHERING INDICES

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Pedogenic and weathering processes are intricately related to paleoclimate evidence in loess. Soil processes (clay formation and translocation, carbonate concentration, and iron alteration and translocation) are all tied to weathering reactions that occur in the soil. Proxy indicators reveal environmental change, but the environment itself may alter the proxy indicators. Is the paleoclimate evidence biased by inherent complexity? One way to address this quandary is to investigate specific soil formation and weathering processes. This study applies quantified soil development indices and weathering indices and compares these against existing climate proxy indicators for the S1 Paleosol in the Chinese Loess Plateau.

Six field locations were surveyed and sampled in two northwest-to-southeast transects in the Chinese Loess Plateau. A range of field data (horizonation, color, texture, structure, carbonate morphology) was used to calculate a profile development index modified from Harden's (1982). The index was applied to the entire S1 profile at each location, and to segments within the S1 profile. Samples were taken for chemical analysis to establish leaching trends. Inductively coupled plasma optical emission spectrometry (ICP-OES) achieved composition for 10 major elements of samples taken at 10 and 20 cm intervals in the profile. Weathering and leaching indices calculat-

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T17. Rapid Late Quaternary Climate Changes and Human Response in Arid Central Asia (Posters)

Reno Hilton Resort and Conference Center, Pavilion

ed ratios of more mobile to more stable elements. These indicated degrees of chemical weathering at specific horizons, but also indicated translocation and enrichment of certain elements.

Profile development indices demonstrated a separation of paleosol units within the S1 stratum at the cool/dry (northwest) ends of the sampling transect, but verified significant soil welding toward the warm/moist ends of the transect (southeast). Soil welding has been suggested as a complicating factor in the use of key locations as primary paleoclimate records. Weathering and leaching indices indicate a higher degree of chemical activity within the paleosol layers, separated by less elemental translocation in intervening loess subunits. Chemical weathering supports the soil welding evidence. In fact, chemical alteration is evident as translocation into the lower L2 loess stratum immediately below the S1 paleosol sequence.

58-6 BTH 67 Yang, Xiaoping

THE DOUBLE PEAKS OF THE FREQUENCY CURVE OF SAND GRAIN SIZE IN THE SOUTHEASTERN PART OF THE BADAIN JARAN DESERT, INNER MONGOLIA, CHINA
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Particle size analysis of the samples of dunes from the southeastern Badain Jaran Desert, western Inner Mongolia is undertaken by dry sieving in order to study the relationship between the grain size variations of the aeolian deposits and wind intensity. The frequency curves of the grain size distributions of all samples show similar double peaks. It is found that the first peak takes place at the ca 2.3 ϕ (0.2mm), and the other at ca 3 ϕ (about 0.125mm). The first peak is to a large extent consistent with the mean grain size of the samples (ca 2 ϕ). However, the characteristics of the second peak cannot be reflected in mean grain size. We suggest that the first peak is formed by sand transported by winter monsoon. But the second peak should originate from sand fraction blown by summer monsoon. For the paleoenvironmental studies in the northwestern China, one needs to pay attention not only to the mean grain size but also to the feature of the frequency curve of the aeolian deposits.

58-7 BTH 68 Wang, Luo

ALTIMUDINAL TRENDS IN STABLE CARBON ISOTOPE COMPOSITION FOR POEACEAE ON QINGHAI-TIBETAN PLATEAU

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In a global survey of $\delta^{13}\text{C}$ values of plants collected from a wide range of altitudes, spanning many taxonomic and physiognomic groups as well as a wide geographic range. Korner *et al.* found that the $\delta^{13}\text{C}$ values increased with altitude. Other researchers found that the $\delta^{13}\text{C}$ values in single species increase with altitude. However, Most of these studies were carried out on a very restricted range of sites. So far, relatively few systematic studies have addressed how the $\delta^{13}\text{C}$ values in single species growing in a complicated environment like Qinghai-Tibetan Plateau change with altitude.

This time, the stable carbon isotope compositions are determined on leaves of Poaceae plants (*Trisetum spicatum*, *Roegneria nutans*, *Stipa purpurea*, *Elymus nutans*) sampled along a 2000-km transect on Qinghai-Tibetan Plateau of China. The $\delta^{13}\text{C}$ values for all samples increase with altitudes generally, the mean $\delta^{13}\text{C}$ increase with altitude is 1.37‰/km. Carbon isotope ratios of *Trisetum spicatum* and *Roegneria nutans* increase significantly with altitudes. The result of linear analyses indicates that the temperature and the CO_2 partial pressure are the major factors causing the $\delta^{13}\text{C}$ ratios of C_3 plants to increase with altitudes. In this study, we find C_4 plants: *Chloris virgata*, *Eragrostis ferruginea*, *Eragrostis nigra*, *Arundinella yunnanensis*, *Orinus thoroldii*, *Pennisetum centrasiatium*, some of them distributed above 4000m, even reached 4520m.

58-8 BTH 69 Zhu, Liping

AN ENVIRONMENTAL SEQUENCE REFLECTED BY MULTI-PROXIES OF CORE SEDIMENTS OF LAKE CHEN CO. SOUTHERN TIBET

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The Tibetan Plateau is an ideal place for studies of past environmental. There are many places where ice cores, tree-ring series, lake cores, and hundreds years of historical documents can be collected. This study deals with a sediment core in the Lake Chen Co (28°53'–58'N, 90°28'35'E) in southern Tibet. The core was taken with a piston corer in 8 m of water, 800 m from the bank on a bottom slope of 1.5 percent. It was divided into 216 1-cm-thick samples for analysis. The uppermost 30 cm of the core was selected for ²¹⁰Pb and ¹³⁷Cs analyses to calculate sedimentation rates. No radiocarbon ages are yet available, but the core is estimated to span 1400 years on the basis of the average sedimentation rate of 0.16 cm/a. All samples were analyzed for physical (magnetism and particle size), chemical (CaCO_3 , trace elements, total organic carbon (TOC), ^{13}C isotopic composition, hydrogen index (HI)), and biological (ostracod) properties. The analytical data indicate significant environmental change over the last 1400 years. Warm conditions from ca. AD 620 to AD 740 are shown by high ARM^*/Hf , TOC, and HI, by low ^{13}C , and by the ostracod assemblages. High CaCO_3 and Sr/Ba and low Fe/Mn suggest that this period was relatively dry. A second warm interval, from ca. AD 1120 to AD 1370, is inferred from high ARM^*/Hf , TOC, and HI. This interval, however, may have been more humid, based on low CaCO_3 and Sr/Ba. High Fe/Mn and an increase in ostracod shells imply a larger and deeper lake. From ca. AD 1550 to AD 1690, cold, dry conditions are indicated by all of the proxies, for example low ARM^*/Hf , TOC, and HI, and high CaCO_3 and Sr/Ba. Ostracod shells decrease rapidly during this interval. Warm conditions have prevailed since about AD 1900. We compared the record from Lake Chen Co with the records from ice cores, tree-rings, and historical documents and found good agreement among them. Interestingly, the warming stages coincide with times of prospering of the agriculturally based, Tibetan ethnic group. Relationships between human impacts and climate are worth pursuing at this site.

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59-1 BTH 70 Li, Xiaoze

FROM PALAEO-RED TO YELLOW DESERT: EVIDENCE FOR THE EVOLUTION OF ARID ENVIRONMENT IN CENTRAL ASIA

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There are many exposures of eolianites distributed near the north and north-eastern fringes of the Tibetan Plateau. The outline of geological evolution of palaeodeserts of China beginning in the Early Cretaceous can be divided into 4 main periods: (a) a red desert period characterized by trade-winds in and before the Earle Cretaceous; (b) a red desert period characterized by planetary west winds from the Late Cretaceous to the Miocene; (c) a transitional period from red desert to yellow desert in the Pliocene; (d) a yellow desert period characterized by winter monsoon and planetary west winds in the Quaternary. In northwest China, the red desert began to wither away and a yellow desert began to develop about 4.6 Ma BP. The red desert died out and the yellow desert was stable from 2.5 Ma BP. Spatially, the red desert in the Tarim Basin of west China, withered earlier than that in the Loess Plateau area. The red desert disappeared completely at 3.4 Ma BP or so in the Tarim Basin at the Yecheng eolianite sections, and at 2.5 Ma BP in the Loess Plateau based on loess and red earth deposits. An indicator for yellow desert motion is change in the position of the desert and loess transitional zone, and for the red desert it is change in the position of the planetary west wind desert and east wind desert transitional zone. While the global climate cooled from the Early Cretaceous to the Cenozoic, the west wind desert and east wind desert transitional zone moved to the south, and the red desert retreated gradually in the pre-Quaternary. Concurrently, the yellow desert and loess transitional zone shifted to the south and developed. The yellow deserts in China developed from the red deserts of the Early Cretaceous following a temperature decline after about 150 Ma BP. So far, we can demonstrate that the history of desert and arid environments in north-western China began at least from the Early Cretaceous. Acknowledgment: the National Natural Science Foundation of China (Granted No: 40272079)

59-2 BTH 71 Zhang, Pingzhong

SPELEOTHEM RECORD OF THE LATE PLEISTOCENE CLIMATE ON LOESS PLATEAU AND QINGHAI-TIBETAN PLATEAU TRANSITION ZONE, CHINA

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In order to fully understand the causes and mechanisms of recent environmental change, it is necessary to develop a highly detailed and reliable record of past climatic fluctuations. Unfortunately, there is a paucity of high-resolution paleoclimatic data from the Chinese loess plateau and the Qinghai-Tibetan plateau transition zone. As the physical and isotopic hydrologic patterns in these regions are very complex, and thus very hard to model, there is a great necessity for a more accurate and thorough paleorecord. Speleothems collected from Wanxiang Cave, a limestone cave located at 33°19' N, 105°00' E contain a detailed record of climate change. The climate of this region is dominated by the rainy summer monsoon and the dry winter monsoon. The intensity of the Asian monsoon has undergone dramatic changes throughout the Pleistocene which are recorded in the geochemistry of the speleothems. Geochemical variations along speleothem growth axes combined with precise U-series dating provide a high temporal resolution record of the Southeast Asian monsoon intensity over the last 300,000 years. The $\delta^{18}\text{O}$ of precipitation at this site is inversely related to temperature due to the dominance of the amount effect over the temperature effect. Speleothem calcite formed during stadial periods, when monsoon intensity was weak should, therefore, exhibit more positive $\delta^{18}\text{O}$ values than interstadial periods, assuming the calcite precipitated in isotopic equilibrium from waters which closely reflected precipitation. To test these assumptions, we have performed a pilot study on cave waters and modern calcite collected from Wanxiang Cave to determine the principle controls on the calcite isotopic composition. Measurement of $\delta^{18}\text{O}$ of cave waters, precipitation, and modern calcite shows that cave waters reflect the mean composition of precipitation at this site and that modern calcite is forming in isotopic equilibrium. Variations in $\delta^{13}\text{C}$ of speleothem calcite may reflect variations in the amount of CO_2 degassing as well as changes in the ratio of C_3 to C_4 vegetation, both of which respond to changes in monsoon intensity. The high-resolution time series obtained from these speleothems may aid in understanding the natural variability of the climatic, hydrologic, and ecologic systems in China on long time scales.

59-3 BTH 72 Ma, Jinzhu

GROUNDWATER GEOCHEMISTRY EVOLUTION AND UNSATURATED ZONE ARCHIVES OF CLIMATIC CHANGE IN ARID NW CHINA

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Isotopic and geochemical techniques were used to determine the groundwater age, understand the origins of salinity, and clarify the impact of climatic change on groundwater in the Minqin Basin. The radiocarbon age of the oldest groundwater is 40 ka. Minqin Basin groundwaters are generally negative, and the deepest water is notably depleted in heavy isotopes, signifying cooler recharge conditions during the late Pleistocene than at present. Shallower water, with values between ^{-7}C - ^{-11}C and ^{-18}O , is mainly paleowater, mixed with limited modern recharge. Temperatures were 4-5°C lower than at present based on ΔD data. Trends in major elements in Minqin Basin groundwater,

as well as in redox characteristics, follow a progressive sequence of geochemical evolution. Overall the groundwaters in the Minqin Basin evolved from alkali-sulphate types in the recharge area to alkali-sulphate-chloride types along the groundwater flow direction. A wide range of minor and trace elements indicate a reducing condition in deep groundwater and an oxidizing condition in shallow groundwater. Groundwater chemical accumulation and salinity increased slowly during the past 40 ka in the deep aquifer, while water quality deteriorated significantly in the upper shallow aquifer due to a combination of human activity and rapid climatic change during the last 2000 years. The history of groundwater recharge and climatic changes during the last 800 years has been estimated and reconstructed using environmental chloride from an unsaturated zone profile in the Badain Jaran Desert. The long-term recharge is estimated to be 1.3 mm yr⁻¹. A dry episode occurred before 1290 AD. From 1500-1530 AD the climate underwent a rapid change from dry to wet. At the beginning of 1800s, important wet events occurred, but the climate deteriorated drastically during the last 200 yrs. These results correlate well with ice core records of Tibet Plateau from 1200 to 1900 AD, but differ during the most recent 100 yrs.

59-4 BTH 73 Madsen, David B.

CLIMATE CHANGE AND HUMAN ADAPTATION ALONG THE NORTHEASTERN MARGIN OF THE TIBETAN PLATEAU

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Archaeological surveys and test excavations in northwestern China, together with the dating of Tengger Desert lakes and spring bogs, suggests periods of dramatic cultural change are linked to periods of rapid environmental change. Sites dating from as early as 40-50,000 ¹⁴C years B.P. to as late as the mid-Holocene suggest an increasing adaptation to harsh, high-elevation environments, with successively higher elevations occupied at later intervals. This adaptation to extreme environments appears to have been episodic rather than gradual, with shifts in Upper Paleolithic and Neolithic site locations, tool types, and adaptive strategies occurring in tandem with major changes in climate. Preliminary dating suggests the most intensive use of harsh environments occurred during warmer and wetter interstadials.

59-5 BTH 74 Elston, Robert G.

LATE PALEOLITHIC OCCUPATION OF NORTH CHINA

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Until recently, almost all that was known about the early Upper Paleolithic of North China derived from one site, Shuidonggou (Ningxia Hui Autonomous Region; 106.5° E, 38.3° N), conclusively dated between 29.5 – 23.8 krcyBP and characterized by a distinctive flat-faced core and blade technology sharing basic similarities with the Initial Upper Paleolithic (IUP) of Northeast Asia. Limited expression of Shuidonggou technology beyond the type-site, and the terminal date for the site itself, suggested a small population that did not survive the Last Glacial Maximum. Research conducted in Gansu and Ningxia in the summers of 2001 and 2002 produced radiocarbon dates suggesting Shuidonggou is both earlier and more widely distributed than previously thought. Radiocarbon assay of carbonate encrusting a flake in a Shuidonggou assemblage from Temple Canyon #1, (Nei Mongol Autonomous Region, 105.7° E 38.7° N), produced a date of 40,690 +/- 890 (Beta 161632), suggesting this technology may coeval with the IUP technologies of Mongolia and Siberia, from which it was previously thought to be derived. Radiocarbon dates of 31,360 - 24,840 rcyBP (CAMS 93162, CAMS 93161) from Guyuan 3 (Ningxia, 106.6° E, 35.8° N), 25030 +/- 80 rcyBP (CAMS 93167, CAMS 93168) from Tong Xin 3 (Ningxia, 105.7° E, 36.7° N), 24760 +/- 220 rcyBP (CAMS 93169) from Tong Xin 8 (Ningxia, 105.2° E, 36.7° N), and 24660 +/- 200 rcyBP (CAMS 93172, 93173) from Zhuan Long 5 (Gansu, 106.1° E, 35.3° N), collectively suggest a much broader distribution for Shuidonggou-age materials, well south of the type site. More recent dates of 18350 +/- 70 rcyBP (CAMS 94203) from Panyang 3 (Ningxia, 106.6° E, 35.8° N), 16460 +/- 45 rcyBP (CAMS 94204) from Tong Xin 4 (Ningxia, 105.8° E, 36.8° N), and 10670 +/- 40 rcyBP (CAMS 94202) from Panyang 4 (Ningxia, 106.6° E, 35.8° N) attest to a time gap corresponding to the Last Glacial Maximum and subsequent reoccupation south of Shuidonggou, possibly from areas still further south.

59-6 BTH 75 Rhode, David

PRELIMINARY ASSESSMENT OF THE UTILITY OF DUNG AS FUEL DURING THE INITIAL OCCUPATION OF BERINGIA, BASED ON ANALOGUES FROM THE TIBETAN PLATEAU

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The absence of trees and brush in Beringia prior to ~12,000 RCYBP is often cited as a reason why human foragers could not have entered the New World during or prior to the last glacial maximum. Alternative fuels for cooking and heating are rarely considered, however. Here, we present preliminary data on the use of dung as fuel by Tibetan pastoralists that suggest the lack of wood plants in Beringia presented no obstacle to human occupation. The Tibetan Plateau above ~3000 m is sub-arctic steppe and tundra characterized by a variety of short-grass and herbaceous ecosystems bereft of trees and woody shrubs. Like the Beringian sub-arctic, the plateau is cold and dry, with winter temperatures averaging -10 to -15°C, absolute minimum winter temperatures less than -40°C, average summer temperatures rarely exceeding 10°C, and absolute maximum temperatures typically less than 25°C. Most of the Tibetan Plateau receives less than 400 mm per year, often less than 200 mm, and most of it falls in the summer growing season. Tibetan pastoralists survive on the plateau by collecting dung to fuel cooking and heating fires. The dung of ruminants, principally that of yaks, is preferred, but that of sheep/goats, horses, and camels is

also used for specific purposes. We are currently involved in an ethno-archaeological assessment of dung collecting and use among these pastoralists. Preliminary data suggest a single dung forager can collect enough dung in about 40 days to provide fuel sufficient to last a typical family for a year (or an average of less than one hour collecting per day). While we have yet to investigate dung collecting in areas where wild yaks and other large mammal species survive, we are confident, based on data currently in hand, that the large herbivore populations that occupied Beringia produced more than sufficient fuel to supply the needs of human foragers prior to 12,000 RCYBP.

59-7 BTH 76 Li, Xiaoze

HOLOCENE CLIMATIC RECORDS FROM PROGLACIAL DUNES IN CENTRAL AREA OF QINGHAI-TIBET PLATEAU

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There is about 100 Km² of proglacial dunes and gobi planes, with altitude range from 5200 to 5500 m asl., in the west side of the ice field Puruogangri which is the biggest ice field in Asia, at the central Qinghai-Tibetan Plateau in China. The dunes and gobies are developed on layers of tills made by the correlated glacier's movement, and spatially, located near to its correlated glaciers. Both the gobi planes and its gravel ventifact are developed. The dunes are of active and mostly lunare type with single direction and very slow movement from west to east, and with laminae layers of humic materials in laminae system of dunes. This proglacial desert sediment is infrequent in the world, first example in middle latitude and high altitude area in China and records for environment and climate change in the central area of the Plateau in Holocene time. Based on a 35 meter thick section of dune laminae series, 13 layers of humus laminae have been obtained, and gained a series of ages of carbon 14 as 12709 a.BP, 10792 a.BP, 9274 a.BP, 8167 a.BP, 6791 a.BP, 6171 a.BP, 4985 a.BP, 4750 a.BP, 3694 a.BP, 2460 a.BP, 2326 a.BP, 1720 a.BP, 922a.BP, etc. These humus ages are mostly correspond to warm times identified by oxygen isotopic curves of ice core Guliya at west Kunlun Mt. and ice core Dunde at Qilian Mt. which both Mt. are all located on the north edge of the Qinghai-Tibetan Plateau. So these humus and eolian sand layers may indicate the vertical shifts of bioclimatic zone. Statistically, the attitudes of foreset laminae of different dunes distributed as 40-130°a¹²⁰-34°a, and the recovered wind direction is 220-310°a, average as 260°a. This is in line with the locally west wind. The dunes have been formed at a site after the correlated glacier had retired and tills exsposed and plentiful sand materials could provided from the tills. So, in this way, the proglacial eolian sandy geomorphology is mainly depended on the movement of the glacier in the west edge of the ice field by the way of making sand materials, and also is a indication to trajectory of a retiring glacier.

59-8 BTH 77 Chen, Fahu

PALAEOCLIMATIC IMPLICATIONS OF MAGNETIC PROPERTIES AND GEOCHEMISTRY OF HOLOCENE SEDIMENTS FROM BOSTEN LAKE, XINJIANG, CHINA

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59-9 BTH 78 Chen, Fahu

THE PALAEOENVIRONMENTAL SIGNIFICANCE OF CARBON ISOTOPES IN ORGANIC LACUSTRINE SEDIMENTS IN ARID CHINA

ZHANG, Chengjun and CHEN, Fahu, Center for Arid Environment and Paleoclimate Research, Lanzhou Univ, 298, Tianshui Road, Lanzhou, 730000, China, fhchen@lzu.edu.cn The carbon isotope composition of organic lacustrine sediments is a convincing palaeo- environmental proxy used to investigate the vegetation changes in arid China by means of isotope geochemistry. Sources of organic matter in lacustrine sediments are terrestrial plants (C₃, C₄, CAM) and aquatic higher plants and algae, displaying a characteristic carbon isotope composition. For this study, Holocene organic lacustrine sediments of Bosten Lake, were analyzed with respect to the carbon isotope composition. The results of carbon isotope analysis all fall into the range of C₃ and C₄ plants (-10‰ to -32‰). An accompanying analysis of modern terrestrial and aquatic plants indicates the organic matter and organic components in the lacustrine sediments marked by heavier carbon isotope values originates primarily from submerged macrophytes rather than C₄ plants. The carbon isotope values of submerged macrophytes in lakes of the Badan Jilin Desert, in Bosten Lake, Qinghai Lake, and others range from -12.9‰ to -18.8‰. Carbon isotope values of terrestrial plants collected on the Tibetan Plateau and in the Qilian Mountains at altitudes exceeding 4000m amount to ¹³C₂₅‰ to ¹³C₂₈‰, demonstrating that all collected plants belong to the C₃ type. In the arid Badan Jilin Desert and the Chaidam Basin plant carbon isotope values reach ¹³C₂₇‰ to ¹³C₂₈‰, but a few C₄ type plants were found in addition. In the warm and wet region of China (Chengdu, Guangzhou, Nanjing, etc.) the plant carbon isotope values are lighter (-28.8‰ to -32‰) than in the cold and arid region. Because C₄ plants are less abundant in the cold and arid region of China, there is a close relationship between carbon isotope values of organic matter and rainfall. We conclude that the carbon isotope composition of organic lacustrine sediments in arid China mainly originates from organic matter of terrestrial C₃ plants, submerged macrophytes and algae. Heavier carbon isotope values of organic lacustrine sediments result from organic matter of submerged macrophytes and algae with a high aquatic productivity. Lighter carbon isotope values of organic lacustrine sediments mainly derive from C₃ plants and may be regarded to reflect more favourable conditions for the terrestrial vegetation, thus pointing to warmer and wetter climatic conditions.

59-10 BTH 79 Zhu, Yan

HOLOCENE ENVIRONMENTAL CHANGES IN THE SHIYANG RIVER BASIN, ARID CHINA BASED ON POLLEN ANALYSES

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The Shiyang River Basin (at 37°E02' -39°E17' N, 100°E57' -104°E57' E, and elevations of 5000-1200m) is an internal river system located in the arid lands of NW China. The Shiyang River originates in the Qilian Mountains and disappears into the northwestern Tengger Desert. During the late Pleistocene and Holocene there was a palaeo-lake at the northern end of the drainage supplied by the Shiyang River, but by the 1950's the palaeo-lake was dry because human use of river water increased. The results of pollen analyses of the SJC section, at the edge of the palaeo-lake, indicate that the Holocene can be divided into three periods: a wetter early Holocene (11.6-7.1 Cal BP), a dry Middle Holocene (7.1-2.4 Cal BP), and a moderately dry Late Holocene influenced by human activities (2.4-0 Cal BP). In the wetter early Holocene, uplands were covered by dense forests and the Palaeolake expanded. However, during several dry events (9.65-9.25 Cal BP, 8.75-8.2 Cal BP, 7.9-7.5 Cal BP, 7.25-7.1 Cal BP) the upland forest deteriorated and the palaeo-lake shrank. In the early Middle Holocene (7.1-3.8 Cal BP), the palaeolake became gradually shallower as river flow decreased. The driest climate occurred in the late Middle Holocene when the palaeolake was drastically reduced and the SJC section site became dry land, indicating that desiccation processes began prior to human use of inflowing water. Effective moisture in the late Holocene was higher than that in the middle Holocene and lower than the early Holocene. However, from 2100 Cal BP (Xihan dynasty) to the present, there were three periods of agricultural development in the Shiyang River drainages: 1) from Xihan dynasty to Donghan dynasty; 2) Tang dynasty; 3) Ming dynasty to present. Because most river waters were diverted to irrigated lands during these intervals, the palaeolake became desiccated, ground water levels dropped, and vegetation deteriorated.

59-11 BTH 80 Hartmann, Kai

A HIGH RESOLUTION RECORD OF HOLOCENE LAKE SEDIMENTS FROM THE ALASHAN DESERT, NW CHINA

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Short term fluctuations of lake level changes during the early to middle Holocene lake history of Juyan Lake (Alashan desert, Inner Mongolia) has been determined from geomorphological, geochemical, XRD, and pollen analyses. Morphologically disconnected from hydrological influences of the Hei River catchment, eastern Juyan Lake seems to reflect the local Holocene climatic evolution. Well preserved palaeoshores indicate a maximum lake extension of the recently dry basin of about 350 km². The catchment covers an area of about 3,400 km², mainly located in the southern foothills of Gobi Altay mountain ranges.

An 8.25 m long sediment core from the northwestern part of eastern Juyan lake provides detailed information about changes in sedimentation processes, e.g. variations in salt contents and hydrology between 10 cal ka and 240 cal AD. The age model is based on 5 AMS-datings on organic compounds: 9420±110 (10,626), 7013±41 (7800), 4605±30 (5315), 3127±29 (3358), 1786±22 BP (1709 cal BP). Grain-size analyses indicate short term variations of lake phases were interrupted by aeolian deposition during early Holocene time, while a long term stable lake phase prevailed from middle Holocene to historical time. High aragonite, hydromagnesite and halite content indicates extremely saline conditions due to the ion supply from the nearby catchment. Hence, the water budget was mainly controlled by local runoff and precipitation. Pollen spectra match sedimentological and mineralogical results. Due to the varying *Artemisia*/Chenopodiaceae ratio and the similarly changing abundance of some desert taxa (*Nitraria*, *Calligonum*, *Reaumuria*), it is possible to distinguish between periods with steppe vegetation, mainly indicating wetter conditions, and with desert vegetation, mainly suggesting drier conditions. According to the age model, wetter conditions prevailed between about 8.2-7.5, 6.6-6.2, 5.6-4.8, 4.3-4.0 and 3.2-2.8 cal ka BP.

59-12 BTH 81 Chen, Fahu

A MID-HOLOCENE DRY INTERVAL IN CENTRAL CHINA: EVIDENCE FROM LAKE SEDIMENT LITHOLOGIES AND ECOLOGICAL PROXIES

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In China, the mid-Holocene is traditionally thought to be a warm and humid magathernal period with a strong summer monsoon. Here we present high resolution pollen data and lacustrine lithological evidence from the margin of the present summer monsoon on the western inner Mongolian Plateau. The data shows that present lakes and wetlands in the Tengger Desert experienced desiccation in the mid-Holocene around 5000-7000 cal years ago. Forest vegetation declined in the mountains along the northern margin of the Tibetan Plateau during the same period. These proxies suggest the dry climate of this interval was due to the failure of the Asian summer monsoon. This mid-Holocene drying episode is documented in a number of lakes in the middle latitudes of North China, indicating the impact of the event was quite wide spread. These results suggest the dry 5-7000 cal yr BP interval in north central China is related to a mid-Holocene decline in global monsoon circulation. We suggest the failure of the monsoon may be the result of the rapid cooling of the Tibetan Plateau and is ultimately related to a decrease in solar radiation.

59-13 BTH 82 Jin, Heling

CLIMATIC CHANGE AND EVOLUTION OF HUNSHANDAKE DESERT IN CHINA SINCE MIDDLE HOLOCENE

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The Hunshandake Desert, which locates in the eastern part of Inner Mongolia of China, has the shape of ellipse that prolongs in latitudinal direction. The longest axis has extended for 1260 km, its width ranges from 30 to 100 km, and the calculated area of the desert is about 1.8-10⁴ km². This study focuses on the climatic change processes since the middle Holocene and its relation with the evolution of Hunshandake Desert. Magnetic Susceptibility (Ms), the ratio of humid-implied chemical elements to arid-implied chemical elements and the stratigraphical deposition phases and granularity are used as the proxies to indicate the degree of summer monsoon,

the humidity and desert evolution respectively. The results show that the study region has experienced seven strong summer monsoon stages, during which the humidity and the vegetation coverage increased; and six weak summer monsoon stages, during which the humidity and the vegetation coverage decreased. Influenced by the climatic change, the Hunshandake Desert has underwent seven stabilizing (or area reducing) stages, during which palaeosol developed, depositional particles became fine, the content of silt and clay increased; and five desert extending stages, during which Aeolian sand deposited, depositional particles became coarse and the content of fine sand increased. Suggested by the correlation analyses, we get to the conclusion that climatic humidity, vegetation coverage and the degree of desert stabilization has good positive correlation with the degree of summer monsoon, namely that the degree of summer monsoon is one of the controlling factors that influenced the climatic change and the desert evolution.

59-14 BTH 83 Endo, Kunihiko

PALEOENVIRONMENT IN THE LOWER REACHES OF HEIHE, INNER MONGOLIA, NORTH CHINA. MIGRATION OF HEIHE AND JUYAN LAKES

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1. INTRODUCTION On the north slope of Qilian Mountains, broad alluvial fans extend toward northernmost end of the Heihe drainage basin. Juyan terminal lakes, such as Sogo and Gashun lakes are situated in desert environments. Recently they were dried up, excluding temporary supply of water. In addition, another large lake, the Old Juyan lake existed in the east. It has been dried up in the historical time. Topography and surface geology of Juyan and Old Juyan lake areas were investigated in relation to historical evidence, as a part of RIHN Oasis project.

2. OLD JUYAN LAKE SEDIMENTS AND THE SHORELINES By the shore of Tian-e-hu, a small lake at NW end of Old Juyan lake, 1.5 to more than 10 m thick lake sediments are exposed and partly eroded, showing yardan topographies. Mischke et al. (2002) investigated this sediment by using ostracoda, and indicated that the lake existed at least 2700 to 5400 cal.y.BP. In our study, one of yardan mounds by the shore of 2002 was investigated and a radiocarbon age shows the lake already existed at 4600 cal.y.BP. Surrounding the Old Juyan lake including Tian-e-hu, a number of gravel bars are distributed and preserved well. They are good evidences of the former lake shorelines. 23 gravel bars were distinguished along the 2002 survey line. A radiocarbon age of the 5th gravel bar from the highest is about 3300 cal.y.BP. Corona satellite photos show the distribution and alignment of the lake shorelines well around the areas of Old Juyan lake. It suggests the gravel bars may be the evidence of a large lake covering all of Old Juyan lake area.

3. MIGRATION OF HEIHE AND JUYAN LAKES On the southwest of Old Juyan lake, some historical sites ranging from 2000 to 650 y.BP are located. It suggests that the Old Juyan lake existed upto the historical ages. At present, a sand dune zone separates Old Juyan lake and historical sites. Therefore the course of Heihe was changed from NE to NNE probably by advance of the sand dune zone. The river water must cut and erode existed higher sand dune zones, then flow into the Juyan lake basin. Along the north course, that of the present east river of Heihe, there are some outcrops composed of a number of flood deposits interbedded with thin weak soils. Near the lowest horizon, a thicker soil underlies the flood deposits. Its age is about 600 cal.y.BP. This age may support the migration model of Heihe and Juyan lakes.

59-15 BTH 84 Zhao, Yan

LATE HOLOCENE VEGETATION AND ENVIRONMENT HISTORY OF DAJIU LAKE

BASIN, SHENNINGJIA, CHINA USING POLLEN, MACROFOSSILS AND GEOCHEMISTRY

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Shennongjia is a relatively closed high mountain area, where lakes and swamps are relatively undisturbed by human activities. A stable and continuous layer of peat ca. 3 m thick accumulated during the Holocene. We examined a stratigraphic sequence of 120 cm from the Dajiu Lake Basin for pollen, macrofossils and geochemistry; the profile represents the vegetation history from ca. 2500 yrs. B.P. until today. The profile revealed that climate in this area has been generally cool and wet throughout the period, but some vegetation and climatic fluctuations and small human disturbances can also be seen clearly in the pollen, geochemistry and plant macrofossil record. Good correlations exist between *Rumex*, *Juniperus*, *Rhus*, *Cerealia*, *Alnus* and geochemistry. For macrofossils, *Sphagnum Section Subsecunda* and *Drepanocladus spec.* correspond well with geochemistry. We conclude that combining the three analytical methods has great potential for providing high-resolution reconstructions of vegetation and climate.

59-16 BTH 85 Ren, Zhaoxia

DROUGHTS, FLOOD DISASTERS, AND CLIMATE CHANGE DURING THE LAST 2000 YEARS IN HEIHE RIVER BASIN

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The Heihe River is one of the largest inland rivers in Northwest China. Over the past 1000 years there has been a trend of climatic warming and drying since the end of Little Ice Age in Northwest China. Over this period, annual air temperature has risen about 1-1.3°C, precipitation has been reduced by 50-78mm, and runoff has been reduced by about 14% in the middle sector of Tianshan and eastern sector of Qilianshan. Because of abundant historical data on droughts, floods, and changes in temperature in the past 2000 years in the Heihe River basin, we were able to construct a drought and flood sequence. Statistical and power spectrum analyses were used to determine the periods and phases of droughts and floods over the past 2000 years. Droughts, flood disasters, and precipitation show a good negative correlation over the past 40 years with a correlation coefficient of 0.892. This allows us to build a relation between the drought and flood sequences and percentage anomalies of annual precipitation. From this we use the drought and flood sequence to reconstruct a precipitation sequence for the past 2000 years in Heihe River basin. Integrating information on droughts and floods with historical data on changes in temperature, we conclude that: (1) On a century time scale, drought periods tend to be cold, while wet periods tend to be warm over the past 2000 years; (2) Cycles in frequency of droughts and floods have 240 and 200 periodicities, respectively, but also short periods of 4 and 2-3 years, respectively.

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ly. On a century scale, climatic changes of droughts and floods fluctuate, with times of droughts longer than those of floods; (3) The reconstructed precipitation sequence over the past 2000 years in Heihe River basin shows that precipitation during cold periods is about 200mm, while precipitation during warm periods is about 240mm; (4) During the last 2000 years we conclude that six cold periods and the six warm periods occurred. Other means can be used to distinguish between warm and cold stages and identify the warm or cold events in each stage, including advances of glaciers and periglacial phenomenon in northwestern China, ice cores, tree_rings, and lake sediments records.

59-17 BTH 86 Chen, Fahu

DUST STORM HISTORY OVER THE LAST 2000 YEARS DOCUMENTED BY LAMINATED LAKE SEDIMENTS IN ARID CENTRAL ASIA

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Arid central Asia is one of the main dust and eolian silt source regions in the world. Here we use lake sediments in Sagan Lake to document dust history over the last 2000 years. Sagan Lake is a hydrologically closed lake in the Qaidam Basin of northwestern China, one of the two driest regions in central Asian. The annual precipitation around the lake is only 18.5 mm, but increases with altitude in the lake basin. Mean annual air temperature is 2.75°C. Rivers formed by glacial melt and snow water in surrounding mountains form ground water in the fluvial plain and there is no surface river flow into the lake. Rather, the lake is directly recharged by springs around the lake margin. Therefore, the terrestrial detritus can only be transported into the lake through dust storm winds. The lake surface is frozen from mid-October to April, making it possible to deposit coarse dust-storm sand and silt in the lake. We collected aeolian samples on the frozen lake surface and measured grain size to understand the process of detritus deposition in the lake sediments. We found that both aeolian samples on the frozen lake ice surface and from the lake floor have the same grain-size distribution, and match samples from sediment cores. An 8.52m long core and several short cores from 1.0 m to 3.0 m long were drilled in Sagan Lake. Lake sediments in the cores have very clearly laminated features. Chronology was established using ²¹⁰Pb and ¹³⁷Cs for the most recent 200 years, together with 10 AMS ¹⁴C dates on plant remains in the cores. Dust history was reconstructed for the last 2000 years at a 5-10 year resolution, and shows quite clearly an increased trend in dust storm events over the last 20 years and strong dust storms during the middle of the Little Ice Age.

59-18 BTH 87 Gou, Xiaohua

THE CLIMATE VARIATION SINCE 300 BP IN THE EASTERN PART OF QILIAN MOUNTAIN, CHINA

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Based on the *Sabina przewalskii* samples obtained in the eastern part of Qilian Mountain, west of China, a standardized tree-ring chronology was established. The correlation analysis was carried out between the tree-ring index and the temperature as well as precipitation at Wushaoling Meteorology Station, which is 70 km away from the sampling site. The results showed that the tree-ring index significantly correlates with the precipitation of March and April, with a coefficient of 0.525. The precipitation of March and April in the study area were reconstructed for the past 300 years. It can be seen that the climate has become wetter in the past 300 years. The statistics confirm that the reconstruction series is reliable.

SESSION NO. 60, 1:30 PM

Monday, July 28, 2003

T19. Quaternary Paleolakes: Their Utility in Paleohydrologic, Paleoclimatic, Tectonic, and Biogeographic Studies (Posters)

Reno Hilton Resort and Conference Center, Pavilion

60-1 BTH 88 Haberzettl, Torsten

SEDIMENTOLOGY AND PHYSICO-CHEMICAL LIMNOLOGY OF CRATER LAKES IN THE PALI AIKE VOLCANIC FIELD, SOUTHERN PATAGONIA (ARGENTINA)

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Southern South America is the only continental land mass between 38°S and the Antarctic Circle. As such it represents a unique opportunity to reconstruct terrestrial paleoclimatic conditions in an area that is subject to shifts in polar and mid-latitude wind and pressure fields. Here we present data from crater lakes in the Pali Aike Volcanic Field (PAVF) located between 50°-52°S and 69°-71°W. The PAVF is a tectono-volcanic belt 50km wide and >150km long located 80km west of the city of Rio Gallegos (Patagonia / Argentina). Several maars formed in this area between 3.78 and 0.17Ma ago. As the last glaciation, the Llanquihue, did not reach this area there is potential for long continuous deposition in these crater lakes. Though more than one hundred lakes are visible on satellite images during a field campaign in the austral summer of 2002 only two lagunas turned out to be very promising for further sedimentological and physicochemical limnological investigations due to occasionally desiccation of the other lakes. Altogether 16 gravity cores up to a length of 129cm were taken from these permanent lakes - Laguna Potrok Aike and Laguna Azul. The cores were analyzed by various chemical and physical methods. To get a general view of the lakes of this area also chemical and physical data of several episodic lagunas was collected. Laguna Potrok (max. diameter: 3470m) showed no stratification in water chemistry at all which might be due to the size and the exposure to strong winds in this area. The age of 2.153±0.150 yr cal BP of the base-ment of a core points to an average sedimentation rate of 0.5mm a⁻¹. With an age of 1.073±0.92 yr cal BP the sedimentation rate of the conspicuously smaller, well stratified Laguna Azul (max. diam-

eter: 560m), with a thermocline at 20m and sub-oxic conditions at the sediment / water interface, is almost twice as high. In both sediment records distinct shifts in the sedimentological parameters occur during the last millennium. Furthermore Laguna Potrok Aike has three major distinguishable lake terraces representing different high stands of the water body. During a field campaign in 2003 long cores will be taken from Laguna Azul and Laguna Potrok Aike. Additionally an existing 59m long record dating back to >31.600 yr BP from Magallanes Maar, a dry maar in the PAVF, will be sampled in order to get information of older epochs.

60-2 BTH 89 Wille, Michael

LATE HOLOCENE ENVIRONMENTAL HISTORY OF SOUTHERNMOST PATAGONIA,

ARGENTINA; POLLEN ANALYSES OF FIVE SEDIMENT CORES FROM VOLCANIC LAKES WILLE, Michael¹, HABERZETTL, Torsten¹, LÜCKE, Andreas², MAYR, Christoph², OHLENDORF, Christian¹, SCHÄBITZ, Frank¹, SCHLESER, Gerhard-H.², and ZOLITSCHKA, Bernd¹, (1) GEOPOLAR, Institute of Geography, Univ of Bremen, Celsiusstraße FVG-M, Bremen, 28359, Germany, mwille@uni-bremen.de, (2) ICG V, Sedimentary Systems, Isotope Geochemistry and Palaeoclimate, Rsch Chr Jülich, Jülich, D-52425, Germany

The interdisciplinary project SALSA aims to fill the gap of paleoclimate reconstructions for the southern hemisphere from continental archives. It provides information by high resolution multi-proxy analyses of sediment cores from crater lakes in the Pali Aike Volcanic Field (PAVF) located between 50° and 52° S in Patagonia, Argentina. The PAVF is a tectono-volcanic belt 50km wide and >150km long located 80km west of the city of Rio Gallegos, immediately north of the Strait of Magellan, where several maars formed between 3,78 to 0,01Ma. The last (Llanquihue) glaciation, did not reach this area. Five short sediment cores (length: 90-130 cm) from Laguna Azul (two cores) and Laguna Potrok Aike (three cores) were analyzed for several proxies including microfossils. Sixteen AMS-radiocarbon dates provide a time control covering the last 2000 years. Paleoenvironmental reconstruction shows that in pollen diagrams from both lakes pollen types of the Patagonian steppe vegetation dominate without major fluctuations. The dominant taxa are Poaceae and Asteraceae. The dwarf shrub *Eriogonum* shows higher values in Laguna Azul than in Laguna Potrok Aike. Therefore pollen spectra represent mainly the actual vegetation pattern in southern Patagonia i.e. a more xeric steppe type typical for the eastern part and a slightly more humid steppe type occurring in the western part of the area. Higher contribution of Andean forest taxa (—long distance transport) in Laguna Azul is remarkable, because it is located ca. 60 km further east (east of the steppe-forest border than Laguna Potrok Aike. Major changes occur in the upper parts of the pollen diagrams (20-0 cm in Laguna Potrok Aike and 50-0 cm in Laguna Azul). An increase in *Rumex* pollen is interpreted as indicator for pasture and probably shows the start of human impact by sheep and cattle raising settlers since the end of the last century. The contemporaneous increase in *Pediastrum* algae points to a change in water ecology at both lakes probably related to an increase in nutrients.

60-3 BTH 90 Newkirk, Derrick R

THE IMPACT OF CLIMATE AND PRE-COLUMBIAN AGRICULTURE ON SOIL AND NUTRIENTS IN SOUTHWESTERN COSTA RICA

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Lake sediments are useful archives for examining local land use and erosion over time. In particular, the amounts and types of phosphorus (P) eroded from soils into lake sediments may be indicators of nutrient cycling and bioavailability as a function of soil development. This is important on a broader scale because weathering of continental material is the only source of new P into the global P cycle.

Human impacts on landscapes have been recorded on many temporal and spatial scales. An example of this is found in Laguna Zoncho, a lake in southwestern Costa Rica, where a lake sediment core reveals clear changes from forest to maize agricultural ecosystems over the past 3000 years. To examine the effects of soil disturbance and nutrient dynamics in the region, we carried out detailed analysis of P fractions related to soil development on sediment samples from a Zoncho core. These P fractions, termed mineral P, occluded P (iron bound), and organic P change as a function of increased soil maturation, with mineral P dominating in immature soils and being replaced by occluded and organic P fractions as soils mature.

Results from Laguna Zoncho reveal two interesting features of terrestrial nutrient cycling and soil development in this region. Despite pollen evidence showing clear and profound shifts in plant species related to maize agriculture, the net soil nutrient status has remained constant through time. The composition of P is much more organic rich than in other temperate settings studied by us previously, likely due to high rainfall and temperatures in the region. Throughout the ~3000 yr record, a slight shift toward higher % organic P exists, which might be the result of increased dissolved nutrient input into the lake and higher in-situ algal production. Additionally, a strong transient shift toward higher occluded P occurs around ~400 years ago, and coincides with the advance of native forests. This could be due either to increased erosion, effectively mining down to deeper soil layers with higher occluded P, or to a short-term (i.e. ~100 year) interval of arid conditions resulting in more occluded P on the landscape. These two, apparently disparate hypotheses will be tested by examining regional paleo rainfall records, particle size analyses in Laguna Zoncho sediments, and pollen records from this and other sites.

60-4 BTH 91 Castiglia, Peter J

HOLOCENE LAKES AND LATE QUATERNARY CLIMATE VARIABILITY IN THE CHIHUAHUAN DESERT, MEXICO

CASTIGLIA, Peter J and FAWCETT, Peter J, Earth & Planetary Sciences, Univ of New Mexico, MSC03-2040, 1 University of New Mexico, Albuquerque, NM 87131, castiglia@alumni.union.edu Beach ridge and lacustrine deposits from Laguna El Fresnal and Laguna Santa María in the Chihuahuan Desert, Mexico reveal Holocene lake highstands and glacial to interglacial changes in lacustrine sedimentation. Situated about 70 km south of the US-Mexico border, these currently dry basins preserve Holocene lake level variations that are attributed to millennial-scale changes in winter storm frequency, and reduced temperatures and evaporation rates over the southwestern U.S. and northern Mexico. Constructional beach ridges dated at ca. 230 and 495 cal yr B.P. (Little Ice Age), 4220 to 4795 cal yr B.P. (early Neoglacial), 6980 to 7585 cal yr B.P. (mid Holocene), and 9255 and 9430 cal yr B.P. (early Holocene) provide the first detailed Holocene lake-level chronology for northern Mexico. In addition, these results show unambiguous evidence for wetter than present conditions during the mid Holocene, a time that is widely considered to have been relatively dry in this region. Distinct pluvial episodes during the early Holocene and probably during the late Pleistocene are marked by two shorelines above an intrabasin sill. At these times, conditions were wet enough to form one large lake, pluvial Lake Palomas, which

encompassed all of the sub-basins. We estimate that the largest spatial extent of this combined lake covered approximately 7030 km² during maximum pluvial conditions.

An ~17m-long core from Laguna El Fresnal reveals glacial to interglacial changes in lacustrine sedimentology for the last ca. 70,000 calendar years. Colder than modern climate conditions coupled with low-energy lacustrine deposition before ca. 30,000 cal yr B.P. are marked by low total organic carbon and a gradual increase in clay-dominated sediments. Maximum pluvial conditions ca. 21,000 cal yr B.P. are characterized by peaks in sand-size sediment, high magnetic susceptibility (MS), and low organic productivity within El Fresnal basin. The transition to relatively drier, warmer climate ca. 10,500 cal yr B.P. is shown by a marked decrease in MS, increased organic and inorganic carbon concentrations, and pulses of fine sand. These glacial to interglacial changes in lacustrine sedimentology are synchronous with other regional paleolimnological records.

60-5 BTH 92 Kennedy, John

LATE QUATERNARY PALEOHYDROLOGY OF A LINKED PLUVIAL-LAKE AND ANCESTRAL RIO GRANDE SYSTEM, PASO DEL NORTE REGION, SOUTHWESTERN USA AND NORTHERN MEXICO

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During major glacial-pluvial intervals of the Late Quaternary, a complexly linked system of intermontane basin lakes and through-going streams dominated the geohydrologic setting the Paso del Norte region of southern New Mexico, Trans-Pecos Texas, and Chihuahua, Mexico.

Hydrogeologic setting and fluctuating paleoclimatic conditions were the major controls on size and permanence of lakes and streams in this now arid to semiarid Chihuahuan Desert region of the Basin and Range—Mexican Highland section. Bolson complexes of the region have both open and closed topographic components, but many closed subbasins are partly drained hydrologic systems with groundwater inflow and outflow links with adjacent areas. The entrenched Rio Grande/Bravo fluvial system formed the regional discharge zone or sink for large amounts of surface and subsurface flow during much of the Middle and Late Quaternary.

The Mesilla and El Paso/Juárez Valleys of the Rio Grande/Bravo (1090-1175m) bisect the floors of the Los Muertos-Guzman-Santa Maria and Tularosa-Hueco bolson complexes (1175-1210m), which are the sites of the region's two largest pluvial lakes, Palomas (Chihuahua) and Otero (NM). At highest (Wisconsinan) stages, Lakes Palomas and Otero had areas of at least 7500 and 2000 km², respectively. Linked closed basins with smaller pluvial lakes include the Playas-Basilillo and Hachita-Moscicos basins that drain to the Rio Casas Grandes Valley of northwestern Chihuahua. Watersheds (~3000m max elev, 63,700 km² area) contributing to Lake Palomas include highlands bordering the northern Sierra Madre Occidental (Rios Casas Grandes, Santa Maria and Carmen headwaters) and southeastern ranges of the Datil-Mogollon—Transition Zone province (Mimbres River source). The Sacramento-Sierra Blanca and Organ-San Andres-Oscura ranges form the major highlands of the Lake Otero watershed (~2750m max elev, 17,500 km² area). In many places, major shoreline features with good age control are visible on LANDSAT imagery; and advanced GIS technology enables basin-scale paleohydrologic and hydrogeologic reconstructions.

60-6 BTH 93 Menking, Kirsten M.

HYDROLOGIC MODEL CONSTRAINTS ON LATE PLEISTOCENE CLIMATE IN CENTRAL NEW MEXICO

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The climatic conditions leading to highstands of "pluvial" Lake Estancia in central New Mexico have been a matter of considerable debate, resulting in a range of estimates for Pleistocene precipitation and temperature in the southwestern United States. Using a hydrologic balance approach, Leopold (1951) determined that highstands were produced by precipitation values 50% greater than modern, given the assumption that summer temperatures were 9 °C colder while winter temperatures were unchanged. Antevs (1954) estimated that June-September temperatures were cooler by 5.5 °C and that precipitation was 60% greater. In contrast, Galloway (1970) called on temperature decreases of 10-11 °C throughout the year and a reduction in mean annual precipitation of 14% to raise Lake Estancia to highstand levels. In still another study, Brakenridge (1978) suggested that highstands could be achieved through no change in precipitation if all monthly temperatures were reduced by 7-8 °C.

We applied several models developed in recent decades to evaluate some of the above estimates of Last Glacial Maximum (LGM) climate (U.S. Department of Agriculture Soil and Water Assessment Tool for runoff, MODFLOW with LAK2 package for groundwater, and an energy balance lake model developed by Hostetler). Models were calibrated under modern climate and vegetation conditions using archival streamflow data and groundwater head values from wells, and were then forced with the climatic scenarios of Leopold and Brakenridge. Results show that simple year-round cooling of 7 °C is insufficient to raise Lake Estancia to its LGM highstand. Increased annual precipitation, in the range estimated by Leopold and Antevs, can raise water level to elevations near the LGM highstand, but only after a prolonged interval of time. Time constraints on lake level rise imposed by the Lake Estancia age model suggest that even greater increases in precipitation may have occurred.

60-7 BTH 94 Jayko, A. S.

LATE PLEISTOCENE LAKES AND GROUNDWATER DISCHARGE, PANAMINT VALLEY, CALIFORNIA

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Panamint Valley is intermittently occupied by perennial water bodies linked to two fundamentally different sources, the Owens River system (ORS) and the regional groundwater aquifer (RGA). The bedrock of the different flow paths is sufficiently unique to influence the water chemistry, which in turn influences the ostracode assemblages. Previous Sr isotopic studies indicated the presence of two chemically distinct water sources. Likewise, microfaunal studies of the ORS demonstrated faunal variations that respond to climate-driven variation in water chemistry.

Lacustrine deposits within Panamint Valley extend through an elevation range over 360 m. During glacial periods, ostracode assemblages indicate high total carbonate alkalinity to calcium ratio (alk/Ca) and a cold, dilute lake with variable salinity fed by surface flow from the ORS. During

interglacials, the assemblages indicate high total dissolved solids (brine) and very low alk/Ca ratios fed by the RGA. Deposits and archived core suggest large lakes and surface flow by the ORS during marine oxygen-isotope stages (OIS) 2 and 6, while saline marsh or wetlands supported by the RGA persisted during some of OIS 3 and most of OIS 4.

Lacustrine and wetland deposits that range in elevation between 415 - 512 m contain Limnocythere sappaensis, indicating a saline lake with ORS flow; 14C dates from associated tufa give OIS-2 ages. Ostracodes, including Cyprideis beaconnensis, occur between about -34 to -78 m depth in DH-1 core and have amino acid racemization ratios (AAR) and a single 14C age of 40,710 +/- 670 BP suggesting OIS-3 age or older for the section. The fauna, brine shrimp pellets and the foraminifera Elphidium sp. in two samples, indicates a saline to briny wetland or shallow lake fed by the RGA. Comparison of DH-1 with DH-3 and Owens Lake core suggests the interval spans much of OIS 4. The high stand deposits lying 320 to 260 m above the playa at elevations of 550 to 610 m indicate ORS flow. AAR from ostracodes and snails in these deposits indicate one lacustrine period. An OIS-6 age for this period can be inferred by comparison of the high stand AAR with the archived core AAR results that underlie the 14C age cited above. Ostracodes and foraminifera indicate that Panamint Valley was used by Pacific migrant shorebirds during OIS-3 and 4, and by Gulf of Mexico migrants during OIS-6.

60-8 BTH 95 Couch, Robert F.

LATE PLEISTOCENE STRATIGRAPHY OF THE ANCESTRAL CHINA LAKE SEDIMENTS, INDIAN WELLS VALLEY, SOUTHEASTERN CALIFORNIA

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During a recent Navy study to characterize the hydrogeology of the Indian Wells Valley (IWV) in southeastern California, cores from 15 soil borings and surface soil samples were dated using accelerator mass spectrometry determinations of carbon-14. The purpose of the radiocarbon analyses was to provide age control and stratigraphic correlation of lacustrine olive clay and silts. Ten samples yielded dates ranging from 14,690 to 32,220 years before present (ybp), a time frame that bounds the period of the last major Pleistocene lake in IWV, known as the ancestral China Lake. This time frame correlates well with the last major Sierra Nevada glacial advance, or stage, as marked by a dramatic increase in rock flour abundances seen in USGS cores from the upstream Owens Lake. Previous studies date this last stage at 30,500 to 15,000 ybp. Owens Lake outflow into IWV increased during this time, creating a sizeable ancestral China Lake. The first-encountered clays seen in the IWV cores are not coeval, however, because the clays represent sedimentary facies intercalated with fan-delta and deltaic sequences located at various distances from the lake's primary depocenter. The distribution of the lacustrine facies is generally consistent with a conceptual shoreline map developed during this study. Shallow sediments under the current China Lake playa appear to be Late Pleistocene in age, likely reflecting removal of younger sediments by Holocene wind scour and eolation. Six deeper and older core samples ranged in age from 31,350 to 46,010 ybp, confirming that a stable lake persisted in the basin during this time. Two gastropod shells apparently from a near-shore death assemblage yielded dates of 14,060 and 12,825 ybp. The fossil horizons appear to reflect the salinization of the lake and declining freshwater input from upstream Owens River prior to the final infilling during the Younger Dryas age. The river surged again one last time, recorded in overbank/distributary deposits of the delta plain that yielded a date of 11,215 ybp. In the southeastern IWV, a gypsum-rich silty clay hummock dated at 10,070 ybp puts the desiccation of the last large ancestral China Lake at the close of the Pleistocene.

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60-9 BTH 96 Reheis, Marith C.

TIMING OF PLUVIAL LAKE-FILLING EVENTS IN THE WESTERN GREAT BASIN

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Internally drained valleys of the Great Basin, western U.S., were repeatedly filled with deep lakes and desiccated during the Pleistocene. The most prominent and best-preserved geomorphic features of these lakes formed during highstands between 17 and 14 ka (toward the end of marine oxygen isotope stage 2, or OIS 2). Previous studies of older deep-lake cycles relied mainly on cores and a few stratigraphic exposures beneath the youngest deposits and were dated by tephrochronology and paleomagnetic techniques. According to the ruling paradigm for Lake Lahontan, OIS 2 lakes were about as large as the older lakes; higher shorelines of previous lake cycles, if recognized, were ascribed to effects of tectonics or stream capture. However, work since 1995 has documented shoreline features of older lakes (based on weathering characteristics) that reached higher levels due to climatic effects in at least seven basins in the western Great Basin, located throughout Nevada and extending into adjacent northern California and southern Oregon. Analysis of topographic maps suggests that nearly all basins in this area contain remnants of older shorelines at higher elevations than those formed in the latest Pleistocene.

Combined field and geochronological studies in three basins demonstrate the presence of shoreline deposits associated with at least two or three lakes that were older and larger than the OIS 2 lakes. We dated shoreline sequences using cosmogenic ³⁶Cl depth profiles on barrier beaches deposited at or near a highstand and TIMS U-series dating on lacustrine tufa, which records the presence of a lake but not necessarily a highstand. Geochronological results indicate that all three basins contain shorelines of lakes present between about 125 and 200 ka (correlative with OIS 2) that were significantly higher (+17 to +35 m) than the younger OIS 2 shorelines. At least two of the basins also contain shoreline remnants at intermediate heights (-4? to +15 m higher than OIS 2) that were apparently deposited during OIS 4, a relatively brief glacial stage in the region. These OIS 4 deposits indicate that the lakes can respond very rapidly to relatively short climate perturbations. Even higher lakes in several basins are represented by pre-OIS 6 shorelines that reflect effectively wetter conditions than those present during OIS 2.

60-10 BTH 97 Sharpe, Saxon E.

THE SOLUTE ECOTONE, A KEY TO PAST HYDROLOGY

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An ecotone, which typically develops along one or more environmental gradients, is a biologic gradient where species change from one community to another. Accordingly, distinctive ecotones among aquatic species, such as mollusks and ostracodes, are produced by changes in solute composition. The solute composition (or dominant ions) of natural waters includes bicarbonate-carbonate, sulfate, and chloride anions, and sodium, calcium, and magnesium cations. The sum

of ion concentration is commonly expressed as total dissolved solids (TDS) in mg per liter. Three major solute types exist that are of biologic importance and the solute ecotone between them generally occurs between 1,500 and 3,000 mg/L TDS, although it may form at lower TDS values.

Solute composition is commonly determined by hydrologic setting and process, local geology, and climate variation. Because the distribution of many mollusks is linked to solute composition along the ecotone, a change in waters within the solute ecotone can affect the occurrence of these taxa. Therefore, the presence of aquatic mollusks in sediment cores may be used to help interpret paleohydrology and paleoclimate by mapping modern hydrochemical fields to estimate changes in calcium, (bi)carbonate and TDS over time. Hence, change in aquatic molluscan assemblages in sediment cores may be used to describe past changes in inflow or outflow and hydrologic characteristics.

60-11 BTH 98 Adams, Kenneth D.

LAKE LEVELS AND SEDIMENTARY ENVIRONMENTS DURING DEPOSITION OF THE WONO AND TREGO HOT SPRINGS TEPHRAS IN THE LAKE LAHONTAN BASIN, NEVADA AND CALIFORNIA, USA

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In the 1970s and 1980s, Jonathon O. Davis painstakingly constructed a tephrochronologic framework for the Lahontan Basin by documenting the occurrences, environmental settings, and ages of multiple tephra units spanning the late Quaternary (Davis, 1978). This framework has proved invaluable to subsequent researchers working to reconstruct the history of paleoenvironmental fluctuations in the Lahontan Basin and other lake basins in the western U.S. The ages, depositional settings, and elevations of various tephra layers provide direct evidence of lake levels through time. As an example, Davis (1983) defined lake level to be between 1256 and 1260 m during deposition of the Trego Hot Springs bed (THS; 23,200 +/- 300 14C yr B.P.), based on exposures of the tephra in a deltaic complex along Squaw Creek. A lake at this elevation in the western subbasins of Lahontan would cover approximately 6500 km² and have a volume of about 360 km³. Subsequently, Benson et al. (1997) reinterpreted the Squaw Creek exposures and presented isotopic evidence that Lake Lahontan was much smaller during the deposition of the THS bed, probably close to the size of modern Pyramid Lake. New and existing evidence from outcrops of the THS bed in deltaic, beach, and other lacustrine deposits confirms Davis' (1983) original interpretation that Lake Lahontan was near 1260 m when the tephra was deposited.

Benson et al. (1997) also inferred that lake level during deposition of the Wono bed (27,300 +/- 300 14C yr B.P.) was at or below 1207 m, the spill point from Pyramid Lake to the Smoke Creek-Black Rock subbasin of Lake Lahontan. Outcrops of the Wono bed in deltaic deposits and lacustrine sands, however, indicate that Lahontan was at an elevation of at least 1215 m at that time in the western subbasins, indicating a much larger lake than inferred by Benson et al. (1997). In the Carson Sink subbasin, the Wono bed is contained within coarse beach gravels at an elevation of about 1204 m, indicating a lake surface at about this elevation. Accurate delineation of the family of lake-level curves for the Lahontan Basin is important not only for paleoclimatic reconstructions but also for specifying spatio-temporal variations in the water load for isostatic rebound modeling.

60-12 BTH 99 Delusina, Irina

CAUSES OF HIGH LAKES STANDS IN THE GREAT BASIN DURING THE "PLUVIAL ÉPOQUE" AT 18 KYR BP: PALEOCLIMATIC EVIDENCE

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During the last glacial maximal stage in North America about 18 kyr BP, numerous large lakes existed in the Great Basin of the United States. Richard Foster Flint's classic explanation for the existence of these lakes is that the expansion of continental ice sheets in North America produced pluvial conditions in the Great Basin. By "pluvial conditions", Flint meant an increase in the ratio of precipitation to evaporation. His explanation has been adopted by many subsequent researchers, despite the fact that Flint provided alternative mechanisms for high stands of lakes in other regions during glacial stages.

Our analysis of existing studies from the Great Basin indicates that not all of the data are consistent with the idea that glacial stages in North America produced substantial increases in precipitation in the Great Basin. Furthermore, published modeling of climate patterns in the Great Basin during glacial times suggests that increases in precipitation occurred primarily in the winter, in association with snowfall, and not during the summer when they would have the greatest effect on lake levels. This suggests that hydrologic contributions to lake levels (groundwater discharge, river run-off, etc.) may have been more important than direct precipitation in raising the lake levels. The pollen data also provide a contradictory picture of paleohumidity.

60-13 BTH 100 Mensing, Scott A.

A HOLOCENE RECORD OF VEGETATION AND CLIMATE CHANGE FROM PYRAMID LAKE, NEVADA

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Closed basin lakes along the eastern Sierra Nevada Range, including Pyramid Lake, preserve a record of lake-level fluctuations associated with wet and dry climatic episodes. Pleistocene Lake levels are recorded in wave-cut terraces and lake-deposited tufas above the modern shoreline, but the Holocene climate record is preserved primarily in the sedimentary record. Pyramid Lake receives the majority of its input from the Truckee River, which heads in the Sierra Nevada. It is the only large closed-basin lake in the western Great Basin to have escaped desiccation during the Holocene. For this reason, it is an ideal site for reconstructing Holocene climate change.

Three sediment cores spanning the last 7500 calendar years before present (cal yr BP) were analyzed for pollen at decadal to century-scale resolution. Dry periods were defined using the ratio of Chenopodiaceae (saltbush) pollen to Artemisia (sagebrush). This ratio suggests that the mid-Holocene (7500 – 6300 cal yr B.P.) was the warmest and driest portion of the record. Pyramid Lake was greatly reduced in size and the surface of Lake Tahoe was ~4 m below its modern elevation. Dry conditions persisted until ~5000 cal yr B.P. at which time there was a gradual but erratic increase in precipitation that continued as a generally wetter climate through 3500 cal yr B.P. A return to very dry conditions is seen between 2500 and 1800 years B.P. The last 1800 years have seen repeated wet-dry cycles, however none of the dry periods were as intense as those occurring during earlier periods. The record supports the evidence for prolonged droughts centered at ~800 and ~600 cal yr BP identified from submerged logs at Mono Lake.

The drought record reconstructed from fossil pollen correlates with the high-resolution record of multidecadal and multicentennial droughts identified in the oxygen isotope record from Pyramid Lake and compares favorably with other proxy records from the Great Basin. The timing of major

shifts in climate also corresponds to the timing of rapid changes in drift-ice accumulation identified in the North Atlantic. These changes have been documented to coincide with changes in solar output. Our results imply that similar mechanisms may be responsible for Great Basin Holocene climate changes.

60-14 BTH 101 Kuehn, Stephen C.

DISTAL CORRELATION OF NEWBERRY VOLCANO TEPHRAS AND UPDATED TEPHRA STRATIGRAPHY FOR THE SUMMER LAKE SUB BASIN OF PLUVIAL LAKE CHEWAUCAN

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Newberry volcano has a long history of silicic pyroclastic volcanism and has produced many extensive tephra deposits. During the last approximately 550,000 years, the volcano has erupted at least 60 rhyolitic and dacitic tephra that record a range of eruptive styles. Glass compositional variations in these tephra units have been characterized by electron microprobe and compiled into a database containing more than 8,600 individual point analyses. Potential distal ash correlations have been established by using the similarity coefficient of Borchart et al. (1971 and 1972) in conjunction with discriminant function analysis. Similarity coefficients for correlated tephra range from 0.95 to 0.99 and correspond to probabilities of 90-100%.

The Holocene Newberry Pumice correlates to at least two distal locations in Oregon and three that span central Idaho. This distribution suggests that recognizable distal deposits are likely to exist in western Montana. The Pleistocene Paulina Creek tephra is the source of the Olema ash bed and correlates to at least two sites in Oregon and several locations in northern California. Tephra 9917C is highly similar to Pringle Falls tephra K and D. Lava Pass tephra and three related deposits are highly similar to a distal ash preserved at a depth of 142 m in the Knolls core in the Bonneville basin, Utah.

More than 75 individual tephra beds are intercalated with Pleistocene lacustrine sediments at Summer Lake, Oregon. More than 50 are exposed in the Ana River (AR) outcrop section. Others are known from the Wetland Levee (WL) and Bed and Breakfast (BB) cores. Similarities in glass compositions suggest that at least 14 of the tephra beds may originate from Newberry volcano. Glass in Newberry tephra Paulina Creek, Ice Quarry, 9912D, 9920C, 984F, 984G5, 978D, 9917C, and 9881C tephra are highly similar to ash layers at Summer Lake. Paulina Creek correlates to WL-7-2. Ice Quarry correlates to bed AR-2/WL-9-4. 9912D is similar to AR-N1 (equivalent to WL-37-I and WL-37-II), AR-N, and AR-M. 9920C is similar to AR-Q/WL-37-IV and AR-P/WL-37-III. 984F correlates to AR-S. 984G5 correlates to AR-T/WL-38-3. 978D is similar to AR-V. 9917C is similar to AR-DD, FF, and GG. 9881C is similar to AR-NN. In addition, two tephra of uncertain source found at Summer Lake, the Wono tephra and AR-G, are present at Newberry.

60-15 BTH 102 Fisher, Timothy G.

BIG LAKE RECORDS PRESERVED IN A LITTLE LAKE'S SEDIMENT: AN EXAMPLE FROM SILVER LAKE, MICHIGAN, USA

FISHER, Timothy G., Department of Geosciences, Indiana Univ NW, 3400 Broadway, Gary, IN 46408, tfisher@iun.edu, LOOPE, Walter L., United States Geol Survey, Munising, MI 49862, JOL, Harry M., Department of Geography and Anthropology, Univ of Wisconsin - Eau Claire, 105 Garfield Avenue, Eau Claire, WI 54702-4004, and PIERCE, William C., School of Natural Resources and the Environment, Univ of Michigan, MI Silver Lake is a former embayment of Lake Michigan, separated by a barrier-bar/dune complex. Lake sediment stratigraphy based on vibracores and a GPR transect consists of Lake Michigan Formation (LMF) sand and clay overlain by marl, peat and organic-rich mud, which records lake level fluctuations in both Michigan and Silver Lake. A hardwater corrected date of 11,310 14C BP (Beta169830) at the marl and LMF contact records the beginning of the Greatlakean substage. A 10,460±50 (WW2787) 14C BP age from a buried soil overlain by pebbly sand may be interpreted as a transgression of Lake Algonquin. In other cores, the abrupt transition to marl records a localized perched water table during the Chippewa Low. Peat deposition starting at 8400 yr BP indicates freshening of the water while the abrupt transition to sandy muck at 6600 yr BP is explained by flooding Silver Lake from rising Lake Michigan. Peat-top elevation constrains the lake level curve of the Chippewa transgression. Fine-grained sediment in the western edge of the basin is likely LMF clay overlapping the barrier suggesting that the barrier is Calumet age or older. Eolian sand in the uppermost mud is variable, and occasional bands of sand may relate to when the dunes lost their wooded cover ~400 yr BP.

60-16 BTH 103 Yansa, Catherine H.

WHITE SPRUCE PARKLAND IN THE NORTHERN GRASSLAND BIOME OF NORTH AMERICA DURING THE TERMINAL PLEISTOCENE

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Other paleobotanists have suggested that *Picea glauca* (white spruce) migrated northwards across the northern Great Plains of North America with the retreat of the Laurentide Ice Sheet. These researchers proposed that white spruce forests quickly colonized recently deglaciated landscapes in the Dakotas and Minnesota in the United States, eventually reaching southern Saskatchewan and Manitoba in Canada by about 12,000 14C yr B.P. New paleobotanical and radiocarbon evidence, presented here, concurs with this migratory scenario, but question previously published chronologies and differs in its paleovegetation interpretation. Previous chronologies were based on the 14C dating of organic sediments, which are known to provide erroneously older ages. A revision of the timing of white spruce occupation of the northern Great Plains during the late Pleistocene has been compiled based on the analysis of over 80 pollen and 200 plant macrofossil samples, and 12 associated 14C ages (obtained from terrestrial plant macrofossils) from six sites located in the northern Great Plains of the United States and Canada.

The fossils and 14C ages from the Wendel site, situated on the Glaciated Till Plain, indicate that a parkland of *Picea glauca* and prairie herbs colonized southeastern North Dakota by 11,500 14C yr B.P. These spruce trees probably occupied the shorelines of numerous ponds and lakes, and were subsequently replaced by grassland at about 11,000 14C yr B.P., as a result of greater regional aridity. Further west on the Missouri Coteau upland, a belt of hummocky moraine with numerous kettle lakes, the *Picea glauca* parkland phase occurred later, 10,800 to 10,600 14C yr B.P. in southeastern North Dakota (Coldwater Lake), and 10,300 to 10,000 14C yr B.P. further north in Saskatchewan (Andrews, Kyle, Beechy, and Neufeld sites). The results from this study indicate that a non-analog vegetation colonized the northern Great Plains immediately following deglaciation, as has been reported elsewhere. The anomalous mixture of prairie herbs, species of which exist today in this mixed-grass prairie region, and white spruce, a boreal taxa, suggest that the vegetation was not that of a boreal forest, as earlier proposed. Consequently, regional temperatures during the late Pleistocene were probably not as cool as previously thought.

60-17 BTH 104 Johnsen, Timothy F.

FISHING FOR ANSWERS IN THE DEGLACIAL RIBBON LAKES OF THE THOMPSON BASIN, BRITISH COLUMBIA: ADVANCES IN CORDILLERAN PALEOHYDROLOGIC, PALEOCLIMATIC AND ISOSTATIC RECONSTRUCTIONS

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During the decay of the Cordilleran Ice Sheet (CIS), ~9 to 12 ka BP, numerous deglacial ribbon lakes developed within the moderately deep valleys of the Interior Plateau of British Columbia, yet they have rarely been studied beyond the reconnaissance level. This study integrates geomorphology, sedimentology, aerial photographs, differential GPS, GPR, DEMs and GIS to (i) investigate, survey and correlate paleolake levels, (ii) reconstruct paleolake geography, evolution and environment, and (iii) reconstruct glacio-isostatic rebound.

Two definable glacial paleolake levels were identified, associated with Glacial Lake Thompson (GLT) and Glacial Lake Deadman (GLD). DEMs of paleolake levels, inferred lake bottom and modern topography were integrated in a GIS to quantify lake parameters. Lakes were ribbon-shaped (width to length ratio of ~3:100), deep (>140 and ~50 m, respectively), and of significant volumes (84 and 24 km³, respectively). Glacio-isostatic tilts of these lake shorelines (1.8 - 1.7 m km⁻¹) are among the highest measured in the world and are related to the unusual crustal properties of the Cordillera. Glacio-isostatic depression in the interior was likely hundreds of metres.

The sedimentary record of these lakes reflects the severe adjustments of a landscape undergoing deglaciation and hints at a new model of CIS decay, at least locally. Seventeen glaciolacustrine lithofacies were identified recording deltas, subaqueous fans, high rates of sedimentation, numerous river-generated underflows and a diversity of sediment dispersal and deposition processes. High sedimentation rates and numerous river-generated underflows suggest that ribbon lakes likely received their meltwater and sediment supply from ice remnant on the plateau. This inference is counter to the accepted model of CIS decay that describes plateaus becoming ice-free prior to valleys.

GLD drained catastrophically with the breach of an ice dam, producing drainage bedforms and erosional surfaces within the basin, and discharging ~20 km³ of water. It is possible that this event may have triggered the failure of glacial lakes downstream. Eventually the floodwaters reached the marine environment of Georgia Strait, a total distance of ~250 km, where exotic deposits dated at ~10,500 ¹⁴C yr BP may have been produced by this jokulhlaup.

60-18 BTH 105 Carling, Paul

THE SHORELINE MORPHOLOGY OF THE QUATERNARY LAKE CHUJA-KURAY, ALTAI MOUNTAINS, SOUTH-CENTRAL SIBERIA

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A temporal series of large lake(s) formed in the Quaternary within the Chuja-Kuray Basin of the Altai Mountains in Siberia due to glacier dams blocking the drainage. Variations in the drainage through and over the ice, coupled with variation in meltwater supply and evaporation at the lake surface, ensured rapid and repeated lake level fluctuations. Consequently, the margins of the basins exhibit multiple and often complex palaeo-shorelines. Several processes control the development of shorelines. The main factors are: wind-wave regime, water level fluctuations, sediment supply, geology, tectonics, and the local geomorphological history of the basin. The shorelines are on bedrock, moraine, river terraces and fans which formed in earlier periods and which were active or morphologically stable when the shorelines developed. As water level rose, or fell, shorelines were inundated or abandoned. In the first case the shorelines could be preserved, albeit with morphological modification, by processes acting below the wave base. Abandoned shorelines could be modified by sub-aerial processes but were preserved. Pre-existing shorelines were cut into by later shoreline development. Shoreline building is determined by the fetch and the direction of the prevailing winds. The NW-SE extension ensured (during periods of maximum lake level) a fetch of 70 km in the Chuja and 30 km for the Kuray Basins. North-Easterly winds dominated and were funneled to the SE by basin topography, developing NE wave trains. Dominate wind direction is confirmed by strong strandlines on the W, SW and SE sides of the basin, where longshore drift was N to S. For high-stand lakes, the glaciers terminated as floating ice which calved. Ice-berg evidence are groups of drop stones. These are large (>8m) with well defined glacial striae. Abrasion, abrasion-accumulative and accumulative shorelines have been identified. Of these the latter are impressive and often complex, including spits, tombolas and barrier-beaches enclosing lagoons. Length of individual barriers are up to several kilometers, whilst heights vary from 5 to 8 meters with widths of 30 to 40 meters. The beaches consist of sands and gravels and the internal structure was locally revealed through excavation and GPR survey.

60-19 BTH 106 Sui, Shuzhen

LAKE EVOLUTION HISTORY AND CLIMATE CHANGE OVER THE PAST 230 KYRS FROM MAAR LAKE TIANYANG, TROPICAL SOUTH CHINA

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Two parallel and long lacustrine cores TY1 (225m) and TY2 (230m) were collected from the center of dry maar Lake Tianyang in tropical South China (20°31'N, 110°48'E). Its sediment keeps continuous, high-resolution archives for past climate changes and lake evolution history. The two cores' lithology are same, including three parts: the bottom basalt part (below 224m), the middle diatomite part intercalated with clay (224-34m) and an exception of peat sediment at 38-34m, and the upper alluvial sediment part (34-0m). The K-Ar and TL age of the bottom basalt of Core TY1 was about 470 kyr BP. The lake sediment records a history of about 400 kyr (Zheng, 1999). Diatom analyses are made on the upper 130m depth of Core TY2. The variations of diatom species composition and their relative contents reveal the limnological and climatic changes over the past 230kyr. During MIS7a-d (130-100m), MIS6 (100m-75m) and MIS4-3 (75-34m), the lake and climate condition was quite unstable; while during MIS 5, the lake and climate condition was quite stable. *Aulacoseira granulata* was the dominant diatom species during MIS7-3, accompanied by *A. granulata* var. *angustissima*, *Cyclotella meneghiniana*, *C. stelligera*, *C. stelligera* var. *tenuis* during MIS 7-6, and by *Fragilaria* etc attached and benthic diatom species during MIS3d. During warm-hot MIS7, oligotrophic conditions turned into mesotrophic conditions, at the same time eutrophic conditions are alternated with oligotrophic conditions; pH are mainly neutral to alkaline with occasional slightly acid conditions. During cool MIS6, mesotrophic conditions turned to oligotrophic conditions. Warm-hot MIS5 were always in mesotrophic condition with only very little fluctuation. During cool MIS4-3, the abundance of diatom dramatically decreases and reaches

to nearly zero above the core depth of 34m. During the 34-130m period eutrophic periods are exactly corresponding with acid periods, and alternating with oligotrophic periods. All these indicate that the climate in South China during the last 230 kyr were warm-wet and cool-dry. During MIS6-5 Tianyang maar was a shallow-water lake, and during MIS 4-3 it firstly changed into marsh characterized by abundant attached and benthic diatom species, and then completely dry during the cool-dry MIS3d period. * It is supported by Project CAS KZCX2-SW-118, NSFC 40002012.

60-20 BTH 107 DeVogel, Stephen

A RECONSTRUCTION OF LATE QUATERNARY PALEOHYDROLOGY OF THE LAKE EYRE BASIN, ARID CENTRAL AUSTRALIA USING GIS TECHNIQUES

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Lake Eyre, a closed-basin intermittent lake, receives the majority of its moisture from the summer monsoon. In times of increased monsoon intensity, generally associated with the La Nina phase of the ENSO cycle, the lake experiences significant flooding. But Lake Eyre has not always been an ephemeral lake. It was a perennial lake during several phases of increased monsoon activity during the late Quaternary (esp. 125 ka, 80 ka, 65 ka, 40 ka). Elevated shorelines mapped around Lake Eyre and the Frome-Gregory system, to the southeast, reflect these paleo-highlands. Using the age and elevation data from past research, we are able to use digital elevation models to map these paleo-lakes. Areas and volumes were calculated and the paleohydrologic processes, including the flow direction of spillovers, were reconstructed by incrementally filling each lake meter by meter. At the peak 125 ka filling, the Frome-Gregory system rose to more than +18 m AHD and overflowed to Lake Eyre which filled to +10 m AHD. Together they covered more than 35,000 km², more than three times the area of the modern Lake Eyre playa, and they held 430 km³ of water. By comparison, the deepest historic filling (1974) held 30 km³.

60-21 BTH 108 Davies, Caroline P.

PALEOHYDROLOGY AND PALEOCLIMATES FROM LACUSTRINE ENVIRONMENTS OF THE DHAMAR HIGHLANDS, YEMEN

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The Dhamar highlands of Yemen is a tectonically active region characterized by high intermontane valleys surrounded by the highest mountains (3000 masl) on the Arabian Peninsula. These highlands are bounded by the Rub al-Khali desert to the north, and the Indian Ocean to the south and east, which subjects them to the influence of the Indian Ocean monsoon. Lacustrine deposits from these highlands record significant changes in Quaternary paleohydrology. This poster presents sedimentary, geochemical, and chronological data analyses of the lacustrine sediments and their implications for paleohydrology and paleoclimate change in southwestern Arabia.

The intermontane basins record very long histories of paleohydrologic change. Currently the region is semi-arid without major reservoirs of surface water. However, thick lacustrine sequences suggest periods of significantly moister past environments. Additionally, a peat deposit with a radiocarbon age of 9,820 + 60 yrs B.P. also documents moister conditions during the early Holocene. The occurrence of multiple paleosols indicate periods of land surface stability, while carbonate-rich horizons are evidence of increasing aridity and again signal significant changes in the paleohydrology.

The relationships of paleohydrologic change associated with active tectonics and paleoclimate changes such as influences of the Indian Ocean monsoon are examined through sedimentary and geochemical analysis. Fluctuations in sedimentation and chemical regimes extend into the Pleistocene and provide signatures in the sediment profile that identify episodes of lacustrine deposition, soil development, and periods of greater aridity. Fluctuations in the lacustrine record of the Dhamar highlands reflect both local changes in paleohydrology and a regional record of paleoclimatic conditions in southwest Arabia.

60-22 BTH 109 Enzel, Yehouda

HYDROCLIMATOLOGY OF THE MIDDLE EAST DURING LONG-TERM DROUGHTS/WET EPISODES DETERMINED FROM HOLOCENE DEAD SEA LEVEL VARIATIONS

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Transferring lake levels into hydrological changes and then into parameters such as precipitation or synoptic climatology is a problematic task. The difficulties arise from age dating, modern data, and in quantifying reservoirs/fluxes in the hydrology. We conducted such a research in the Dead Sea (DS), which is a terminal lake of a large hydrological system in the Levant. It may thus be viewed as a large rain gage for the region. Its levels respond to regional climate variations and therefore we will present the newly developed late Holocene DS level curve. Then, we determine the regional hydroclimatology that affected level variations. To achieve this goal we compare between modern natural lake levels variations and instrumental rainfall record and quantify the hydrology during level rise, fall, or stability. To quantify that relationship under natural conditions rainfall data preferrably the artificial DS level drop since 1960s are used. In this respect, Jerusalem station (JRM) offers the longest, pre-1960s uninterrupted rainfall record. JRM rains serve as an adequate proxy for the DS headwaters rainfall because principal component analysis indicates that temporal variations of annual precipitation in all stations in Israel north of the current 200 mm yr⁻¹ isohyet are largely synchronous and in phase. This station also represents well northern Jordan and southern Lebanon, especially during extreme droughts and wet spells. The historic levels of the DS and rainfall data are utilized to calculate the mean annual and standard deviation of JRM rainfall during natural rise (648 mm), fall (445 mm), and stable (553 mm) levels of the DS. These values can characterize Holocene rains during DS level changes. We determine a) the modern and propose the past regional paleohydrology and Eastern Mediterranean (EM) climatology that affected the severity and length of droughts/wet spells associated with multi-year episodes of DS level changes; and b) that EM climate tracks were different in average number and latitude in wet and dry years in JRM. The mean composite SLP and 500 mb height anomalies point that causes for wet and dry episodes span the entire EM and are rooted in anomalous Northern Hemisphere circulation. The close association of DS level changes and culture shifts in the Levant will be shortly discussed.