

# Abstracts

Abstracts to be presented at the XVI INQUA Congress.

Reno, Nevada  
July 24–30, 2003

## INDEXING SYSTEM

Numbers (example: 2-4, 77-6) indicate session number and order of presentation within that session.

Further information concerning the presented papers on which these abstracts are based should be obtained by contacting the authors of the abstracts.

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### SESSION NO. 1, 10:00 AM

Thursday, July 24, 2003

#### Plenary Symposium

Reno Hilton Resort and Conference Center,  
Reno Ballroom

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1-1 10:00 AM Bradley, Raymond S.

#### PALEOCLIMATIC PERSPECTIVES ON THE ANTHROPOCENE

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*"If men could learn from history, what lessons it might teach us. But passion and party blind our eyes, and the light which experience gives is a lantern on the stern, which shines only on the waves behind us..."* Coleridge, 1831.

When INQUA was founded in 1928 there were ~2.2 billion people on earth; today there are 6.3 billion and world population is likely to reach 9 billion within the lifetime of today's graduate students. With this rise in humankind, our impact on the planet has risen to the global scale and we have entered uncharted waters in terms of how climate and the environments that sustain life on earth will respond to the changes being imposed on them. While there are no analogs for the future that we face, the earth has undergone dramatic changes in the past that may at least place our current parlous state in perspective and give us pause as we consider what actions we must take to plot a safe course ahead. Paleoclimatology provides our "lantern on the stern" and we need to consider how that light can help illuminate the way forward.

1-2 10:40 AM Boulton, Geoffrey

#### FROM GLACIAL GEOLOGY TO PALAEOGLACIOLOGY

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After the demonstration by Louis Agassiz in the 1840s of the reality of the glacial theory, scientists have systematically attempted to establish the extent of former ice sheets, and to create a narrative history of Quaternary glaciations and the environmental and climatic changes associated with them.

However, although intensive studies of the sediments produced by former ice sheets have created criteria by which past glacial events can be identified in the stratigraphic record, there has been very limited success in using the attributes of sediments to infer the properties of the glaciers that produced them. Meanwhile, the last 50 years has seen the development of a rigorous, quantitative science of glaciology that has made it possible to simulate and predict the climate driven behaviour of glaciers, and which, in the last decade, has been applied to glacial erosional and sediment transport processes.

It therefore timely to attempt to create a science of palaeoglaciology, where understanding of the physics of glaciers and their interactions with the surface over which they flow are combined with understanding of glacial sediments, quantitatively to reconstruct the nature of former ice sheets and their role in the Earth system.

Theories of glacial erosion and transport have been embedded in large scale, high resolution, computer simulation models of Quaternary ice sheets in such a way as to predict properties of the geological record such as the thickness, distribution and age of tills, the distribution of indicator erratics, the distribution of eskers and tunnel valleys, the evidence of relative sea level change, the glacial sedimentary and isotopic flux to the oceans etc. These are then compared with actual geological evidence in a way that severely constrains ice sheet simulations, and permits us to infer glaciological characteristics of the ice sheet such as its time dependent form and flow, the locations of ice streams, the rate of basal melting, ice velocities and shear stresses, and such large scale properties of the continents as the glacial component of the long term denudation rate and associated crustal movements.

Although these are early days, this programme for research must be part of the perspective of Quaternary Science if it is to continue to make a major contribution to understanding the Earth system.

1-3 11:20 AM Meltzer, David J.

#### WHO, WHEN, FROM WHERE, HOW AND HOW OFTEN? PLEISTOCENE PEOPLING OF THE AMERICAS

MELTZER, David J., Department of Anthropology, Southern Methodist Univ, Dallas, TX 75275-0336, dmeltzer@mail.smu.edu

In the decades since INQUA last convened in the United States, our knowledge of the peopling of North America has expanded dramatically. Yet, some of the questions unanswered then remain unanswered now, despite an increase in the number of sites, and a battery of new and sophisticated methodological tools and analytical techniques brought to bear on the problem.

Nonetheless, much has been learned, and though the peopling process is better understood, it is also proving to have been more complicated than once thought.

Most notably, we now have evidence that the initial colonization took place earlier than previously supposed. The evidence comes from the Monte Verde site in Chile, radiocarbon dated to ~12,500 B.P. By virtue of how old and where Monte Verde is relative to the presumed Beringian entryway, the site raises a flurry of questions about who the ancestors of this group were and where they came from; when they crossed Beringia; and the route (coastal or interior) by which they traveled south from Alaska. It further begs the question of how this group relates to the better known, North American-wide Clovis occupation, which appears at 11,500 radiocarbon years ago (and was for decades thought to represent the initial colonizing pulse).

Evidence of a pre-Clovis occupation in the Americas has thrown Clovis itself into new light, and has prompted a re-evaluation of traditionally accepted notions about that archaeological phenomenon. Much attention nowadays is focused on an exploration of its roots, whether in Siberia or within North America itself; on the means by which Clovis so suddenly appeared across North America at about 11,500 B.P. (a rapid spread, or merely diffusion of a new and highly distinctive technology - fluted points - across an extant population?); and on just what this wide-ranging and apparently fast-moving people & technology reflects in terms of human adaptation.

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### SESSION NO. 2, 1:30 PM

Thursday, July 24, 2003

#### Contemporary Geomorphic Processes in Quaternary Science (Posters)

Reno Hilton Resort and Conference Center, Pavilion

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2-1 BTH 1 Webb, Robert H.

#### LATE QUATERNARY DEBRIS-FLOW AGGRADATION OF THE COLORADO RIVER IN CATARACT CANYON, UTAH, USA

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Catacart Canyon is incised into Mesozoic and Paleozoic rocks of the Colorado Plateau in south-central Utah. Before regulation of the Colorado River, Catacart Canyon was 63 km long and had 52 rapids created by debris fans issuing from tributary canyons. Debris-flow deposits emanate from nearly all tributaries and steep chutes where the Halgaito Shale is exposed in the cliffs above the river; where this unit is not recognizable in the Paleozoic stratigraphy, debris flows are uncommon. Shales with similar clay minerals are related to high Holocene debris-flow frequency elsewhere on the Colorado Plateau. Between river kilometer 348 and 343 (km decrease downstream), the gradient of the Colorado River is 0.28 m/km, increasing to 2.94 m/km in Catacart Canyon between km 343 and 336. We hypothesize that frequent Holocene debris flows in Catacart Canyon created a natural dam that affects its gradient as far as 75 km upstream. Drill holes near the confluence of the Green and Colorado Rivers (km 348.5) measured more than 38 m of sand beneath the river, and tributary mouths upstream are backfilled with fine-grained sediments, creating bottomlands. The longitudinal profile of the Colorado River is hypothesized to be structurally controlled and strongly influenced by climate; during glacial and interglacial climates in the Rocky Mountains, bedrock downcutting occurs primarily owing to large floods, and during interglacials with monsoonal precipitation, aggradation from local debris flows prevailed. During the Pleistocene-Holocene transition in the Southwest, summer precipitation increased, runoff

## SESSION NO. 2

decreased, and Cataract Canyon had frequent debris flows. Response of the river and its tributary streams to climate changes are recorded in fluvial gravels, fan aprons, and debris-flow deposits. Seven levels of Quaternary terrace gravels (Qtg) are preserved in discontinuous deposits along the Colorado and Green Rivers about 81 km upstream of the confluence; these deposits are not present in Cataract Canyon. The lowest, youngest Qtg deposits on the Colorado River disappear under the present-day water surface between river kilometers 390 and 400. Early Holocene debris-flow activity in Cataract Canyon appears to have aggraded the bed of the Colorado River by as much as 40 m, decreasing its gradient upstream.

### 2-2 BTH 2 Rowland, Joel C.

#### MORPHOLOGY AND IMPORTANCE OF FLOODPLAIN TIE-CHANNELS

ROWLAND, Joel C.<sup>1</sup>, DIETRICH, William E.<sup>1</sup>, DAY, Geoff<sup>1</sup>, LEPPER, Kenneth<sup>2</sup>, and WILSON, Cathy<sup>2</sup>, (1) Earth & Planetary Science, Univ of California, Berkeley, 307 McCone Hall, Berkeley, CA 94720, rowland@eps.berkeley.edu, (2) Luminescence Geochronology Lab, Los Alamos National Lab, MS J495, Los Alamos, NM 87545

Largely overlooked and poorly documented, tie channels represent an important and common feature of lowland floodplain systems around the world. In these lowlands systems, tie channels are sinuous but non-meandering channels which connect the main stem river to floodplain lakes. These channels allow the bi-directional transfer of water, sediment, biota, carbon and contaminants between river and lakes. As a primary link between rivers and floodplains, tie channels influence floodplain sedimentation (both the quantity and pattern), hydrology, ecology, geomorphology and stratigraphic evolution of lowland river systems.

We have conducted field investigations of tie channels in Papua New Guinea (the Fly River), Louisiana (Raccourci Old River - 65 km upriver of Baton Rouge) and Alaska (Birch Creek). These field investigations include extensive surveys of both cross and along channel morphological trends, grain size characteristics, water levels and geochronological sampling for optically stimulated luminescence (OSL) dating. In all three systems, both the planform and cross-sectional morphology of the channels show remarkable similarities over scales which range by an order of magnitude. The similarities in channel form suggests a commonality of tie channel morphodynamics across a wide range of scales and hydrological settings. Our results also suggest that size of tie channels and possibly the rates of tie channel development systematically scale to the size of the river system along which they occur.

Morphologically, tie channels share many similarities with tidal, submarine and deltaic channels. Determining the hydrodynamics that control the observed tie channel morphologies should provide critical insights into the controls on alluvial channel formation and morphology for a range of settings.

### 2-3 BTH 3 Aarseth, Inge O.

#### HOLOCENE LACUSTRINE ROCK PLATFORM AND QUATERNARY CRYOPLANATION OF ROCK SURFACES IN AND AROUND BERGEN, NORWAY

AARSETH, Inge O. and FOSSEN, Haakon, Department of Earth Science, Univ of Bergen, Allég. 41, Bergen, N-5007, Norway, inge.aarseth@geo.uib.no

A shoreline cut in bedrock is recently discovered and mapped around the shores of Lake "Storavatnet" on the island of Osterøy, 25 km NE of Bergen, Norway. The lake consists of two connected parts, 5 and 7 km long and 3-900 m wide, with a natural lake level of 151.5 m a.s.l. The rock platform is sloping 5-10° towards the shore and the width varies from 0 to 20 m. The platform is developed in various kinds of bedrock, including well foliated Lower Paleozoic micaschist and amphibolite, as well as older granitic gneisses and quartzite. The weathered material is angular and some is still located in situ on the platform itself or on the lower slopes. Both shapes and sizes varies in relation to mineralogy and structure of the underlying bedrock with pebbles on the micaschist, tabular cobbles on the amphibolite and cubic cobbles to boulders on the gneissic rocks.

On several locations caves and notches are developed on the platform. Caves are preferentially located along fractures in the micaschist, particularly in fracture overlap zones. Unweathered glacial striation is found below the natural lake level while weathered glacial grooves sometimes can be found above the platform. The main part of the platform must have been formed by frost weathering along the lakeshore after termination of the oblique glacial rebound, some 6000 years ago. An older and 8-12 m higher rock platform, up to 1.5 km wide, is found between the two parts of the lake. Mapping by georadar show a relatively horizontal bedrock surface with some depressions filled with bogs or small lakes.

In the central part of the suburb Åsane, 10 km N of the City Centre of Bergen, an area of 1,5 x 3 km has a nearly horizontal bedrock surface only broken by four small lakes and some hilly bedrock remnants. Refraction seismic as well as georadar has been used in mapping the bedrock surface. The 4 km long river draining the area drops 2.5 m, and the bedrock surface along the river channel is almost horizontal and mainly older than the Holocene. The formation is thought to be similar to the cryoplanation of the rock surfaces on Osterøy island. Climatic investigations in the basin at Åsane show a temperature inversion situation in wintertime with intermittent cyclones giving precipitation and rise of the lake levels. Drifting of lake ice and main glacier is thought to be responsible for removing the weathered material.

### 2-4 BTH 4 Mills, Hugh H.

#### HOLOCENE TO EARLY PLEISTOCENE PIEDMONT DEPOSITS IN A HUMID TEMPERATE CLIMATE: SOUTHERN BLUE RIDGE MOUNTAINS, USA

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Coarse piedmont gravels on the western footslopes of Rich and Snake Mountains, Watauga County, North Carolina, are only a few meters in thickness and overlie thick saprolite. Relative-age dating based mainly on weathering-rind thickness of amphibolite clasts was used to map piedmont surfaces into six relative-age classes. The map pattern of surface ages is dramatically different from those reported previously for alluvial fans and pediments. Map polygons tend to be elongate downslope, approximately parallel to streams heading in the uplands, and to have fairly constant widths - there is little tendency for a fan shape. The cross-piedmont order of surface ages is essentially random. This pattern, together with observations on the present erosional activity of piedmont streams, suggest that the processes responsible for abandoning a fan surface and establishing another at a lower level operate chiefly in the cross-piedmont direction. Apparently, new fan surfaces are created by a process of stream entrenchment accompanied by lateral erosion and stream migration. The lack of paired terraces indicates that entrenchment takes place only at the margins of young piedmont deposits. The probable explanation for this is that streams migrate away from the margins of bouldery young surfaces toward areas that are more erodible (e.g., saprolitized bedrock or highly weathered older deposits). The piedmont deposits may be very long-lived. Burial dating based on the differential decay of cosmogenic <sup>10</sup>Be and <sup>26</sup>Al in quartz yielded an age of 1.4 Ma for one deposit with one of the greatest mean weathering-rind thicknesses (15.1 mm). This age is supported by the previous finding of reversed paleomagnetism in sediments from the same section, indicating a

minimum age of 780 ka. The relative-age of piedmont surfaces is reflected by the form of the transverse profile. Profiles of young surfaces show only slight transverse convexities, while older surfaces show pronounced convexities.

### 2-5 BTH 5 Thomas, Michael F

#### LANDSCAPE RESPONSE TO LATE QUATERNARY CLIMATE CHANGES IN NE QUEENSLAND, AUSTRALIA

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The humid tropics of NE Australia (c17degS) experienced major climate changes during the Last Glacial Cycle, as shown by pollen records at Lynch's Crater. At the Last Glacial Maximum rainfall may have been reduced by c60% and sclerophyll woodland replaced rain forest. Present-day rain-falls vary from 2000->5000mm according to altitude. A record of landscape activity is drawn from the E facing escarpment and rivers draining to the Coral Sea. Numerous, mainly fine-grained alluvial fans are developed along the escarpment, from minor catchments and on larger rivers, and these were dated (using TL and 14C AMS) to 25-14ka; they were subsequently entrenched. Extensive colluviation implies increased sediment yield from hillslopes, while the fans on larger rivers may signify loss of stream power. These are effects of reduced rainfall and plant cover, but sedimentation continued under increasing rainfall in the early postglacial climates.

Large landslides and debris flows occur on the escarpment slopes and boulder beds mark alluvial/debris flows in valleys and along the coast. OSL dating of sandy facies within the coarse deposits show good bleaching and provide preliminary dates for some of these events. Two large landslides date to 43+-4ka and 18+-3ka, with evidence of renewed Holocene activity. Intercalated sands and boulder beds indicate deposition c80 to c29ka from different sites, again with some Holocene sediments superimposed. Very coarse flow deposits record scattered high-energy events, and these have occurred throughout the LGC. Landscape response to changing Quaternary conditions probably reflected the operation of several major factors including: 1/ hillslope/catchment weathering and sensitivity to short-term climate fluctuations and individual events; 2/ spatio-temporal distribution of extreme events; 3/ short-term 10<sup>2</sup>y-10<sup>3</sup>y climate oscillations; 4/ longer-term 10<sup>4</sup>y-10<sup>5</sup>y shifts in rainfall and vegetation patterns. System responses to these factors also involve lags and delays that are poorly understood. Available data cannot resolve the complex timescales involved, but they indicate the importance of understanding these factors.

### 2-6 BTH 6 Bobrowsky, Peter

#### SPECTACULAR, LARGE-SCALE DEFORMATION STRUCTURES IN GLACIOLACUSTRINE SEDIMENTS, PEACE RIVER, ALBERTA, CANADA

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Recent road construction has uncovered a spectacular exposure of large-scale soft sediment deformation structures at Sagitawa Lookout, south of the town of Peace River, Alberta. The Peace River Valley, is known for its thick exposures of Quaternary sediments and its long history of landslides. The Quaternary valley fill comprises, from oldest to youngest, preglacial sand and gravel, Late Wisconsin glacial sediments, thick silt and clay of glacial Lake Peace and loess in local areas.

The Sagitawa Lookout section shows a wide variety of chaotic structures extending laterally over several hundred metres. This deformation zone occurs at the very top of the glaciolacustrine sequence and above many of the landslides in the Peace River Valley. Individual structures often extend over many metres in both the horizontal and the vertical dimensions. Several massive blocks of sediment within the deformation zone exhibit relict sedimentological forms such as, ripples, graded beds, crossbeds and other glaciolacustrine phenomenon such as dropstones. Such large soft-sediment deformation features have never before been documented in Glacial Lake Peace sediments. The impressive size and the chaotic nature of the sediments along with their stratigraphic setting provide a unique geological enigma.

### 2-7 BTH 7 Dramis, Francesco

#### DISCONTINUOUS PROCESSES IN ROCK GLACIER GENESIS AND EVOLUTION

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Rock glacier is a geomorphological term proposed by Capps (1910) to define a debris body characterised by a surficial blocky cover, displaying fluidal structures. Most Authors consider rock glaciers as the main indicator of permafrost occurrence in high mountain areas. Some of them interpret the rock glacier as a continuous mass transportation system, in which the overload in the upper area is continuously supplied by frost wedging induced scree production from the surrounding rock walls. Basing on this assumption, the measurements of creep velocity have been used to determine the age of the rock glaciers. With this paper we want to stress that rock glacier are generally made up of different kinds of deposits, related to different depositional events including also discontinuous phenomena, such as rapid mass movements (e.g. rock avalanches, debris avalanches or debris flows). At least in some cases, these processes may be definitely considered as the main source for the deposition of the upper blocky layer. This latter, once deposited, may also induce changes in the thermal conditions of the ground, favouring permafrost aggradation in the underlying debris mass.

### 2-8 BTH 8 Migon, Piotr

#### CRYOPLANATION - A UNIQUE QUATERNARY PHENOMENON?

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One of the tenets still present in the geomorphology of Quaternary period is that smooth preglacial slopes have become transformed into stepped slopes through a set of surface processes embraced by the term 'cryoplanation'. Although this transformation is poorly constrained quantitatively in respect to rates of rock-cut cliff retreat and terrace enlargement, high efficacy of cryoplanation has been often assumed.

However, field evidence accumulates to suggest that benched profiles evolve slowly, are much controlled by geological structure, and may have a substantial pre-Quaternary inherited compo-

ment. Observations reported here come from the present-day maritime periglacial environment of Svalbard and the Pleistocene periglacial zone of Central Europe. In southwest Svalbard, late Pleistocene and early Holocene raised marine cliffs have undergone insignificant retreat over 10<sup>4</sup> yr time scale, as negligible volumes of weathered material at cliff base and exposed marine pebbles below the cliffs indicate. In the Sudetes mountains, Central Europe, benched profiles are present in areas outside the limit of Pleistocene continental glaciations or above the trimlines within this limit. Given pre-Eemian age of the last glaciation in the area it is suggested, that one cold period of c. 100 kyr duration is not long enough to allow for creation, or re-creation of benched slopes. Furthermore, certain rock types appear not to support benched profiles, even if exposed to periglacial conditions throughout the Quaternary. Coarse granite in particular is hardly prone to postulated cryoplanation, whereas moderately steep slopes in foliated metamorphic rocks show stepped profiles relatively often. Many cliffs are developed along linear outcrops of resistant rocks and probably increase in height rather than retreat.

The paradigm of powerful cryoplanation and significant remodelling of periglacial upland surfaces in the Quaternary is increasingly questioned. Limiting the role of cryoplanation implies that periglacial uplands may act as environmental archives of the Quaternary in much higher degree than previously thought.

## 2-9 BTH 9 Kite, J. Steven

### ALGIFIC (COLD-AIR PRODUCING) TALUS AT ICE MOUNTAIN, WEST VIRGINIA, USA: STRUCTURE AND DYNAMICS OF A RARE CENTRAL APPALACHIAN ECOLOGICAL REFUGIUM

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Cold-air flowing from the base of the Ice Mountain talus at ~235 m above sea level supports 5 rare plant species not known below 900 m elevation elsewhere in the Central Appalachians. Cold-air flowing from the talus maintains a paleo-refugium that may have operated without significant interruption for 10,000 years. Other Central Appalachian algific talus localities were noted historically, but have been destroyed through ice mining or other human activities.

A multi-faceted geophysical and geological study of the talus reveals an unremarkable stratigraphy in which 1-2 m diameter sandstone blocks lie unconformably on impermeable Devonian shale bedrock. Terrain conductivity and Very Low Frequency electromagnetic surveys indicate ~8 m talus depth and possible perennial ice lenses at the talus-bedrock contact. Talus morphology is unusual in that a general concave profile has been undercut by North River, giving a steep convex profile for the lower 30 m of the slope. Most of the talus is bare of soil and vegetation, except crustose lichen. The steeper lower talus is mostly vegetated, with a discontinuous organic mat broken by 25-50 cold-air vents. The upper and middle talus has numerous openings that allow air in or out of the talus. The openings on the lower slope range from 0.01 to 1 sq m; hence the total cold-air vent cross-sectional area is a tiny fraction of the total area of openings on the concave slope above.

Air drains from algific vents whenever talus air temperature is less than outside air temperature at the toe of the slope. Cold air drainage is nearly continuous, with temperatures observed from -6.5 to +9.0 degrees C. A northwest aspect precludes direct sun on the talus, except for late afternoons in spring and summer. Snow and other precipitation infiltrating into the talus may further moderate temperatures during subsequent warm weather. The slope functions as a unidirectional cold air sink. Warm air may rise out of the upper and middle talus, but there is insufficient vent surface area to allow either complete drainage of cold air from the talus or entry of warm air rising from the valley.

This study suggests that loss of lower-talus vegetation or widening of existing vents would imperil the algific talus ecosystem and that historical algific slopes can be restored through revegetation and vent constriction.

## 2-10 BTH 10 Kovanen, Dori J.

### GLACIAL IMPRINTS OF THE OKANOGAN LOBE, SOUTHERN MARGIN OF THE CORDILLERAN ICE SHEET: A GIS-AIDED RECONSTRUCTION

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Glaciation is a fundamental control on the morphology and processes acting on, mid- to high-latitude continental margins. In northeastern Washington State (USA), the Okanogan lobe of the Cordilleran Ice Sheet flowed southward through the Okanogan trough from the Interior Plateau of British Columbia and invaded the Waterville Plateau during the late Wisconsin (Fraser Glaciation). This had a profound influence on the landscape and meltwater routing and flooding events in adjacent areas (e.g., Channeled Scablands). To help improve our understanding of the spatial distribution, morphology, processes, and dynamics of the Okanogan lobe, we have extracted glacial bedform (i.e., drumlin, macro-flutes, till lineations, and eskers) information from digital elevation models (DEMs) and aerial photographs, delineated the ice-flow pattern, and reconstructed the ice-surface profile. Our study reveals the spatial distribution and morphology of glacial features and their landscape. The arrangement of sediment-rich (soft bed) areas and exposed bedrock (hard bed) may reflect a link to the local topography and probably the ice-sheet delivery of sediments. A higher proportion of drift is found along the western and central portion of the Waterville Plateau, while progressively more bedrock is exposed to the east and generally at lower elevations. The late-glacial history in this area is more complex than previously thought; some glacial landforms overlap older forms indicating more than one ice-flow event and possibly a switch in flow/thermal regimes. Reconstructions of the ice-surface morphology and estimated driving stresses (17–26 kPa) implied from ice thickness and surface slope in the terminal area suggest fast basal flow characteristics during the last ice-flow event.

## 2-11 BTH 11 Molnia, Bruce F.

### DISARTICULATION AND RECENT RAPID RETREATS OF THE BERING GLACIER, ALASKA

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The surging Bering Glacier is the largest glacier in continental North America. During its two most recent, two-part surge events (the 1957-1960 & 1965-1967 surge and the 1993-1994 & 1995 surge), rapid ice displacement resulted in part of Bering's piedmont lobe advancing > 10 km. Following each surge event, terminus retreat was also rapid. Between 1967 and 1993, Bering's terminus retreated as much as 10.7 km. The average rate of retreat at four locations was 0.43 km/yr. Annualized rates ranged from 0.04 km/yr to 2.8 km/yr. Extreme rapid retreat events were observed in 1977 and 1984, in which parts of Bering's terminus retreated ~ 1.0 km in just a few hours.

Since 1996, rapid retreat is again underway. Between 1996 and 2002, part of the terminus retreated ~ 6 km (~ 1 km/yr). By 2001, continuing retreat resulted in much of the terminus returning to near its 1993 pre-surge position. In 2000, 2001, and again in 2002, parts of the terminus were observed retreating as much as 700 m in less than 24 hours, as successions of large ice-

bergs disarticulated from the margin and drifted into ice-marginal Vitus Lake. In June 2002, a 1.2-km-long iceberg, the largest yet seen, separated from the terminus.

Bering Glacier's rapid retreats are not the exclusive result of melting and calving. The greatest loss of ice results from disarticulation, a previously unreported process that not only affects Bering Glacier, but also many other large, rapidly-thinning glaciers that terminate in deepwater lakes and fiords. As the glaciers thin, buoyancy lifts their termini from their beds. Once a terminus loses contact with the bottom, disarticulation begins along pre-existing planes of weakness, such as surge-fracture scars or old crevasses. Large irregularly-shaped, tabular icebergs result, many greater than a kilometer in maximum dimension. As with ice shelves, the presence of meltwater may facilitate disarticulation.

Calving events are gravity-driven, occur at the ice edge, and are high energy, often producing high-intensity noise and a wave. Disarticulation events are buoyancy-driven, may simultaneously occur in a zone that extends as much as 1.5 km inward from the terminus, and are generally quiet and wave-free.

Aerial photographs of Bering Glacier made in 1936 and 1948 capture on-going disarticulation events. These photographs document rapid retreat following surges that occurred about 1920 and from 1938-1940.

## 2-12 BTH 12 Barnard, Patrick L.

### THE ROLE OF PARAGLACIAL PROCESSES IN THE EVOLUTION OF HIGH MOUNTAIN LANDSCAPES, THE HIGH HIMALAYA OF INDIA AND NEPAL

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Within high mountain environments, erosional and depositional landforms provide evidence for the nature of landscape evolution, and the rates and magnitudes of denudation, sediment transfer and deposition. Using sedimentological and geomorphic techniques, field mapping and cosmogenic radionuclide (CRN) dating, we studied moraines, fans, outwash terraces and strath terraces in the Khumbu (Everest) Himal, Garhwal Himalaya of India, and Langtang Himal of Nepal to examine this evidence and to quantify timing and rates of landscape evolution. Many of the valleys are dominated by major fans that onlap moraines and comprise massive bouldery diamicts, commonly 10-25 m thick, and rarely comprising more than 1 or 2 units. These fans are the result of debris and hyperconcentrated flows, mainly produced by glacial lake outburst floods. CRN dating shows that fan/terrace and moraine ages cluster around 1-2 ka, 4-5 ka, 7-8 ka, 12-14 ka, and 16-17 ka. Each of these clusters can be tied to significant regional or global climatic events, and indicate a strong temporal and hence climatic link between glaciation and fan formation. This catastrophic style of sedimentation that characterizes the fans is consistent across the range of Himalayan areas studied. This suggests that sediment transfer within these environments occurs as paraglacial resedimentation events, while low-energy fluvial reworking dominates during the intervening times. Dating of strath terraces yielded an average denudation rate of ~4-5 mm/yr, which is remarkably consistent across the study areas, and provides background denudation rates. This contrasts with fan incision rates of ~17-24 mm/yr. Therefore, while climate-driven glacial fluctuations may determine the short-term geomorphic response of the landscape, long-term denudation rates are driven primarily by tectonics.

## 2-13 BTH 13 Roberts, Michelle A.

### ICE, ERUPTIONS, AND AVALANCHES: DISTINGUISHING LAHAR ORIGINS WITH EXAMPLES FROM MOUNT SHASTA, CA

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Mount Shasta in northern California provides an ideal setting for studying lahars of three primary origins: climatic fluctuations, eruptions, and debris avalanche transformations. Though multiple factors could be involved, there are characteristics in lahar deposits that are indicative of the triggering event. Climatically-induced lahars occur almost exclusively in drainages headed by glaciers, resulting from the rapid retreat of ice, or the failure of a moraine-dammed lake. As non-cohesive lahars, they become diluted as they progress downstream. Holocene lahars along Mount Shasta's largest drainage, Mud Creek, have formed levees containing 1 – 2 meter boulders; downstream the deposits form alluvial fans with smaller clasts. Headed by the Konwakiton glacier, Mud Creek has produced lahars into historic times. West of Mud Creek, unglaciated drainages have not produced lahars since the end of the last glaciation. One of these drainages contains a latest Pleistocene lahar that likely occurred as the ice receded, possibly resulting in the breach of a moraine-dammed lake.

Lahars with eruptive origins have large concentrations of pumice clasts several centimeters in size. A lahar on the Mud Creek fan contains pumice clasts up to 10 cm belonging to the Red Banks eruption 9700 <sup>14</sup>C years ago. Another characteristic of eruptive lahars is intensive oxidation from high heat, resulting in a red or pink color. The extent of eruption-induced lahars is dependent on the amount of ice and snow in contact with pyroclastic deposits, and they are often non-cohesive in behavior.

Debris avalanches transform into lahars through disintegration of avalanche blocks. High clay content in the avalanche matrix creates a cohesive lahar able to travel long distances. Deposits from an enormous debris avalanche which occurred ~ 350 ka on the north side of Mount Shasta have been recognized for years (Crandell, 1989), but there is evidence that this avalanche triggered lahars on the south flank of the mountain. A south-flank lahar similar in age to the avalanche contains large amounts of pumice, evidence that an eruption occurred prior to or coincident with the avalanche. Whether this avalanche occurred during a glacial period is unknown, though the large amount of water required to mobilize it would be readily available during extensive glaciation.

## 2-14 BTH 14 Laemmermann-Barthel, Joerg

### SEDIMENT BUDGET OF PIOCENE AND QUATERNARY UNCONSOLIDATED DEPOSITS OF THE RHINE GLACIER AREA, SWISS MIDLANDS AND THE UPPER RHINE GRABEN

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The Pliocene and Quaternary unconsolidated rocks of the Alpenrhein valley / Bodensee amphitheatre, Hochrhein, Swabian terrace landscape, Swiss Midlands and the Upper Rhine Graben together with its Alpine drainage areas represent an almost closed denudation-accumulation system. Based on a newly developed combined stratigraphy valid in all five landsystems and an extensive data base (e.g. drillings, outcrop studies, mapping, seismics, pollen analysis) the sediment volumes of a

minimum of four glacial megacycles will be quantified in a project within the ICDP framework by using an electronic data base and GIS techniques. New insights are expected into the morphodynamic response of the Alps to climate change and the interplay with their uplift, the mechanisms of the growth and decay of Alpine foreland glaciers and the morphogenesis of the Alpine foreland inclusive changes in the drainage pattern. The sediment volumes will be compared with heavy mineral distributions and dating results to identify sediment sources in the Alps and shifts of the glacial and fluvial drainage systems over time. This linkage will also allow for a control of the number and magnitude of glacier advances into the Alpine foreland and the Quaternary denudation history of the Alps. A great number of scientific and commercial drillings have been analysed and put together in a sequence stratigraphic framework. The regional interconnection of these point data is based on the identification of discontinuity surfaces which define the sediment volumes of the various glacial megacycles. Until now, we quantified three megacycles (MEG, Riss, Würm) in Upper Swabia and the Upper Rhine Graben with the stratigraphic base level concept. To control the results of our litho- and eventstratigraphic approach, we will use palynological and heavy mineral investigations. Further, we started to collect samples for OSL and TIMS U/Th dating.

## 2-16 BTH 16 Bartolini, Carlo

LOCAL RELIEF, EXHUMATION RATES AND ROCK UPLIFT RATES IN THE NORTHERN APENNINE

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The present, subdued relief of Northern Apennine divide depends on: i) the Basin and Range type structure of the inner sector of the Apenninic Chain ii) the prevailing flysch lithology iii) the current – mild - morphoclimatic regime

These factors hamper a high relief to set out, despite the high rock uplift rates that affect the Chain, as exhumation rates obtained from low temperature thermochronological methods have recently pointed out.

As geomorphic and thermochronologic evidences point out, the higher rock and surface uplift rates occur at present over the drainage divide of the Northern Apennine. According to Zattin et al. (2000), the pre-exhumation configuration features a 4 to 5 km thick cover (depending whether a geothermal gradient of 20°C/km or 25°C/km is assumed) of overlying Ligurian and Epiligurian Units, which was completely eroded in the last 5 My. at a mean rate, then, of 0.8 to 1 mm/yr.

Since geological data suggest that little or no topography was present in the area between 5.0 and 2.0 Ma BP, rock uplift rates should have been quite similar, during that period, to the computed exhumation rates of approximately 0.8 mm/yr. Surface uplift was therefore negligible. A residual veneer of Ligurids, presently buried under the fluvial deposits both in Mugello and in the nearby Casentino basin indicate that the 5 km thick Ligurids cover had not been completely wiped out when the basin became the site of flood plain sedimentation, that is around 2.0 Ma. The high exhumation rates occurring between 5.0 and 2.0 Ma despite the prevailing low relief was made possible by the high erodibility of most lithotypes which make up the Liguride Complex.

Despite the current much lower rock uplift rates, the present average altitude of the Apuan peaks (1500 to 1900 m) is very close to that of the Apennine divide. As a matter of fact, the higher rock uplift is here largely compensated by the higher erodibility of the turbiditic sandstones which make up the Chain backbone.

Because of the prevailing low erodibility, the local relief of the Apuan Alps is to such an extent greater than that of the typical Apennine chain, to deserve their odd name whereby a crumble of "Alps" lies well within the Apennines.

## 2-17 BTH 17 Manville, Vern

FIRE AND WATER: LATE QUATERNARY MEGAFLOODS IN THE TAUPO VOLCANIC ZONE, NEW ZEALAND

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The Taupo Volcanic Zone in the central North Island of New Zealand is an area of intense Quaternary silicic volcanism, characterized by frequent caldera-forming explosive eruptions from multiple short-lived, nested, and/or overlapping volcanic centers. Both of the largest caldera lakes, Taupo and Rotorua, are fringed by extensive terrace and shoreline deposits laid down in the aftermath of explosive rhyolitic eruptions that provide evidence for prolonged highstand periods followed by sudden falls in lake level, that, in some cases, are linked to catastrophic outbreak floods. The Rotorua caldera, formed at 220 ka during eruption of the Mamaku Ignimbrite, contains both post-Mamaku lake sediments and extensive highstand terraces developed after eruption of the Rototiti Breccia from the adjacent Okataina caldera at 64 ka again blocked the outlet. Further south, Lake Taupo, the largest lake in New Zealand, partially occupies a composite caldera and volcano-tectonic collapse structure formed during the 26.5 ka Oruanui eruption and last modified during the 1800a Taupo eruption. Post-eruption, Lake Taupo refilled to ~500 metres above sea level (mASL), an increase of c. 140 m over its modern level, and impounded an additional 80 cubic kilometers of water. The highstand lake initially overtopped the lowest area on the caldera rim to establish a semi-stable outlet controlled by a sill of older welded ignimbrite. Headward erosion through thick but unwelded Oruanui pyroclastic further east established a new, lower outlet at ~405 mASL prior to 21 ka, releasing c. 60 cubic km of water in a flood that transported enormous boulders and which may have permanently changed the course of the largest river in the North Island. Most recently, the 1800a Taupo eruption also blocked the outlet to the lake, resulting in a 34 m rise in lake level. Catastrophic failure of the ignimbrite dam following overtopping generated a flood whose discharge peaked at 17 000 – 30 000 cumecs, releasing 5 years of normal outflow in 3 weeks. The geomorphic expression of this flood is found in boulder deposits, erosion surfaces, and overbank aggradation deposits and buried forests that can be traced for over 200 km downstream. Caldera-lake outbreak floods are a recurrent feature of volcanism in New Zealand and constitute a significant new and far-reaching hazard.

## 2-18 BTH 18 Yang, Dayuan

FUNCTION CHANGES OF THE CHANGJIANG RIVER IN THE QUATERNARY

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Our study indicates that the functions of the Changjiang River have changed greatly during the Quaternary. The Jinsha River, located in the upper reaches of the Changjiang River, has cut across several rivers which southward flowed into fault basins, and eastward flowed into Sichuan Basin, formed the Ya'an Gravel Stratum in Sichuan Province in about 1000 ka BP. Then it has cut and formed the Three Gorges. Below Yichang it formed extensive gravel fan deposits. In the channel of the middle-lower reaches it usually developed sandy gravel deposit. Therefore, the functions of the Changjiang River in the Medio Pleistocene mainly were deeply cutting and transporting coarse gravels. In the Pleniglacial of the Epipleistocene, it developed coarse gravels and formed calcitic cementations in the upper reaches and deeply cut to develop many deep troughs in riverbed in the middle-lower reaches, which were at an elevation from -20m—60m. At the same time, the great amounts of sediment were transported to the continental shelf plain. In the Holocene, flood level

had risen continuously, and developed fluvial deposits and floodplain extensively. In the zone along the middle-lower reaches, the thickness of the Holocene deposition reached 30-40m, which has gone far beyond the normal thickness of the alluvial flat. Since 2000 a BP, discharging flood and sediment into the sea was the main function of the River. It relieved flood overflowing and silt depositing on the flood plains along the river. But near the river mouth, the sediment depositing increased rapidly and it speeded up the river delta development. Causations for the function changes of the River are inferred in the paper as below: Along with the uplift of the Tibet Plateau, the Western Sichuan Plateau and the Yunnan Plateau had upheaved in succession, and resulted in the Jinsha River flowing eastward. Alternations of glacial and interglacial ages had resulted in the intensity changes of the deep cutting of the Changjiang River, and developed gravel fans in different periods. Sea level rise had resulted in frequent floods in the middle-lower reaches, and the wide floodplains were formed along the banks of the middle-lower reaches. After constructing dykes along the middle-lower reaches, it increased the flood and sediment discharge into the sea, which speeded up the river delta development during the last 2000 years.

## 2-19 BTH 19 Mäusbacher, Roland

INVESTIGATIONS IN SUBROSION DEPRESSIONS IN THE MIDDLE VALLEY OF THE RIVER WERRA (GERMANY)

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In subrosion depressions of the middle Werra valley, high-resolution sedimentological and palynological investigations were executed. In all depressions of this area an almost even sedimentation sequence, which is dividable in different temporal phases of deposition, is visible. Depending on the sedimentation conditions the layers are fluvial or limnic modified. According to the palynological results the area was already settled since neolithic times. An increase of human influences can be recognized for Bronze Age and Iron Age, but is not shown in the sedimentological results. Intensive land use of the area since the 6th century is recorded in the sedimentological and palynological sequence. The formation of massive alluvial clay layers reflect a drastic increase in erosion resulting from the deforestation of the whole region and in particular the floodplain forest. The development of these layers represent a fixed temporal marker in the middle Werra valley especially in the subrosion depressions. Based on the results a spatial process of hollow development in northeast direction can be derived in this area.

## 2-20 BTH 20 Michetti, Alessandro M.

POST-GLACIAL ENVIRONMENTAL EVOLUTION AND GROUND SUBSIDENCE IN THE COMO URBAN AREA (NORTHERN ITALY)

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We conducted investigations on the latest Pleistocene to Holocene geomorphology and stratigraphy of Lake Como region (Lombardia, Italy), based on field survey, interpretation of airphoto coverages, literature stratigraphic, archaeological and topographic data, and the compilation of available subsurface data for the urban area of Como. In this town, located at the S edge of the W branch of the lacustrine basin, remarkable phenomena of ground subsidence have been recorded in the past decades.

Using the reconstruction of the (late) post-glacial landscape evolution of the Como area, we expect to quantify the role played by natural processes and human activity in controlling the lowering of the ground surface. This study is part of the "Lario Project", a multidisciplinary limnogeological research aimed at assessing the vulnerability of the physical environment for land use planning and natural risk mitigation. Lake Como ("Lario") lies at 198 m a.s.l. in a 60 km long, downstream-bifurcated glacial trough sited across the Central Alps, which was intensely modelled by an ice tongue up to ca. 2 km thick during the Last Glacial Maximum.

The urban area of Como, built on a Holocene marshy basin on the lakeshore, in 1955 to 1975 experienced a crisis of subsidence; maximum values of 20 - 40 cm up to ca. 1 m of ground lowering have been measured in the districts close to the lakeshore. In the last ca. 30 years subsidence rates in the same districts decelerated to mean values of 3 to 4 mm/yr, following the ban of extraction of deep ground water, indiscriminately exploited immediately after the II world war. We wanted to know if these values represent the long-term "natural" trend, and therefore have to be expected for the near future. The preliminary results of our study show that ca. 4 mm/yr is the subsidence value over the last ca. 12,000 years in the central part of the town. The anthropic component seems therefore to have been relevant only during the named 1955 - 75 critical phase of ground subsidence.

A sequence of shallow boreholes will be drilled in April 2003 in order to check the proposed model of recent landscape evolution in the Como urban area, and the resulting assessment of Holocene ground subsidence rates. Details of these stratigraphic investigations will be presented during the INQUA Congress.

## 2-21 BTH 21 Soldati, Mauro

GEOMORPHOLOGICAL EVOLUTION OF SLOPES AND CLIMATE CHANGES: LANDSLIDE ANALYSIS AND PALEOCLIMATIC RECONSTRUCTIONS IN NORTHERN ITALY – AN OUTLINE OF A NATIONAL RESEARCH PROJECT

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The scientific research on global changes is nowadays largely focused on the aspects of past environments which enable our understanding and capability of forecasting and challenging future scenarios. In this framework, the contribution of Geomorphology to paleoclimatic and paleoenvironmental reconstructions is certainly significant: the morphogenetic processes which occur on the earth's surface are definitely influenced by climate and, therefore, landforms and superficial deposits may be adopted for assessing the evolution of a landscape in a particular climatic framework. A national research project has been recently founded by the Italian Ministry of Instruction, University and Research (COFIN 2002, Scientific Coordinator: M. Soldati) dealing with the study of the relationships between climate and slope evolution, with particular attention to landslides. More precisely, the aim is to assess the correspondence between concentrations of landslides and climatic events from the Lateglacial to date, with reference to the Southern Alps and Northern Apennines, by adopting slope instability processes as geomorphological indicators of climatic

changes. The research, which involves the Universities of Milan, Modena and Reggio Emilia, Padua, Parma and Turin and some public institutions, is aimed to: - define the state of the art at an international level; - create an archive of dated landslides since the Lateglacial in the southern Alps and in the northern Apennines, using GIS; - analyse landslide phenomena which are believed to be significant indicators of climatic variations; - date landslide events with radiometric, incremental methods etc.; - reconstruct paleoclimatic conditions at the local scale in study areas, by means also of pollen analyses; - evaluate the importance of climatic control vs. type of landslides and the influence of climatic crisis on the occurrence of landslides; - assess the influence of non-climatic causes, such as paleoseismicity and human impact in prehistoric times; - define evolution models with respect to different hydrogeologic and environmental boundary conditions. This is a promising approach with high potentiality since the analysis of landslide activity is fundamental for understanding present and future evolution of slopes and to assess geomorphological hazards.

## 2-22 BTH 22 Hermanns, Reginald L.

### LARGE MASSIVE ROCK SLOPE FAILURES IN THE ARGENTINE AND CHILEAN ANDES BETWEEN 36 AND 38° S

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In the deeply incised valleys of the Austral Central Andes 49 large massive rock slope failures with volumes of a few million to several billion cubic meters were identified. About 85% of them are of the rock avalanche type, the others are related to rock-block slide or rotational slides. All slope failures occurred in Pliocene to Holocene stratified volcanic rocks of basaltic to andesitic composition, although other lithologies are also present in this part of the Andes. The break-aways formed predominantly in sequences of nearly horizontal attitude. However, frequent vertical joints are anisotropies which reduce rock strength. When linked to folded or faulted sequences, landslides are commonly associated with the horizontal panels of the structures. At those places where landslides occurred in inclined strata the dip is always towards the valley. Only two rock avalanches occurred in Pliocene to Quaternary volcanic edifices. In general, slope failures originated along the slope crests high above the valley bottoms. At least 90% of the landslide deposits dammed the valleys, in three cases reorganizing the drainage system. At present, 23 landslide dammed lakes exist. In most cases, landslide deposits obstructed valleys perpendicular to the strike of the valley. However, there are frequent examples of small lagoons within the hummocky morphology of the deposits or between the proximal rim of the deposit and the break-away zone. Rock avalanche deposits in narrow valleys occur as hummocky deposits projected far away from the break-away zone. In those cases where rock avalanche movement was not restricted by relief, deposits have a flat pancake-like morphology without any pronounced rims. As far as studied in detail slope failures are related to Neogene to Quaternary fault systems with dextral transpressive to transtensive dynamics. These faults constitute the northernmost known prolongation of the Liquiñe-Ofqui fault system and comprise various pull-apart basins. Several of the landslides directly form part of the filling of the transtensional depocenters. Due to the flat-lying nature of the collapsed rocks of the valley walls, the position of the break-away high above the bottom of the valley, and the regional relation to the active faults it is interpreted that most landslides formed during strong paleoearthquakes.

## 2-23 BTH 23 Leonard, E.M.

### FLOW OF THE SPRUCE CREEK ROCK GLACIER, TEN MILE RANGE, COLORADO, U.S.A., OVER ANNUAL TO MILLENNIAL TIMESCALES: PALEOCLIMATIC IMPLICATIONS

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Flow rates of the Spruce Creek Rock Glacier in the Ten Mile Range of central Colorado are examined over three time scales. In 1985, three cross-glacier transects were surveyed and marked. Five resurveys conducted between 1987 and 2000 provide a record of short-term flow rates and their spatial and temporal variations. Intermediate-term flow rates are assessed photogrammetrically, using aerial photography dating back to 1938. Long-term flow variations are evaluated through measurement of lichens (*Rhizocarpon s.l.*) on the rock glacier surface, which provide a record of flow spanning the last 2000-3000 years. Lichen data are calibrated using Benedict's (1993) growth curve for the Colorado Front Range.

Survey data indicate that 1985-2000 mean centerline velocities ranged from 5.9 to 10.2 cm/yr on the three transects. Centerline velocities measured over shorter (2-5 year) intervals ranged from 2.8 cm/yr to 13.3 cm/yr. There was no clear trend in velocity through time during the 15-year survey interval. Photogrammetric measurements indicate that centerline flow velocities over the interval between 1938 and 1990 ranged from 18 cm/yr to 23 cm/yr, two-to-three times the rates surveyed between 1985 and 2000. Lichenometric data indicate mean flow rates of about 35 cm/yr over the past 500-600 years and 4-5 cm/yr during the preceding ca. 1800 years. Lichen data indicate that approximately 2/3 of the rock glacier formed in the last ca. 2500 years and suggest that the entire glacier is Neoglacial in age.

These observations strongly suggest a climatic control on both formation and flow rate variations of the rock glacier. The glacier as a whole appears to be a product of late Holocene (Neoglacial) cooling. Flow rates were relatively low through much of the Neoglacial interval, increased during the Little Ice Age interval of the last several hundred years, and then decreased progressively with post-Little Ice Age warming of the last several decades.

## SESSION NO. 3, 1:30 PM

Thursday, July 24, 2003

### Fluvial Archives of Environmental Change (Posters)

### Reno Hilton Resort and Conference Center, Pavilion

## 3-1 BTH 24 Bridgland, David R.

GLOBAL CORRELATION OF LATE CENOZOIC FLUVIAL DEPOSITS: AN UPDATE ON IGCP 449 BRIDGLAND, David R., Department of Geography, Univ of Durham, South Road, Durham DH1 3LE United Kingdom, d.r.bridgland@durham.ac.uk

IGCP 449 has been engaging the fluvial community, especially those interested in long fluvial sequences, since 2000. It started in NW and Central Europe and by the end of 2003 will have

been represented at meetings on every major continent. Results to date can be summarized under the following headings:

#### Key sequences

These are the river systems with lengthy fluvial archives benefiting from multiple lines of dating evidence. Targeted for eventual inclusion within the project database, they include:

NW Europe: Thames, Seine, Somme, Maas, Rhine, Central Europe: Wipperf, Vltava, Svatka, Danube E Europe: Dniester, Dnieper, Volga, Don Middle East: Orontes, Euphrates Africa: Nile, Vaal/Orange India: Ganges, Narmada, Pravara Australia: Murray/Darling, Shoalhaven China: Yellow River North America: Susquehanna, Mississippi, St Lawrence South America: Parana

Patterns of fluvial sedimentation and valley evolution over Neogene and Quaternary timescales The data thus far assembled has revealed clear differences between fluvial records in different areas, apparently related to different types of continental crust with different uplift/subsidence histories. These fall into three groups:

1. Uplifting pattern, with extensive terrace staircases, climatically forced. Early and pre-Quaternary terraces are >100m above existing valley floor. Requires young (post-Archaean) crust. Cause of uplift is the subject of debate. Examples: Thames, Somme, Wipperf, Vltava, Dniester, Shoalhaven, Yellow River.

2. Subsiding pattern, with stacked fluvial sediments. Requires young crust, subsiding because within or peripheral to sedimentary accumulation basin (sediment loading). Examples: Lower Rhine, Ganges, Kőrös Basin, offshore Mediterranean coastal rivers such as the Gediz, Büyük Menderes, Axios & Seyhan.

3. Stable pattern, with terrace preservation a factor of diversion events and/or decrease in discharge rather than significant incision. Early and pre-Quaternary deposits occur within a few metres of modern river level. Restricted to ancient cratonic crust, apparently experiencing minimal Late Cenozoic uplift or downwarping. Examples: Narmada, Pravara, Vaal, Lower Volga.

Glacio- and hydro-isostatic effects can be overprinted on these patterns, providing a further link to Quaternary climatic fluctuation.

## 3-2 BTH 25 Rose, James

### FLUVIAL SYSTEM RESPONSE TO LATE CENOZOIC CLIMATE CHANGE - THE BRITISH PERSPECTIVE

ROSE, James<sup>1</sup>, HAMBLIN, Richard J.O.<sup>2</sup>, MOORLOCK, Brian S.P.<sup>2</sup>, and RIDING, James B.<sup>2</sup>, (1) Geography, Univ of London, Royal Holloway, Egham, TW20 0EX, United Kingdom, j.rose@rhul.ac.uk, (2) British Geol Survey, Keyworth, NG12 5GG, United Kingdom Investigations of the geometry, sediment composition and timing of river systems over the British land area reveals a number of characteristic patterns, that reflect climate forcing over the late Cenozoic. Precession-forced changes are reflected by large, low energy catchments draining low relief landscapes with thick soil cover and thick biomass, delivering only fine-grained suspended load from the catchment interior to the coastal region. Any coarse-grained material moved at this time is a function of local availability rather than regional energetics and the products of this activity were deposited at long timescales which recorded the effects of neotectonics. Obliquity-forced changes, enhanced by erosion-initiated uplift, operated in large, well organised catchments in which climate cycles changed from permafrost (possibly with glaciation in the mountains) to temperate, and transported coarse grained materials across relatively large areas to the adjacent seas at relatively rapid sedimentation rates. With the onset of eccentricity-forced climate cycles and the development of lowland glaciation the major river catchments were disrupted or even obliterated, sediment was stored in newly created sumps in much altered, or newly created river valleys, and major fluvial features such as the North Sea Delta were switched off. Within this forcing pattern, local factors have had a distinctive role on river activity in a way that did not apply during earlier parts of the Cenozoic, and rivers reworked their sediment load in a spatially discontinuous, and temporally erratic pattern. These factors include: i) extensive lowland glaciation which locally redistributed sediment and stimulated subsequent paraglacially-driven activity with enhanced erosion and sediment transfer; ii) glacio-isostatic rebound which locally enhanced river energy and river activity; iii) extreme changes in shoreline position which caused equally extreme changes in channel and valley configuration causing local, rather than regional sediment storage and iv) very rapid and short lived changes of climate such as at the end of the Last Glaciation, which have caused highly unstable, and geographically discontinuous landforms and sediment bodies, a pattern that is being replicated at the present day by Human activity.

## 3-3 BTH 26 Lewis, Simon G.

EARLY MIDDLE PLEISTOCENE FLUVIAL SEDIMENTS AT NORTON SUBCOURSE, NORFOLK; IMPLICATIONS FOR DRAINAGE BASIN EVOLUTION IN EASTERN ENGLAND LEWIS, Simon G., Geography, Queen Mary, Univ of London, Mile End Road, London, E1 4NS, United Kingdom, s.lewis@qmul.ac.uk, PARFITT, Simon, Palaeontology, Nat History Museum, Cromwell Road, London, SW7 5BD, United Kingdom, PREECE, Richard, Zoology, Univ of Cambridge, Downing Street, Cambridge, CB2 3EJ, United Kingdom, and SINCLAIR, John, Environmental Science, Univ College Northampton, Moulton Park, Northampton, NN2 7AL, United Kingdom

The early Middle Pleistocene drainage pattern of eastern England comprised a number of major eastwards-flowing rivers, including the ancestral River Thames and the Bytham River. The former was diverted and the latter destroyed by glaciation during OIS 12. These rivers supplied distinctive suites of gravels into the southern North Sea basin, forming shallow marine deposits, with equivalent on-shore deposits forming a series of fluvial terraces, which can be mapped on lithological and altitudinal grounds. At Norton Subcourse in Norfolk temperate climate deposits are exposed. These overlie marine gravels and are, in turn overlain by fluvial deposits of the Bytham River and glacial outwash deposits associated with Middle Pleistocene glaciation. The sediments at Norton Subcourse have yielded a range of biological data including large and small mammal remains, insects, molluscs and ostracods and also a well preserved pollen signal, from fine-grained sediments laid down in a large river channel. The ostracod assemblage indicates freshwater conditions. The biological data indicate that the deposits span the first half of a warm climate cycle, with summer temperatures at least as warm as those in the region today. The vegetation signal includes mixed deciduous taxa, typical of the early temperate sub-stage of an interglacial. The mammalian fauna includes hippopotamus, an extinct equid, hyaena and several rodent species, including the extinct water vole *Mimomys*, which is of biostratigraphical significance. On biostratigraphical grounds the interglacial probably correlates with the early part of the 'Cromerian Complex' (or possibly older), though attribution to a specific oxygen isotope stage is not yet possible. The sequence provides some temporal constraint on drainage basin evolution and changes in sea level in the region and also enables refinement of the early Middle Pleistocene stratigraphy of the region.

**3-4 BTH 27** Marks, Leszek**CORRELATION OF HOLSTEINIAN FLUVIAL SERIES IN POLAND AND BELARUS**

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Buried fluvial series of the Holsteinian interglacial in Poland and Belarus have been correlated using palaeogeographical analysis based on records from numerous boreholes and biostratigraphically studied key sections. Stratigraphic position and palaeogeography were determined by correlation with Holsteinian marine sediments in the Kaliningrad District of Russia and the Late Elsterian glaciolacustrine series in the southern peribaltic region.

Studies of over a hundred interglacial sites from Belarus have revealed regional differences in distribution and composition of Holsteinian sediments. River series prevail in central and eastern part of the country, whereas Holsteinian deposits within the Neman drainage basin of western Belarus are mainly of lacustrine origin and fluvial sediments are scarce. In contrast, central Polish fluvial sections are pretty numerous and fluvial sediments are considerably thicker.

Geological setting of Holsteinian river deposits in mid-eastern Poland and western Belarus appears to be determined by location of the underlying glaciolacustrine sediments. In fact, the Holsteinian river system up-stream has been created in this area by erosion due to spilling of water from Elsterian glacial lakes. Conditions favouring extensive drainage towards the Holsteinian Sea existed in western Belarus and in Poland, whereas the river network of central and eastern part of Belarus was drained to the Black Sea basin.

In the adjacent areas of Poland and Belarus, the main interglacial watercourse was different from the modern one and the western direction of drainage prevailed. The main watershed between the Baltic and the Black Seas during the Middle Pleistocene was located westwards in comparison with its present position. However, the secondary watershed between the Central Poland rivers and those drained directly into the Baltic Sea has been only slightly modified since that time.

**3-5 BTH 28** Wright, Matthew R.**SEISMIC STRATIGRAPHY AND PALAEOENVIRONMENTS OF QUATERNARY INCISED-VALLEY SYSTEMS IN THE EASTERN ENGLISH CHANNEL**

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This paper presents the results of research into the nature and origin of the Quaternary incised-valleys in the Eastern English Channel (EEC).

During the Quaternary the area of the EEC on the European continental shelf has fluctuated between marine and terrestrial conditions due to glacial-eustatic variations. These variations mean that in the EEC during the cold glacial maxima, sub aerial inner continental shelf conditions prevailed and large rivers eroded out fluvial valley systems. These systems were subsequently infilled by sediments from cold stage terrestrial and fluvial systems, and marine deposits accumulating during intervening transgressive interglacial phases. The aims of this research are to examine the nature and extent of these palaeovalley systems in the EEC. This will hopefully lead to a better understanding of their age and origins.

Some 1000 km line of high-resolution shallow seismic profile have been used to establish the geometry and bedrock bounding surface of these Quaternary formations. Sediment isopachyte, and depth to rockhead mapping reveals the extent and depth of incised-valley features below the seabed. The data has revealed palaeovalleys up to 5 km wide, infilled with 30 m of sediment in places. Interpretation of shallow seismic and lithostratigraphic data, retrieved from sequences in water depths ranging from -30 m to -50 m, indicates formation during multiple cut-and-fill events. The complex facies architecture includes coarse gravels, fine sands and silts, as well as organic peat deposits, indicating a broad range of depositional environments. Biostratigraphical analyses of vibrocore samples provide palaeoenvironmental reconstructions of the infill sequences. Aminostratigraphy will hopefully provide age control.

**3-6 BTH 29** Hoek, W.Z.**RIVER RHINE AND CHANNEL RIVER RESPONSE TO LATE QUATERNARY ALLOGENIC FORCING: THE IMPORTANCE OF TECTONIC SETTING**

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We modelled the Late Quaternary development of the River Rhine longitudinal profile to gain insight into its response to climate change and sea-level change on a timescale of 103-105 years. The 1250-km River Rhine originates in the northwestern European Alps, crosses different tectonic domains and drains towards the European passive continental margin. Results indicate that areas with long-term uplift or long-term subsidence (separated by the hinge line) show very different fluvial response.

Long-term uplift prevails in the drainage basin upstream from the hingeline. Here, phases of aggradation and degradation in the fluvial system are controlled by glacial-interglacial climate change. The Alps and their foreland are uplifted rapidly. Degradation prevails in the Alpine Rhine, but during glacial/stadial periods accumulation is predicted in the foreland. The Upper Rhine Graben constantly subsides, and therefore sedimentary units are stacked during long-term aggradation. The Rhenish Massif and Lower Rhine Embayment are uplifting. Here, glacial/stadial valley aggradation and interglacial/interstadial valley incision have created a staircase of alluvial terraces. Terrace gradient lines have been reconstructed and deposits have been dated to verify the timing of events.

Downstream from the hingeline, the Rhine enters the long-term subsiding Rhine-Meuse delta and Channel region. The Weald anticline, however, is uplifting. Here, aggradation and incision phases along the longitudinal profile mainly result from glacio-eustatic sea-level changes. During the Eemian and early Weichselian sea-level highstands (OIS 5e, 5c, 5a) the Rhine entered and traversed a glacial trough basin (Saalian). The present Rhine takes a shortcut south of this basin towards the Holocene (OIS 1) estuary. Glacio-eustatic sea-level fall during OIS 6, 4 and 2 to max. -130 m extended the Rhine profile with ~900 km. The mouth of the axial Rhine/Channel-River system at those times was located midway between Cornwall and Normandy in the Channel region. The model reproduces the creation of interglacial coastal prisms as a result of increasing accumulation space during sea-level rise, and erosion during early-glacial sea-level fall. These phenomena coincide with a shift of the terrace intersection over hundreds of kilometres.

**3-7 BTH 30** Maddy, Darrel**THE LATE CENOZOIC DEVELOPMENT OF THE GEDIZ RIVER, TURKEY**

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Over recent decades substantial progress has been made in the description and interpretation of Quaternary fluvial system development, especially in Europe and North America. These studies now form part of the IGCP449 programme, Global correlation of Late Cenozoic fluvial deposits. Unfortunately, this programme remains severely hampered by sparse geographical coverage in certain areas of the globe. This project seeks comparative information from within one of the identified data-vacuum areas, Turkey. Specifically this project will investigate in detail the nature of the Quaternary fluvial sedimentary and landform records in the Gediz river valley in the vicinity of Kula, south-western Turkey. Here, volcanic activity, triggered by regional tectonic uplift, has played a significant role in controlling fluvial sedimentation. Renewed investigation of this sedimentary/landform archive will allow the application of modern methodologies. The specific objectives of this NERC funded study are:

- To provide detailed baseline data concerning the nature and extent of Late Cenozoic fluvial deposits within the study area.
- To place this fluvial record within a tightly constrained temporal framework allowing correlation with regional tectonic and climate change histories
- To provide a direct contribution to IGCP449

This poster will describe preliminary observations made of this sequence during the first two field seasons of study (2001/2) and discuss the strategy for the planned fieldwork in 2003/4.

**3-8 BTH 31** Schreve, Danielle C.**A MID-DEVENSIAN WOOLLY RHINOCEROS SKELETON FROM TERRACE GRAVELS AT THE TRENT-TAME CONFLUENCE, WHITEMOOR HAYE, STAFFORDSHIRE, UK**

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Late Pleistocene fluvial sands and gravels laid down by the River Tame at Whitmoor Haye in south Staffordshire, close to the Trent confluence, have yielded the remains of fossil mammals attributable to the Middle Devensian (marine oxygen isotope stage [MIS] 3, c. 60-25 ka B.P.). The most significant find, the well-preserved anterior part of an articulated skeleton of a woolly rhinoceros, *Coelodonta antiquitatis* (Blumenbach, 1807) was discovered in September 2002, together with other vertebrate fossils, plant macrofossils, pollen and insect remains. The remarkably good condition and completeness of the material suggested that the rhinoceros had initially been buried as a frozen carcass, although the posterior part of the body appears to have been removed at a later date. The discovery of an articulated skeleton represents a particularly significant find for the English West Midlands, where vertebrate remains have been only rarely encountered to date, and provides an important marker in the dating of this part of the Trent-Tame terrace sequence.

**3-9 BTH 32** Vandenberghe, Jef**FLUVIAL STYLE CHANGES DURING THE LAST 35,000 YEARS IN THE TISZA VALLEY (HUNGARY)**

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In the study of rivers' responses to climatic changes a detailed analysis of regional differentiation is a valuable tool by distinguishing local from regional impacts. The Tisza river system was chosen as a central European equivalent of NW European lowland river systems. It shows a series of drastic morphological changes over the past 35,000 years. During the Weichselian Middle Pleniglacial (before c. 27 kyr BP) the Tisza was meandering or anastomosing. This was not commonly the case in other parts of Europe: for instance the river pattern of most British, some Dutch and east German rivers was braided during that cool, not extremely cold, period. The shift to a multichannel, low-sinuosity pattern during the Last Glacial Maximum is more general. Also the successive change to the formation of large meanders at the beginning of the Weichselian Lateglacial is very common. These meanders persisted during the cooling of the Younger Dryas in the Tisza valley, which is in contrast to some Dutch and British rivers more to the north. Finally, also the evolution to considerably smaller meanders is typical for most European rivers. While the general climatic conditions were slightly warmer and more continental than in NW Europe, especially the very low longitudinal gradient (due to the position of the Tisza in the subsiding Pannonian Basin) is characteristic. In addition, this river has a very fine-grained sediment load, partly induced by the vegetation cover that was denser than in the north. The combination of these properties resulted in a general low-energy level of the Tisza river that provoked river types and processes that were different from the more northern ones at certain periods.

**3-10 BTH 33** Narayana, A.C.**PROCESSES AND EVOLUTION OF FLUVIAL SYSTEM DURING THE LATE QUATERNARY IN THE CENTRAL KERALA REGION, INDIA**

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Kerala, situated along southwest coast of India, is bounded by Arabian Sea on the west and western ghats on the east. Forty rivers of small and medium size drain the region. Most rivers of central Kerala drain into the Vembanad lagoon. The central Kerala is characterized by the geomorphic features of (i) the uplifted prograding shoreline associated with depositional features like spits, barrier islands and paleo-beach ridges, (ii) the zone of subsidence characterized by yazoo drainage, and (iii) inland region of uplift with laterite cappings, oxbow lakes, deserted channels, neck and chute cut-off leading to channel avulsion.

The channel avulsion is either to the north or south suggesting that the rivers are unable to cut-across the coastal alluvium to enter the sea directly and instead they deflect and debouch. A number of lineaments trending N-S, NW-SE, NNW-SSE, WNW-ESE, and E-W are observed. These lineaments active even in the Late Quaternary must have influenced the river courses and channel avulsion. The river distributory system in the coastal plains of central Kerala resembles a delta.

The low strandlines of Holocene period are indicated by the presence of submerged terraces at various levels of water depths (20-90 m) on the continental shelf. These submerged terraces suggest the debouching of rivers in the Past far away from the present day shore. The protruded extension of the 1000 m bathymetry contour with gentle slope in the offshore region supports the view that the fluvial deposition was farther away from the present coastal plains, prior to the Holocene. This further supplements the suggestion of a mighty single stream in the geological past.

The occurrence of coast parallel lagoons (called Kayals) of different sizes and plan-forms imply diverse evolutionary processes during the Late Quaternary. These lagoons act as depositional centres for the modern river discharges.

The Quaternary sediments unconformably overlie the Neogene sediments, which unconformably overlie the Precambrian rocks. Both marine and non-marine sediments of the Neogene period include the formations of Vaikom and Quilon, and the overlying Warkali beds of Late Miocene age. The thickness of the sedimentary sequence exceeds 600 m.

In this paper, the role of surface processes and tectonics in relation to the evolution of fluvial sedimentation is discussed in detail.

### 3-11 BTH 34 Gibling, M.R.

INTERFLUVES OF THE SOUTHERN GANGA PLAINS, INDIA: ATTACHED AND DETACHED FLOODPLAINS IN THE LATE QUATERNARY

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Major rivers of the southern Ganga Plains (Himalayan Foreland Basin) occupy narrow, incised valleys bordered locally by 30 m cliffs and separated by wide interfluvial flats that are too elevated for inundation by the present-day rivers. Interfluvial landforms include planar floodplain surfaces with soil development, small plains-fed rivers, lakes, eolian mounds and extensive tracts of badland ravines. Sea-level fluctuations have not affected stratal patterns, as the area lies 1000 km inland.

At Bithur on the Ganga and along the Sengar River, 15 m cliff sections commence with thick floodplain muds with carbonate nodules and a slight to strong pedogenic overprint. The muds are overlain by lacustrine and eolian sheets of silt and sand, with incised channels filled of reworked carbonate gravel. Radiocarbon dates suggest that floodplains were attached to the major rivers prior to 10-15 ka B.P. but later became detached and were degraded or accumulated local lacustrine and wind-blow sediment. Comparison with late Quaternary marine and continental records of monsoon intensity suggest that detachment took place during a period of increased monsoon precipitation. Discharge of Himalayan and cratonic rivers probably increased relative to sediment load, leading to incision and a reduced frequency of floodplain inundation. Along the Yamuna, top-most cliff strata include 10 m ravine fills of colluvium, currently undated.

In 25-33 m cliffs along the Yamuna and Betwa, reworked gravel lenses, sand and gravel channel bodies, and carbonate cementation mark prominent erosional discontinuities at lower levels. The discontinuities can be traced for >2 km within thick floodplain deposits, and are interpreted as older interfluvial surfaces and strata (probably >100 ka B.P.). The origin of these discontinuities is uncertain. Carbonate veins that cut strata below but not above one discontinuity suggest a link between floodplain degradation and tectonic events; others may reflect climatic change.

The discontinuity-bounded units indicate a pattern of alternate floodplain aggradation and degradation. Such "A/D rhythms" may characterise alluvial successions in continental settings, especially along the cratonic margins of foreland basins where subsidence rates are modest.

### 3-12 BTH 35 FitzGerald, Danny

LAKE MONROE, POSSIBLE FLUVIAL RESPONSE OF THE OUACHITA RIVER TO PLEISTOCENE ARKANSAS RIVER AGGRADATION

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Lake Monroe in the Lower Mississippi Alluvial valley of eastern Louisiana was first reported by R.T. Saucier in 1970 based on an anomalously low gradient of an Ouachita River terrace. Cores support the existence of this paleolake. It is approximately 70 km long, 17 km to 30 km wide, and lake fill is up to 8 m thick. In the upstream portion of the lake gray clay and sandy clay, typically (2.5Y 5/1), is derived from the Ouachita River which flows through Paleozoic sandstones and shales in the Ouachita Mountains. The central portion of the lake is filled with both gray and red clays. The basal clay is gray and also derived from the Ouachita River. The upper clay is red, typically (7.5YR 4/3), and is derived from the Arkansas River which flows through the Mesozoic red beds in the Great Plains. The change from gray to red clay suggests that there was an avulsion of the Arkansas River into the central portion of the lake after the lake formed. Fill in the southern portion of the lake is dominated by red clay because of the proximity to both courses of the Arkansas River. The maximum age of the lake is approximately 30 ky, based on OSL dates of Macon Ridge, which is the eastern lake margin. The Holocene Ouachita River meander belt has incised into the lake sediment. Three hypotheses for the lake have been proposed. First, the Monroe uplift may have ponded both the Arkansas and Ouachita rivers. However, the mapped uplift is located upstream of the southern lake margin. Second, is aggradation of the Mississippi River, damming both the Ouachita and Arkansas rivers at the southern margin of Macon Ridge. However, no high Mississippi River surface is present at this locality and no unequivocal lake sediment was found near the hypothesized dam. Third, is damming of the smaller Ouachita River by aggradation of an Arkansas River course. This seems to be the most likely origin for the lake based on distribution of the lake sediment.

### 3-13 BTH 36 Törnqvist, Torbjörn E.

FIELD AND EXPERIMENTAL EVIDENCE FOR OUT-OF-PHASE FLUVIAL RESPONSES TO RAPID CLIMATE CHANGE

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Although numerous investigations, particularly theoretical studies, have demonstrated that nonlinear, complex responses to allogenic forcing are likely to occur in sediment-dispersal systems, relatively simple combinations of external controls are commonly invoked to interpret fluvial morphodynamics over geologic timescales. Here, a case is presented of fluvial longitudinal-profile adjustment of the northwest European Rhine system under conditions of rapid climate and sea-level change associated with the last deglaciation. Previous interpretations proposed a fairly simple interaction of these two controls, where downstream aggradation due to relative sea-level rise occurred coeval with upstream incision due to climate-controlled reduced sediment supply. It is hypothesized that this type of response could also be triggered exclusively by climate change,

where aggradation in the downstream reaches is the result of a propagating sediment wave, fed by upstream incision, that exceeded sediment transport capacity and was still en route seaward by the time a subsequent, rapid climate and sea-level change disrupted the prevailing boundary conditions. Experimental modeling of fluvial longitudinal-profile evolution demonstrates that a rapid, 25% increase in discharge (with constant sediment supply) leads to coeval upstream incision and downstream aggradation, similar to the inferences made for the Rhine. Such out-of-phase responses considerably complicate the interpretation of the fluvial stratigraphic record, and highlight the need for a holistic approach that considers the entire fluvial system, from source to sink. Also, a more comprehensive understanding is needed as to how common such out-of-phase responses are in the Late Quaternary geologic record.

### 3-14 BTH 37 Baade, Jussi

LATE HOLOCENE FLUVIAL DYNAMICS IN THE RIO GRANDE DE NAZCA CATCHMENT, SOUTHERN PERU

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Along the Pacific coast of Peru variation in rainfall and fluvial dynamics is well correlated to ENSO phases. Only during El Niño events high precipitation activates the fluvial system; often in the form of severe floods. The link of El Niño and fluvial dynamics is well established for northern Peru. In southern Peru, precipitation pattern and response of the fluvial system is more complex. Precipitation is limited to very strong El Niños, and to the coastal lowlands, while drought prevails in upland areas.

The paper presents investigations of flood deposits in the Rio Grande de Nazca catchment. The study area is located close to the village of Palpa (14°30' S), west of the Andes. The Rio Grande and two major tributaries, Rio Palpa and Rio Viscas, head in the mountains and represent allogenic, perennial or intermittent drainage systems. In addition, several smaller catchments with endogenic, episodic drainage are present. The aim is to establish local and regional flood deposit chronologies, taking into account the hydrological character of the catchments.

First results are available from the Rio Palpa alluvial plain and the alluvial fan of the La Muña creek, an endogenic tributary. Mapping a 120 m long and 3 m high river terrace along the Rio Palpa and a transect of 3 pits on the alluvial plain, revealed two distinguished stratigraphical units: A basal unit with gravel beds and a top unit, which varies strongly in thickness and consists of several beds of sandy and silty material. Traces of a long lasting human utilisation of the alluvial plain, probably starting as early as 2 ka BP, are present. A transect of pits in the La Muña alluvial fan revealed a 4 m thick sequence of well layered deposits, including several organic layers, laminated silty and sandy beds, and debris flow deposits. Preliminary dating of the lowest debris flow, based on pottery finds, suggests that the upper 2.5 m of this sequence documents endogenic fluvial dynamics in this part of southern Peru for the last 1.5 ka.

Radiocarbon dating of organic layers and charcoal, analysis of sediment samples, including grain size composition, soil organic matter and calcium carbonate content, and palynological investigations will be presented in this paper.

### 3-15 BTH 38 Mäusbacher, Roland

RECONSTRUCTION OF DEBRIS FLOW FREQUENCY USING LAKE SEDIMENTS OF LAGO DI BRAIES/N-ITALY AND THE INFLUENCE OF VEGETATION AND CLIMATE

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In the catchment of the high-alpine lake Lago di Braies debris flows frequently occur. Thereby the fine grained material of the debris flow events is flushed into the lake. This material forms characteristic layers, quite different than normal, laminated sediments. Via thin sections it was possible to date different debris flow events of the last 3 centuries with an annual resolution. In this period, the frequency of events increases, while the intensity decreases. Up to now it is not possible to distinguish between climate or human impact as reasons. By comparing the results, gained from the lacustrine archive, with an independent dendrogeomorphic archive of same catchment, we achieve a good correlation. Therefore we assume that it is possible to reconstruct a debris flow calendar with this lacustrine archive, which probably covers the last 7000 years. Palynological investigations show that the debris flow process is correlated with an increase of anthropogenic indicators in this area. Especially plantcommunities of meadows and poor grassland are strengthened during in this period. The palynological results reveal another increase of anthropogenic influence in the core section around 550 cm depth (Bronze Age?). Further investigations try to connect high resolution analysis of varves and pollen to investigate changes in climate or human influence and their effect on the debris flow activity.

### 3-16 BTH 39 Daniels, J. Michael

LATE HOLOCENE ALLUVIAL RESPONSE TO HYDRO-CLIMATIC CHANGE IN THE UPPER REPUBLICAN RIVER BASIN, GREAT PLAINS, USA

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Late Holocene alluvial records from the central Great Plains, USA, demonstrate a strong relationship between rates of past fluvial processes and century- to millennial-scale hydro-climatic change. Field-based research from the upper Republican River basin, southwestern Nebraska, provides evidence of late Holocene fluvial processes in the form of soil-stratigraphic and morpho-stratigraphic relationships, alluvial sedimentology, and radiocarbon age determinations. Aggradation of semiarid floodplains occurred sometime after 3500 yr B.P. until the onset of widespread regional drought during the Medieval Warm Period (MWP) (1200 to 800 yr B.P.). This aggradation episode was punctuated by multiple periods of reduced aggradation rates and consequent formation of cumelic floodplain soils. Subsequently, MWP drought caused rapid, widespread channel incision across the central Great Plains and resulted in the formation of ubiquitous late Holocene terraces. MWP channel incision likely resulted from drought-induced reduction in the density of prairie grasses and the associated increase in surface runoff rates and sediment transport capacities of ephemeral streams. Following the MWP incision episode, channels in the region aggraded rapidly, generating floodplain stratigraphy with well-preserved sedimentary structures and an absence of pedogenic features. Paleoclimatic conditions responsible for such widespread and synchronous episodes of aggradation and incision are inferred by analysis of proxy records and contemporary hydro-climatic processes. Proxy records indicate that droughts were more common, more intense and longer lasting during the MWP on the Great Plains than during the period of instrumental record (including the severe droughts of the 1930s and 1950s). Nevertheless, contemporary synoptic-scale conditions responsible for drought provide insight into the mechanisms responsible for widespread late Holocene geomorphic adjustment.

## 3-17 BTH 40 Tillery, A.C.

LATE HOLOCENE BEHAVIOR OF SMALL DRAINAGE BASINS ON THE COLORADO PLATEAU: INFLUENCES OF LITHOLOGY, BASIN FORM AND CLIMATE CHANGE  
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With evidence mounting demonstrating the reality of anthropogenic greenhouse warming, geomorphologists have become especially interested in the impacts of century and decadal scale climate changes during the Holocene on geomorphic processes. Recent studies of the semiarid landscapes of the Colorado Plateau in northeast Arizona indicate that they are lithologically sensitive to climate changes on a millennial and shorter temporal scales. In the area of Blue Gap, Arizona, landscapes seem to have been sensitive to climate changes on an even shorter time scales. All small basins of this escarpment have been characterized by spatially widespread aggradation over the last millennium; older Holocene valley floor alluvial deposits are nowhere present. Detailed study of stratigraphy and soils in the upper reaches of the basin valley fill, supported by radiocarbon dating and dendrochronologic studies, show that this sediment (locally up to 3-4 meters thick) is only 500-1000 years old. The observed rapid aggradation is largely attributed to the highly erodible Jurassic bedrock (Bluff sandstone and the Salt Wash member of the Morrison Formation). Soil studies of hillslopes show that a combination of chemical and mechanical weathering, associated with hydration-dehydration cycles, enables extremely rapid weathering and sediment production on basin slopes. The mode of operation of the fluvial systems in a few sub-basins has notably changed since late 19th century, from net aggradation to channel incision (arroyos). The timing of this change (late 19th century) is unrelated to overgrazing by domestic livestock; instead, we suggest that it may reflect climatic changes at the end of the Little Ice Age (LIA ~1200-1900AD). The variable geomorphic expression of this recent change in climate may be due to the lag time between this climate change and the basin response, with such responses likely linked to variations in basin characteristics such as aspect, vegetation, slope weathering, soil development and sediment production. At least in this study area, the weakly clay cemented sandstones of the Blue Gap field area seem to be especially sensitive to minor climatic changes of the Holocene as compared to more resistant rocktypes elsewhere in the region.

## SESSION NO. 4, 1:30 PM

Thursday, July 24, 2003

## Major Quaternary Glaciations: Extent, Timing, and Global Synchronism (Posters)

## Reno Hilton Resort and Conference Center, Pavilion

## 4-1 BTH 41 Aoki, Tatsuto

## CHARACTERISTICS OF THE GLACIERS IN THE JAPANESE ALPS

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Glaciations during the Last Glacial in the Japanese Alps can be classified into two types: one is "azonal glaciation" and the other is "zonal glaciation". The ELAg (geomorphological equilibrium line altitude) of each former type glacier is determined by the Hs (maximum altitude of the mountain ridge), and forced to depress by the microclimatic phenomena such as drifted snow. The vertical / horizontal distribution of this type of glaciers is azonal and sporadic. On the other hand, the ELAg of latter type glaciers remains constant with the Hs, and reflects the regional air temperature. In the case, the mountain ridge is higher than the regional equilibrium-line altitude, the vertical / horizontal distribution of glaciers belonging to this type becomes zonal and continuous. Modern examples of these two types of glaciations can be found in Kamchatka Peninsula, the Altai Mountains, and the Caucasus Mountains. These facts suggest that this classification is applicable to spatial and temporal variations of glaciations. Most of the Last Glacial glaciers in the Japanese Alps are classified into "azonal glaciation" type. The glaciers belonging to "zonal glaciation" type were located in the Northern Japanese Alps that have high altitude. It is found that some of "zonal glaciation" existed during the Last Glacial Maximum stage were changed to "azonal glaciation" type during the Late Glacial stage. From this point of view, the Last Glacial glaciers in the Japanese Alps existed as a spatio-temporal transition between these two types. To pay attention to the "azonal glaciation" that is controlled by the local conditions is important for the reconstruction of palaeoclimate based on the glacial landforms and their ELAs.

## 4-2 BTH 42 Kuhle, Matthias

## THE FORMER GLACIATION OF HIGH- AND CENTRAL ASIA AND ITS CLIMATIC IMPACT-COMMENTS ON THE INQUA-COG-GLACIATION MAP 1:1 MIO

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During 33 campaigns the Ice Age glaciation of High- and Central Asia has been reconstructed on the basis of glacialic forms. Since the INQUA-congress 1999 5 new areas in the Karakorum, Himalaya and Tibet (Xuebao) have been investigated. Sedimentological analyses and flank polishings prove a 2800 m-thick Karakorum icestream network. This is remarkable for mountains which today are semi-arid. The new Glaciation Map (44 sheets) compiles the data obtained since 1973. Data were gathered from the Zagros in the W to the Minya Konka and from the Himalaya to the Sajan in the N.

Absolute datings classify this glaciation as stage 4-2. Radiation balance measurements up to 6650 m asl indicate highest radiation energies on the Plateau, making Tibet today's most important heating surface. At glacial times 70% of the energies were reflected into space by the 2.4 million km<sup>2</sup>-glacier area, which thus has brought about 32% of the entire global cooling. About 2.5 Ma ago, when Tibet was lifted above the snow line and glaciated, this cooling effect gave rise to the global depression of the snow line and the first Ice Age. The interglacials are explained by the glacio-isostatic lowering of Tibet by 650 m with the effect that the Tibet ice, which had evoked the build-up of the lowland ices, could melt away in a period of positive radiation anomalies. The next Ice Age begins, when the Plateau has again reached the snow line (glacial-isostatic reverse uplift). This explains, why the orbital variations could only have a modifying effect on the Quaternary climate, but were not primarily time-giving: as long as Tibet does not deglaciate, the temperature depression is not sufficient for initiating a worldwide Ice Age; if Tibet is glaciated, but not yet lowered isostatically, a warming-up by 4°C causes an important loss in surface but no deglaciation, so that its cooling effect remains in a maximum intensity. Only a glaciation of the Plateau lowered by isostasy can be removed through a warming phase, so that interglacial climate conditions are prevailing until a renewed uplift of Tibet sets in up to the altitude of glaciation.

## 4-3 BTH 43 Ananicheva, Maria Dmitrievna

## GLACIATIONS OF NOVAYA ZEMLYA AND NORTH-EAST OF RUSSIA (SUNTAR-KHAYATA): DID THEY EXIST IN THE EPOCHS OF GLOBAL WARMING?

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The paper presents results of glacio-climatic calculations for the Optimum Holocene and Eemian Interstadial based on general paleoclimatic scenarios which were adapted to the local glacial belt of the Novaya Zemlya ice sheet and Suntar-Khayata mountain glaciation. The method represents a reconstruction of glacier regime with the help of present glacio-climatic relationships. The chosen glaciations refer to the different by climate regions: Novaya Zemlya ice sheet is located in marine influence conditions of Arctic belt, Suntar-Khayata mountains are characterized by extremely continental climate of East Siberia. This difference defines their specifics of the glacier response on global warming. In Eemian on the Novaya Zemlya ice sheet until 800 m a.s.l., (maximal heights of the ice sheet) possible snow melting exceeded greatly snow accumulation. Taking into account the epoch duration, it is evident the preexisting glaciation had completely disappeared. For Suntar-Khayata our calculations cast some doubt on the glaciers existence in Eemian since the resulting values of the ELA are near the existing heights of topography. The two variants of the precipitation deviation +50 mm and +100 mm, inferred in the calculation, resulted in the ELA rise by 400 m, according to the 1st variant and by 300 m according to the 2nd. Deviations of the ablation-accumulation from the present would be 250 mm and 300 mm respectively. In Holocene optimum the calculated bottom boundary of hionosphere exceeded the ELA at 300-400 meters in Novaya Zemlya. It means that owing to the maximum altitudes of the present ice sheet and absence of tectonic uplifts in Holocene, the ice sheet could not emerge as well as survive since the LGM. However in the area of reticular glaciation in the most elevated Northern Island the bedrock rises higher 1000 m a.s.l. So in the corresponding relief forms glaciers could exist quite steadily and glacier development likely has not been terminated during the Holocene. For Suntar-Khayata we considered two variants of precipitation deviations: +25 mm and +50 mm. As follows from calculations, at different variants the ELA rise at the Holocene would be 50 to 90 m. Taking into account the position of the glacier upper boundary, it could persist through the Holocene warming.

## 4-4 BTH 44 Carr, Simon J

## THE LAST GLACIAL MAXIMUM AND DEGLACIATION OF THE KRKONOSE MOUNTAINS, CZECH REPUBLIC: EVIDENCE OF ASYNCHRONAITY WITH THE SCANDINAVIAN ICE SHEET?

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The nature and timing of the LGM and subsequent environmental changes during the Last Termination in Central Europe is poorly understood, with no high-resolution, well-dated sequences yet interpreted. The location of the Krkonose (Giant) Mountains of the Czech Republic/Polish borders is highly significant, lying in the corridor between the Scandinavian ice sheet and the Alpine ice field, and the first significant mountain belt beyond the limits of the Scandinavian ice sheet during the LGM. Thus, the Krkonose may preserve a unique record of glaciation and palaeoclimate for this period, reflecting climate changes that are perhaps out of phase with the broader NW European transition.

This study reports the findings of a range of investigations in the Upa valley, Krkonose Mountains. Geomorphological mapping identifies a sequence of moraine belts in the upper valley, and a suite of erosional terraces in the middle and lower valley, thought to reflect cycles of erosion and glaciation subsequent to the mid-Quaternary. Lithofacies analysis of sediment exposures in the vicinity of Svoboda nad Upou suggest that Late Quaternary glaciation of the Krkonose mountains was more extensive than previously considered. Palaeoecological analysis of cores extracted from bogs lying between moraines, as well as a site beyond the moraines provides the first detailed paleo-environmental reconstruction for this region for the period of the LGM and last Termination, supported by AMS radiocarbon dating.

The nature and chronology of LGM glaciation in the Krkonose is compared to that of the Scandinavian ice sheet. Evidence for asynchronicity of glaciation and environmental change in the Krkonose are compared to other studies from areas beyond the major ice sheets to evaluate the significance of such phasing. We by evaluating the evidence from the Krkonose and nearby regions in the context of regional climatic patterns during, and subsequent to the LGM.

## 4-5 BTH 45 Rose, James

## A MULTI-STAGE MODEL FOR EARLY AND MIDDLE PLEISTOCENE GLACIATIONS OF WALES AND MIDLAND AND EASTERN ENGLAND

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This presentation will report the results of new research involving systematic mapping and lithostratigraphic studies. The results suggest that there were four major glaciations across the lowlands of midland and eastern England during the later part of the Middle Pleistocene. Each glaciations is related to well defined lithostratigraphic evidence, and each glaciation is attributed to eccentricity forced, global climatic deterioration. The glaciations recognised are: Happsburgh Glaciation (OIS 16), Lowestoft Glaciation of the Anglian Stage (OIS 12), Oadby Glaciation (OIS 10) and Welton Glaciation (OIS 6). There is indirect evidence for a number of older glaciation associated with obliquity climatic forcing. This scheme is substantially different from the model of Mitchell et al. (1973) which identified two Middle Pleistocene lowland glaciations, and that of Bowen (1999) in which the three Middle Pleistocene lowland glacial events are recognised and attributed to OIS 16, 12, and 6. The age allocation presented here is based primarily on the links between the glacial deposits of lowland Midland and Eastern England with the major terrace systems of the Thames, Severn and Bytham rivers, a continuity with Northern Europe in the case of OIS 6, and available geochronometry. Like Mitchell et al. and Bowen et al., there is no independent non-glacial or biological evidence to separate the glaciations. All of the glaciations except one derive from Scottish ice sources. Scandinavian ice reached Britain only in OIS 6 when it also reached its greatest extent in the Netherlands and western Northern Germany. It is considered that this scheme provides a model for lowland-scale glaciation of the British Isles and is in accord with the global history of glaciation (Ehlers, 2003), rather than being anomalous, as has been the case for Britain in the past.

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## 4-6 BTH 46 Wojcik, Antoni

## THE CROMERIAN INTERGLACIAL IN THE AREA OF THE MAXIMUM GLACIATION EXTENT IN SOUTHERN POLAND

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In southern Poland, the profile in Konczyce, gives a new insight on the ice-sheet maximum extent. Until now, it has been called: the South Polish Glaciation, Cracovian or Sanian and has been correlated with Elsterian (Mindel).

The site in Konczyce, presents the profile of Quaternary deposits resting on the Miocene clays. The lower, 9 m thick, segment of the profile comprises river gravels and sands, locally topped with a preserved cover of sandy alluvial loams. Above the river deposits, erratic boulders, fluvio-glacial sands and gravels, glacial till occurs. These glacial series are again covered with river deposits (mainly gravel-sized flysch sandstones originating from the Carpathians and singular rounded pieces of crystalline rocks originating from washing of glacial deposits). This tripartite lower segment of the profile is overlain by almost 10 m thick upper segment. The latter comprises the series of silts and silty loess-like loams with 3 layers of organic deposits (peat) at its lower part. The palynological examination of the lower, about 3.5 m thick fragment of these overlying silty series led to identification of pollen assemblages with *Pinus silvestris*, *Alnus glutinosa*, *Betula alba*, *Corylus*, *Tilia cordata*, *Ulmus*, and *Fraxinus*. This pollen succession was believed to be the closest to the younger optimum of the Ferdynandovian Interglacial, which used to be correlated with the Cromerian IV. However, the middle of the organic deposits can be assigned now to the Interglacial II of the Cromerian Complex, i.e. to the earlier stage than it has been accepted.

The paleomagnetic tests of the lowermost deposits, resting on the upper river series, show reversal magnetic polarity associated with Matuyama epoch. This outcome allows for a new interpretation of the glacial deposits. The river series underlying the upper segment of the profile can be related to the earliest Cromerian Complex. The glacial deposits occurring more below are older than the Cromerian and can be paralleled with the Günz or with the pre-Cromerian traces of the oldest glaciations found in England and Holland or with the Nebraskan glaciation in North America. Based on the paleomagnetic and palynological examinations the glacial deposits in Kończyce profile are older than 750 ka BP and are likely to correspond to the Menapien.

## 4-7 BTH 47 Bevis, Kenneth A.

## RECONSTRUCTION OF THE LATE PLEISTOCENE GLACIER SYSTEM ON STEENS MOUNTAIN, SOUTHEAST OREGON, WITH PALEOCLIMATIC IMPLICATIONS

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Steens Mountain forms a spectacular, asymmetrically uplifted fault-block mountain range within the northernmost Basin and Range located in southeastern Oregon. The fault block is bounded on the east by a steep NE-SW trending escarpment, while the western slope dips much more gently and forms a high plateau dissected by several immense glacial troughs. The distribution and age of glacial drift on Steens Mountain suggests that an ice cap coalesced to flow down major valleys draining the plateau during more than one episode of glaciation.

Morphostratigraphic features, combined with the relative degree of surface and subsurface clast weathering and soil development, indicate a three-fold glacial sequence on Steens Mountain. The intermediate drift unit was interpreted to represent the last glacial maximum of the late Pleistocene. The surface topography of the ice cap associated with this glaciation was reconstructed by: 1) dividing the glacier system into independent lobes draining major valleys, 2) establishing ice-surface contours for each lobe by assuming convergent and divergent flow in accumulation and ablation areas, respectively, 3) using ice thickness and surface slope along the centerline of each lobe to calculate basal shear stresses along their respective lengths, and 4) modifying the initial ice-surface contours until computed shear stresses were near the accepted range of 50-150 kPa.

Using an accumulation-area ratio of  $0.70 \pm 0.05$  for the late Pleistocene ice cap, the mean equilibrium-line altitude (ELA) during this glaciation was determined to be  $2284 \pm 39.5$  m. Modern glacier mass balance is strongly correlated to the mean summer temperature and winter accumulation occurring at the ELA. Regressions of mean June-August temperature and April-1st snowpack were extrapolated to the reconstructed late Pleistocene ELA to obtain proxy mean summer temperature and winter accumulation values of  $7.9 \pm 0.5$  °C and  $50.0 \pm 3.5$  cm H<sub>2</sub>O, respectively. These values were compared to the range of values occurring at modern mid-latitude glaciers. Assuming no change in precipitation from the present, an  $8.0 \pm 1.3$  °C mean summer temperature depression, associated with snowfall equivalent to  $181 \pm 32$  % of the modern value, was determined to have been necessary to sustain the ice cap on Steens Mountain during the late Pleistocene.

## 4-8 BTH 48 Lee, J.R.

## DYNAMICS AND TIMING OF THE EARLIEST LOWLAND GLACIATION OF EASTERN ENGLAND: THE OIS 16 HAPPSBURGH GLACIATION OF THE EARLY MIDDLE PLEISTOCENE

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This poster outlines evidence for the timing and dynamics of the first lowland glaciation of eastern England during the early Middle Pleistocene – the OIS 16 Happsburgh Glaciation. Climatic deterioration and the onset of this glaciation within adjacent upland areas is represented within the geological record by periglacial features, changes in the dynamics of the regions rivers, and the appearance of far-travelled glacially-derived clasts and heavy minerals within contemporaneous fluvial and marine sediments.

Incursion of glacial ice into eastern England led to the accretion of a layer-cake sequence comprised of several till and outwash units (Happsburgh Formation) that at their southern extent, pass laterally into sediments of the Bytham River, the major river system of eastern England of the time. This river system was destroyed by glacial ice during OIS 12. Analysis of preserved glacial landforms, and the sedimentology and lithology of the till units reveals deposition by the deforming bed of a surging British Ice Sheet, and by gravity flow as a series of subaqueous flow tills representing the subaqueous grounding-line positions of several ice-marginal oscillations that terminated within a standing body of water.

An OIS 16 timing for this glaciation is determined by the correlation of glacial sediments. This is based on the presence of derived till clasts, heavy minerals and exotic clast lithologies within a terrace of the Bytham River, the terraces of which provides evidence for at least one cold stage between OIS 12 and the Happsburgh Glaciation. The Happsburgh Glaciation, equivalent to the Don Glaciation of northern Europe, is recognised within the oxygen isotope record as a period of high global ice volume and illustrates that the British Ice Sheet was in phase with global patterns of glaciation.

## 4-9 BTH 49 Smith, Larry N.

## PLEISTOCENE MOUNTAIN GLACIATION IN MONTANA, USA

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A variety of Pleistocene glacier types occurred in Montana, including continental ice sheets (Laurentide and Cordilleran), large mountain ice caps (Northern Rockies and Yellowstone-Beartooth), small mountain ice caps (e.g. Boulder Highlands and West Pioneers), and transection glaciers (e.g. East Pioneers and Flint Creek Range). Numerous valley, cirque and niche glaciers also existed in more than sixty distinct mountain ranges. Glacier distribution and equilibrium-line altitudes are consistent with a climatic pattern where moist air masses entered the NW corner of the state. Prevailing winter westerly winds were directed south of the Cordilleran ice sheet at the glacial maximum.

The extents of Pleistocene glaciers of western Montana were mapped from topographic map and aerial photo interpretation, with limited field verification. The results generally conform to previous regional work, however detailed field studies of glacial extents are scant. In the few places where deposits of older glaciations were mapped, last-glacial maxima—"Pinedale" (Wisconsinan, Weichselian, Würm)—extents closely mimicked older glacial extents except on the west flank of the Yellowstone Ice Cap and in localities where glaciers extended onto the Great Plains. However, most glacial extents have not been field-mapped and meaningful patterns of difference between last-glacial and earlier extents may yet emerge.

Nowhere in Montana are the ages of glacial episodes well-constrained. Most last-glacial moraines are correlated with the Pinedale glaciation (~25,000 to ~16,000 14C yr BP) elsewhere in the Rocky Mountains, rather than dated directly. Radiocarbon dates in the Yellowstone region and south of Glacier National Park, and occurrences of Glacier Peak tephra in the Flathead region show massive retreat or disintegration of the major ice caps prior to the Younger Dryas Chron. It is assumed that many mountain glaciers also retreated at this time. Younger Dryas glaciation was restricted to cirques.

Glacial drainage modifications in western Montana resulted from sedimentation and erosion associated with Glacial Lake Missoula, and local rerouting of pre-glacial streams. Ice-marginal lakes existed in some areas, however their ages and extents are not well known.

## 4-10 BTH 50 Lachniet, Matthew S

## LATE QUATERNARY GLACIATION OF COSTA RICA AND GUATEMALA, CENTRAL AMERICA

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The highest peaks of Costa Rica and the high plateau of the Altos de los Cuchumatanes in Guatemala were glaciated during the late Pleistocene, attesting to a significantly different climate in the Central American isthmus. In Costa Rica, during the last local glacial maximum (LLGM) ice ~35 km<sup>2</sup> in extent covered the highest peaks of the Cordillera de Talamanca, an additional ~2 km<sup>2</sup> of ice existed around Cerro Kamuk, and ~6 km<sup>2</sup> existed on Cerro de la Muerte. In Chirripó Park, three moraine groups define three glacial stages. The Talamanca stage is represented by the most extensive moraines that reach down to 3040 m. The Chirripó stage moraines reach elevations of 3300 m, and the Talari stage moraines formed at around 3300 and 3420 m. Based on moraine elevations and geomorphological evidence, the paleo equilibrium line altitudes (ELAs) during the Talamanca stage were ~3500 m. Cirque floor elevations around Cerro Kamuk of 3300 m suggest a lower (pre-?) LLGM ELA. Radiosonde data from San José place the modern 0°C isotherm at ~5000 m, which suggests a late Pleistocene ELA depression of ~1500 m. In Guatemala, an ice cap of ~60 km<sup>2</sup> existed on the high plateau with ice tongues depositing moraines at elevations of 3470 to 3600 m. The Pleistocene ELA was estimated to be ~3600m.

## 4-11 BTH 51 Carr, Simon J

## THE LAST GLACIATION OF THE NORTH SEA BASIN

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Despite a long history of investigation, critical issues regarding the Last Glacial Maximum in Northwest Europe remain unresolved. One of these refers to the extent, timing and dynamics of Late Weichselian glaciation of the North Sea, and whether the British and Scandinavian ice sheets were confluent at any time during this period, or whether glacial marine environments existed between two separate ice sheets.

This study presents the results of seismic, sedimentological and micromorphological evidence, used to reconstruct the depositional history of regionally extensive seismic units across the North Sea Basin. Micromorphology is suggested to provide an effective means of discriminating between subglacial and glacial marine sediments from cored samples.

Two major episodes of extensive glaciation of the North Sea Basin are identified from this study, and the dynamics of glaciation are inferred. During OI stage 4, extensive glaciation of the North Sea occurred, during the 'Ferder Glacial Episode', when Scotland and Scandinavian ice sheets extended to the continental shelf margin. Subsequent glaciation is identified during the Late Weichselian, when at least two phases occurred. After 30<sup>14</sup>kaBP, confluent ice sheets covered the central North Sea, during the Cape Shore Event, corresponding to the suggested Last Glacial Maximum in NW Europe. Subsequent to 22<sup>14</sup>kaBP, both ice sheets retreated, interrupted at approximately 18<sup>14</sup>kaBP by a short period of ice sheet advance, mainly relating to surging of the eastern part of the British ice sheet.

This poster discusses the processes and environments associated with each glacial episode, providing clear indications of the style of glacial and glacial marine processes operating in this region throughout the Weichselian. Brief analysis of potential external trigger mechanisms for rapid glaciation suggests a correlation between Heinrich events H3-H1 and advance of the British ice sheet, although current chronostratigraphic data is poor for much of the region.

## 4-12 BTH 52 Polyak, Leonid

## LATE PLEISTOCENE GLACIATION HISTORY OF THE SOUTHWESTERN KARA SEA

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The Kara Sea is a critical area for establishing the patterns of Quaternary glaciations in northern Eurasia. It is now generally accepted that the eastern limit of the LGM Eurasian ice sheet is to be sought in the Kara Sea, but little actual data on the structure and stratigraphy of its Quaternary deposits have been presented. Based on a large number of seismic records and sediment cores obtained from the southwestern Kara Sea by the former Soviet Union programs and our expeditions in 2000-2001, we present data on the geometry and stratigraphy of Quaternary deposits together with an improved sea-floor morphology for this area. The overall Quaternary sedimentary cover is subdivided into six major seismo-lithostratigraphic units, SSU VI to I (bottom to top). Despite the remaining uncertainties with chronostratigraphy and with the distribution of some portions of the identified units, the overall picture allows us to characterize major features of the gla-

cial history and related events in the study area. Two units, SSU V and III, are composed of stiff diamictons interpreted as subglacial tills. The older SSU V is mostly confined to the southernmost area and is correlated to the Kara Till of the Yamal Peninsula interpreted to have been emplaced during the Middle Weichselian glaciation (OIS 4). The younger till, SSU III, is correlated to the Kolguev Till of the southeastern Barents Sea and is believed to indicate the distribution of the LGM ice sheet. We map its margin east of Novaya Zemlya Trough where SSU III forms a series of morainic constructions up to 100 m thick. Two distinct morainic belts more proximal to Novaya Zemlya were probably formed during the ice-sheet retreat. Our data also elucidate the patterns of riverine drainage on the Kara Sea shelf during the Late Pleistocene and Holocene. Notably, we identify thick deposits formed by extension of the Ob' river into the southwestern Kara Sea prior to the Middle Weichselian glaciation, but do not see traces of a similar extension in this area during the last sea-level fall. Possibly, this difference is related to erosional and/or glacioisostatic effects of Middle to Late Pleistocene Eurasian glaciations that were progressively diminishing in size.

#### 4-13 BTH 53 Houmark-Nielsen, Michael

**PALAEOGEOGRAPHY AND ENVIRONMENTAL CHANGE IN SW-SCANDINAVIA 40-15 KA BP**  
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 Stratigraphical evidence mainly from Denmark offers a unique possibility to synchronize climatically driven environmental changes and major glacio-dynamic events including former ice streams at the SW-rim of the Scandinavian Ice Sheet. Twelve palaeogeographic reconstructions illustrate the interaction between ice sheet behaviour, sea level change and the distribution of major lakes at 40-15 ka BP. Land, sea and glacier configurations are based on the lithostratigraphy of tills and inter-till sediments. Dating is provided by Optically Stimulated Luminescence and calibrated AMS radiocarbon. The evolution through the last glacial cycle falls in three sequences. The interstadial sequence c. 40-30 ka BP was characterized by a boreo-arctic fjord system controlled by the Norwegian Channel and subarctic treeless vegetation characterize terrestrial environments. The LGM sequence, c. 30-20 ka BP comprises the closure of former fjords and subsequent ice streams guided by glacial lake basins in the Kattegat depression and the Baltic. Steady flow of ice from Central Sweden towards Denmark probably bordered the Norwegian Channel ice stream towards the northwest. The deglaciation sequence, c. 20-15 ka BP is characterized by transgression of arctic North Atlantic waters through the Norwegian Channel, retreat of the Swedish ice and advance of Baltic ice streams succeeded by a return to interstadial conditions. Our reconstruction predicts that while interstadial conditions governed by Atlantic climate amelioration prevailed in the eastern North Sea Region and adjacent landmasses, glaciers originating in the Scandinavian mountains were able to advance east and southward through the western Baltic. On the other hand, during interstadial regimes when subarctic conditions dominated in Denmark and the western Baltic glaciers expanded from southern Norway into the North Sea and Skagerrak. The largest glacier extent was reached in the North Sea around 29 ka BP, about 22 ka BP in Denmark and c.18 ka BP in the Baltic. Our model provides new data for future numerical and qualitative landform-based models, which ideally should be able to replicate the palaeogeographical settings presented here and at least they should address published stratigraphic frameworks.

#### 4-14 BTH 54 Boese, Margot

**GEOMORPHOLOGICAL STUDIES ON THE LATE PLEISTOCENE GLACIATION IN THE HIGH MOUNTAINS OF TAIWAN**

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 The high mountain ranges of Taiwan are unglaciated at present, but investigations based on field work and air photo study in Nanhua Shan (3742 m), Hsueh Shan (3884 m) and Yu Shan (3995 m) show a remarkably extensive Late Pleistocene glaciation and a deeper ELA depression in these areas than reported before [1]. Various glacial landforms and deposits have been mapped, e.g. U-shaped valleys, glacial trimlines, roches moutonnées, moraines and erratic boulders. Landforms were analysed by size, geometry, location and composition. Sediment analyses include lithology, grain size, grain morphology and sediment fabric. A small icecap with valley outlet glaciers and a thickness of about 150 m during the maximum stage was reconstructed for the Nanhua Shan massif [2]. Glacial deposits were found down to 2200 m in the Nanhua Valley. Glacial deposits have been sampled for OSL and rock surface exposure dating, which were applied in the Taiwanese mountains for the first time. The data show a maximum extent of the glaciation during the MIS 4. The ELA depression was 1100 m. Further data were obtained for the Late Glacial/ Early Holocene period, when the ELA was depressed by about 500 m. All ages are consistent with each other and with the geomorphological data in the study areas. The dose rates of the sediments and the bleaching of the grains in glacial environments seem to be sufficient for dating by OSL.  
 1. Cui, Z., Yang, Ch., Liu, G., Zhang, W., Wang, S. & Sung, Qu., 2002. The Quaternary glaciation of Sheshan Mountain in Taiwan and glacial classification in monsoon areas. *Quaternary International*, 97-98: pp. 147-153. 2. Hebenstreit, R. & Boese, M., 2003. Geomorphological evidence for a Late Pleistocene glaciation in the high mountains of Taiwan dated with age estimates by optically stimulated luminescence (OSL). *Zeitschrift für Geomorphologie*, N. F., Suppl.-Bd.130: pp. 31-49.

#### 4-15 BTH 55 Fulton, Robert J.

**THE LAST GLACIATION OF BRITISH COLUMBIA, CANADA**

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 During the last glaciation (Late Wisconsinan) British Columbia, with the exception of a few small nunatak areas, was covered by the Cordilleran Ice Sheet. This was a complex glacier mass centred in the relatively low central part of the province. Early during glaciation, glaciers grew in the mountains and pushed into the low interior where they coalesced to form an ice sheet. At its maximum the Cordilleran Ice Sheet became the main area of accumulation and the ice sheet pushed out from the central part of the province to flow over and through the flanking mountains. Because of the confinement of the mountains, considerable downwasting had to take place before significant lateral retreat could begin. This resulted in the retreating margin of the Cordilleran Ice Sheet being relatively insensitive to minor fluctuations of climate and in a very rapid disintegration of the ice sheet during later stages of retreat.  
 The cooling leading to Late Wisconsinan glaciation in British Columbia began about 29 ka. The maximum position of the CIS is poorly dated but was reached in the south as late as 14.5 ka. Retreat was rapid and by 10 ka, ice cover in British Columbia was approximately as extensive as at present. Illustrations show the general paleogeography of the area at various times during retreat of the Cordilleran Ice Sheet.

#### 4-16 BTH 56 Minnich, Richard A.

**TIMING OF LATE QUATERNARY GLACIATION AT THE EXTREME SOUTHERN MARGIN OF GLACIATION IN NORTH AMERICA, SAN GORGONIO MOUNTAIN, SOUTHERN CALIFORNIA**  
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Moraines and associated landforms on San Gorgonio Mountain in the eastern San Bernardino Mountains of southern California mark the southernmost limit of glaciation in the Western Cordillera of North America. These landforms provide evidence for several glacial advances during the Late Quaternary. Cosmogenic radionuclide surface exposure dating of a succession of these moraines from three glaciated valleys define four glacial advances, which occurred at ~18 ka, 14-15 ka, ~12 ka and ~5-7 ka. These strongly correlate with Northern Hemisphere glaciation including glacial advances during the global Last Glacial Maximum, the Lateglacial, the Younger Dryas Stade and the early-middle Holocene. Our data suggests that glaciers develop and advance in this region when there is a significant decrease in summer temperature that is coupled with the considerable increase of in moisture supply and consequent high winter snowfall. This results in perennial snow accumulation that may persist to form glacial ice. This study highlights the importance of high moisture supply in sustaining glaciation in marginal regions. Furthermore, substantiates the view that glaciation throughout the American cordilleras was synchronous throughout the Late Quaternary.

#### 4-17 BTH 57 Bini, Alfredo

**GLACIAL HISTORY OF THE SOUTHERN SIDE OF THE CENTRAL ALPS, ITALY**  
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 The area covers the sub-alpine valleys between Lago d'Orta, to the east, and Lago d'Isseo, to the east and the corresponding morainic amphitheatres of the high Po plain. Geological mapping was carried out at a 1:10,000 scale in order to allow detailed geological reconstruction.  
 On the high Po plain the boundaries of many ice advances can be distinguished that moved out of subalpine valleys and reached the plain beyond. The different valleys experienced different glacial histories so that the alloformations described from different basins cannot be directly correlated. In the Verbano amphitheatre it is possible to distinguish 13 glaciations. The oldest is of Pliocene age and the youngest is of Late Pleistocene age.  
 In the Lario amphitheatre it is impossible to say how many glacial episodes are represented. It is possible to recognize 4 alloformations (related to 4 glaciations), 4 formations (containing tills from 4 glaciations) and 1 allogroup (more than 1 glaciation). Concerning the age of these glaciations the two oldest are Pliocene and the youngest is Late Pleistocene. The Sebino amphitheatre is very regularly shaped. At least 7 glaciations are recognizable in this area.  
 The survey of the area provides evidence that correlations cannot be established by using elevation or position of the deposits.  
 Between the Pliocene glacial episodes (about 2.4 Ma BP) and Holocene, glacial deposits have been subjected to alternating weathering (warm conditions) and strong erosion (cold phases). The erosion and subsequent slope movements have determined: the intense fragmentation of the deposits and the burial of glacial deposits by up to several meter thick loess deposits. For these reasons the glacial maximum (MEG) is discontinuous and doubtful. Another obstacle preventing the reconstruction of the MEG is that the area has been subsequently affected by tectonic events including uplifting, subsidence, thrusting and lateral displacements.  
 The LGM glacial deposits are principally distinguished by a poorly-developed weathering profile, well-preserved landforms and no loess cover. It must be emphasised that the LGM mapped using these criteria, does not correspond to previous authors' Würm limit. The Würm in older maps was regarded as more extensive.

#### 4-18 BTH 58 Mark, Bryan G.

**LATE QUATERNARY GLACIATIONS OF ECUADOR, PERU AND BOLIVIA**  
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 A review of late-Pleistocene glaciation in Ecuador, Peru and Bolivia is presented to accompany an ArcGIS digital map of glacial limits. Seven principal sites provide the basis of the current understanding of glacial chronology and this mapping compilation: (1) the Potrerillos plateau, Ecuador; (2) the Cordillera Vilcanota-Quelocaya Ice Cap, Peru; (3) the Junin Plain, Peru; (4) the Cordillera Blanca, Peru; (5) the Cordillera Oriental, Peru; (6) the Cordilleras Apolombamba and Real, Peru-Bolivia; and (7) the Altiplano, Bolivia. Minimum radiocarbon dates, the superposition of moraines, and relative dating methods provide evidence that the most extensive glacial advances pre-date the Marine Isotope Stage 2 (MIS 2). Ample series of well-defined, nested moraines indicate multiple episodes of glacial activity in the last glacial cycle, with a few minimum-limiting radiocarbon dates suggesting the local last glacial maximum (LLGM) occurred early in the last glacial cycle. There is also evidence of a late-glacial advance around 16,000 years BP, after the Northern Hemisphere MIS 2 maximum of ~21,000 years BP. Deglaciation from LLGM positions appears to have occurred rapidly. Evidence exists for a late-glacial readvance that may have pre-dated the Younger Dryas of Northern Europe. This work contributes to the INQUA Commission on Glaciation, Working Group on Extent and Chronology.

#### 4-19 BTH 59 Çiner, Atilla

**LATE QUATERNARY GLACIERS AND GLACIAL DEPOSITS OF TURKEY**  
**ÇINER, Atilla**<sup>1</sup>, ZREDA, Marek<sup>2</sup>, BAYARI, Serdar<sup>1</sup>, and SARIKAYA, M. Akif<sup>1</sup>, (1) Dept. of Geological Engineering, Univ of Hacettepe, Beytepe-06532, Ankara, Turkey, aciner@hun.edu.tr, (2) Hydrology and Water Resources, Univ of Arizona, Tucson, AZ 85721  
 We are evaluating the extent of the influence of North Atlantic climatic events and of continental ice sheets on the paleoclimate of Turkey. Here, we report on our mapping of glaciers and glacial deposits, and on the assessment of their suitability for dating by cosmogenic nuclide accumulation and for extraction of paleoclimatic information.  
 Quaternary glaciers and glacial deposits occur in three broadly-defined regions:  
 1. The Taurus Mountains (Mediterranean coast and SE Turkey): Two thirds of the modern glaciers are in the SE part, where Mount Cilo (4135 m) alone supports more than ten large glaciers. In the central part, Aladag (3756 m) and Bolkardag (3524 m) have small glaciers and well developed moraine systems in several valleys. Even though there is evidence of past glacial activity in mountains such as Akdag (3016 m), Beydag (3070 m) and Sandiras (2295 m), no glaciers are present in the Western Taurus Mountains today. In general, glacial deposits in this region are well

preserved and suitable for cosmogenic dating because of the combination of high altitudes, low to moderate tectonic activity, and dry to moderately wet climate.

2. The Pontic Mountain Range (Eastern Black Sea coast): On the Mount Kaçkar (3932 m) five glaciers are present. Although several other mountains, such as Verçenik (3709 m) and Goller (3560 m) contain glacial valleys, the glacial depositional record is poor. Where moraines are present, they are generally unsuitable for cosmogenic dating. They are poorly preserved because of the combination of rapid tectonic uplift and extremely wet climate, both resulting in high erosion rates and destruction of landforms.

3. Volcanoes and independent mountains of the Anatolian Plateau: Mount Ararat (5165 m), near the Armenian border, supports an ice cap covering approximately 10 km<sup>2</sup> and several valley glaciers. The Mount Süphan (4058 m) near Lake Van, and Mount Erciyes (3917 m) in Cappadocia also show evidence of glacial activity and active glaciers. Several other mountains in Central Anatolia, such as Uludag (2543 m), Kesis (3549 m), Mount Mercan (3368 m), Mount Mescid (3239 m), and Balik Lake (2100 m) also bear traces of past glacial activity. The glacial deposits are generally well preserved, and, on some mountains, include several different glaciations.

#### 4-20 BTH 60 Szabo, John P.

##### PLEISTOCENE GLACIATION OF OHIO, U.S.A.: CURRENT STUDIES ON THE STRATIGRAPHY OF GLACIAL DEPOSITS AND RATES OF RETREAT OF WISCONSINAN ICE

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A relatively new map of the Quaternary geology of Ohio and older paleodrainage maps serve as a base maps for re-evaluating the late Pleistocene of Ohio. A pre-Illinoian ice advance reversed the drainage of Ohio that was dominated by a large northwesterly to westerly flowing river system referred to as the Teays River. Pre-Illinoian deposits underlie Illinoian deposits in southwestern Ohio and in deep buried valleys. Illinoian glacial deposits crop out beyond the Wisconsinian glacial limit in central and southwestern Ohio. Ohio was ice free from the Sangamonian Interglaciation to the Late Wisconsinian advances. The first Late Wisconsinian advances deposited sandy tills throughout the state, whereas younger Wisconsinian tills are clay rich.

Recent research in Ohio has sought to differentiate among Illinoian tills and to obtain subsurface data on the extent of these units. Current research into the origin and age of the interlobate area in northeastern Ohio has begun. Dating the timing of glacial retreat from the Wisconsinian limit through the use of bog bottom dates is a continuing process. Because the glacial lobes in Ohio reached closer to the equator than any ice sheet during the last glaciations, the retreat pattern provides insights to minor environmental changes. The ice sheet remained in a newly fully extended position for approximately 5,000 years with readvances reaching similar limits until 17,500 14C yr BP.

Recent dating of multiple small depressions (n ~ 25) along a former flow line approximately 100 km from the outer boundary and extending up ice shows that ice retreat had reached the location of a major moraine boundary by 16,000 14C yr BP. This significant retreat averaged ~70 m/yr, and in the Scioto sublobe deposited several small moraines. All geomorphic landforms (frost-wedge polygons on drift) and sediment indicators (extensive loess deposition), as well as regional climate indicators (e.g. Greenland ice cores), indicate that this retreat occurred during conditions similar to those of the full glacial. Although the details remain sketchy, the next major event in deglaciation occurred as the ice margin retreated north of a continental divide; a series of glacial lakes developed in the Lake Erie basin starting at ~14,000 14C yr BP as the ice margin retreated along the axis of the basin.

#### 4-21 BTH 61 Easterbrook, Don J.

##### GLOBAL, DOUBLE, YOUNGER DRYAS, GLACIAL FLUCTUATIONS IN ICE SHEETS AND ALPINE GLACIERS

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The Younger Dryas (YD) glacier readvance is now generally conceded by most scientists to have been global and essentially simultaneous, although some continue to dispute this. With the many new dates now available, a close look at YD moraines in widely separated parts of the world suggests that not only was the YD global, but may have been a double, rather single climatic oscillation.

Two well-dated, YD moraines were built by the Cordilleran Ice Sheet in the Fraser Lowland in the western U.S., Sumas III (10,980-10,250 14C yrs B.P.) and Sumas IV (~10,250-10,000 14C yrs B.P.). In the Wind River Range of the Rocky Mts., double, 14C- and 10Be-dated, alpine, YD moraines have been documented at Titcomb Basin (11 ka mean 10Be age on inner moraine) and at Temple Lake. Similar, but not yet well dated, double moraines occur elsewhere in the Rocky Mts. and in the Cascade Range of Washington.

A similar YD moraine pattern is also found in New Zealand at Arthur's Pass, where double YD moraines have mean 10Be ages of 11.8 ka and 11.4 ka, and at Birch Hill (mean 10Be ages 12.1 ka and 11.0 ka). The age of YD moraines at Prospect Hill, NZ is 12.7 ka 10Be yrs.

At Julier Pass, Switzerland the mean 10Be age of the outer YD moraine is 11.75 ka and 10.47 for the inner moraine. Even the classic YD moraines of the Scandinavian Ice Sheet are double.

The double nature of these YD readvances in widely separated regions on several continents in both hemispheres suggests a common, global, climatic cause.

#### 4-22 BTH 62 Meyer, Grant A.

##### LATE-PLEISTOCENE EQUILIBRIUM-LINE ALTITUDES, ATMOSPHERIC CIRCULATION, AND TIMING OF MOUNTAIN GLACIER ADVANCES IN THE INTERIOR NORTHWESTERN UNITED STATES

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We present equilibrium-line altitude (ELA) data for late-Pleistocene glaciers in eastern Oregon, central and northern Idaho, and western Montana, U.S.A. Over 500 cirque to small valley glaciers were reconstructed where moraines and other evidence for ice margins could be confidently interpreted on digital topographic maps. ELAs were estimated using the accumulation-area ratio method. Spatial patterns of ELAs show strong correspondence to present-day precipitation patterns, where modern dry regions have relatively high ELAs (e.g., 2600-2900 m at about 44.5°N in the Lost River and Lemhi Ranges, south-central Idaho). Wetter regions at similar latitudes have considerably lower ELAs (e.g., 2000-2200 m in mountains southwest of McCall, Idaho). Abrupt eastward increases in ELA across larger massifs such as the Wallowa, Sawtooth, and central Bitterroot Mountains imply orographic effects on westerly flow. The Columbia River basin of east-

ern Washington and Oregon provided a lowland corridor for moist, eastward-moving Pacific air-masses, producing anomalously low ELAs in bordering ranges, e.g., < 1800 m around 46.5°N in the Clearwater River drainage of northern Idaho, currently the wettest region of the study area. Smaller-scale features such as the Salmon and Payette River canyons also appear to have acted as conduits for moisture. GCM climate model results indicate that at the LGM, an anticyclone centered over the continental ice sheets and southward deflection of the jet should produce dry conditions in the interior northwestern U.S., although the anticyclone and associated easterlies across our ELA study area are weaker than in some previous simulations, and the ELA data point strongly toward a moisture source in the north Pacific Ocean. By 15 ka, northward retreat and decline in ice-sheet elevation cause contraction of the anticyclone, and winter westerlies from the north Pacific continue to strengthen across the study area until 12 ka. An associated increase in snowfall may have allowed more precipitation-sensitive mountain glaciers to remain near their maxima or expand during the post-LGM period, before the dramatic warming into the early Holocene. Similar positions and topography of continental ice sheets during buildup prior to the LGM might also promote glacial advances in mountain ranges of the interior northwestern U.S. by allowing strong westerly flow.

#### 4-23 BTH 63 Mercier, Jean-Luc

##### CARTOGRAPHY OF THE GLACIAL PAST OF THE VOSGES MOUNTAINS

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The Vosges are a mid latitude (48°N, 7°E) small relief, this mountain range is situated between the former Scandinavian and alpine ice caps regions and, therefore, represents a more common geomorphological position in the 48-53°N corridor during the Quaternary. Main results show that an autochthonous ice cap cover this area during the last glaciation. This general ice cap was divided in three before the (Last Glacial Maximum). On the basis of detailed geomorphological analysis and on some 10Be sampling sites, the deglaciation process is discussed and the related chronostratigraphy of landform evolution is established. For the Vosges mountains 4 areas are described: 1) in the south western part: it's the unique area we find the 4 limits; during the Maximum Glacial Extent older than 127 000 BP, extension of ice cap exceeded 70 km for the summit. 2) in the south eastern part: we have no arguments to map the MGEV nor the middle Würm, but in this part we can retrace very precisely the deglaciation of the Vosges. Permanent ice disappear from the main ridge and from eastern cirques at about 6.0 ka BP. 3) "Champ du Feu" area is an individual part covered by an ice cap during LGM and by periglacial process during YD. 4) the northern part, with low altitude, located in triassic sandstone, presents only the more younger glacial deposits.

#### 4-24 BTH 64 Osborn, Gerald

##### GLACIATION IN THE GREAT BASIN OF THE WESTERN UNITED STATES

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Forty individually named ranges, plateaus, and massifs draining wholly or partly into the Great Basin of the western United States show definite evidence of Pleistocene glaciation. The most obvious deposits are a family of moraines designated, among other names, "Tioga", "Angel Lake", and "Pinedale". Such moraines generally can be traced from range to range away from described type moraines. These deposits have been numerically assigned to late Wisconsinian glaciation in the Wasatch Range, White Mountains, Boulder Mountain, and Sierra Nevada on the basis of radiocarbon and surface-exposure ages, and have been assigned to late Wisconsinian time in several other ranges on the basis of relative-age studies.

The type Angel Lake moraine, and most other equivalent moraines across the Great Basin, are thick, hummocky, lobate piles of till rather than looping ridges. The thicknesses of the moraines (often 60+ m) can be explained by heavy debris loads, and/or glacial advance, retreat, and readvance to the same positions a number of times, which is consistent with recent evidence that multiple late Wisconsinian advances, possibly related to Heinrich and Dansgaard-Oeschger events, occurred in the Sierra Nevada.

Pre-Angel Lake deposits occur in many Great Basin ranges, but it is currently difficult or perhaps impossible to determine if these deposits are equivalent to each other and what their relationship is to pre-Tioga deposits in the Sierra Nevada. Numerical ages are rare and relative-age studies suggest that pre-Angel Lake deposits may be products of more than one glaciation. Mapped pre-Angel Lake glaciers were longer than their Angel Lake counterparts, but the length differences do not translate into large differences in ELA depression.

There is evidence of two minor latest Pleistocene or early Holocene advances in some ranges, judging from the presence of overlying Mazama tephra and/or weathering comparisons to local Angel Lake moraines. There does not appear to be a consistent pattern of latest Pleistocene/Holocene glacial fluctuations along an east-west transect through the Cordillera, or even through the Great Basin.

#### 4-25 BTH 65 Urdea, Petru

##### CONSIDERATIONS ON THE QUATERNARY GLACIATION IN THE MIDDLE MOUNTAINS OF ROMANIA

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The problem of the Quaternary glaciation of the Carpathian Mountains system in Romania was studied by many natural scientists in the last century. The problems of the glacial relief and Quaternary glaciation were addressed at the beginning of the twentieth century by Hungarian (Szadeczky, 1905, 1906) and Polish (Sawiki, 1909) researchers. Because the expressed opinions were controversial, I propose to clarify some aspects of this problem of great importance for the evolution of the Carpathian landscape and for the Romanian geosciences.

Starting from the previous research cited in the literature, I investigated representative mountain units in the Southern Carpathians and Apuseni Mountains and conducted the first investigations of glaciation in the Bihor Massif in the middle mountains area.

Under conditions of low temperatures and abundance of snow precipitation, plateau, cirque, and valley glaciers formed in the middle mountains during the Pleistocene. The glaciers left distinctive deposits and morphological features.

The pre-glacial relief played an important role in the formation of glaciers. The predominant winds from north and northwest determined the accumulation of snow and the appearance of the glaciers, especially on the slopes oriented to east and northeast, a situation representative of the Bihor Mountains, Maramureș Mountains, and Muntele Mic.

On the basis of geomorphological evidence, I conclude that the middle mountains of Romania were affected by two glaciations. During the maximum glacial stage, the reconstructed valley and cirque glaciers had modest dimensions, up to 1.5-2 km long and under 1 km<sup>2</sup> in area; only plateau glaciers were larger than 1 km<sup>2</sup>. The local snow-line in the study area was about 100-

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150 m lower than the highest mountains of Transylvanian Alps, at 1500-1550 m. Proceeding with the reconstruction of the climatic conditions, I conclude that at 1836 m asl, the altitude of Vidéasa meteorological station, the annual mean temperature was  $-11.65^{\circ}\text{C}$  (July and August,  $-1.7$  and  $0.5^{\circ}\text{C}$ ), and the annual precipitation was 870 mm. At 1108 m asl, the elevation of Stăna de Vale meteorological station, annual mean temperature was  $-9.5^{\circ}\text{C}$  (July and August,  $2.3^{\circ}\text{C}$ ), and the annual rainfall was 1238 mm. A second glacial stage was even less widespread, with only small cirque glaciers and niche glaciers.

### 4-26 BTH 66 Svendsen, J.I.

**NEW RECONSTRUCTIONS OF THE QUATERNARY ICE SHEETS IN THE EURASIAN ARCTIC**  
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The limits of the Eurasian ice sheets have been reconstructed for four glaciations during the Quaternary: 1) the Late Saalian (c. 160-140 ka) 2) the Early Weichselian (90-80 ka), 3) the early Middle Weichselian (60-50 ka) and 4) the Late Weichselian (20-15 ka). The reconstructed ice limits are based on satellite data and aerial photographs combined with comprehensive geological field investigations in Northern European Russia and Siberia, as well as interpretation of marine seismic- and core data from the adjacent continental shelf and deep sea. This is a synthesis of results obtained during the European Science Foundation Program "Quaternary Environment of the Eurasian North" (QUEEN). A huge glaciation that covered vast areas of northern Eurasia occurred during the Late Saalian (MIS 6). The maximum extent of the post-Eemian glaciation in the Eurasian Arctic occurred around 90-80,000 years ago (Early Weichselian - MIS 5b), when the Barents-Kara Ice Sheet expanded onto the Russian continent and blocked the northbound drainage towards the Arctic Ocean. A regrowth of the ice sheets occurred during the early Middle Weichselian, culminating about 60-50,000 years ago. During the Last Glacial Maximum (LGM) around 22-18,000 years ago the Scandinavian Ice Sheet attained its maximum position. At this time the Barents-Kara Ice Sheet embraced a much smaller area over the Russian Arctic than shown in most earlier reconstructions. A comparison of empirical ice sheet reconstruction with glaciological model simulations suggest that the ice sheet formation to a large extent can be explained by the interaction of sea level regressions, negative shifts in isolation and regional variations in precipitation rates.

This abstract is coauthored with coworkers of the ESF Program "Quaternary Environment of the Eurasian North" (QUEEN).

## SESSION NO. 5, 1:30 PM

Thursday, July 24, 2003

Paleoclimate I (Posters)

Reno Hilton Resort and Conference Center, Pavilion

### 5-1 BTH 67 Fink, David

**TIMING OF THE LAST GLACIAL MAXIMUM IN FIORDLAND, NEW ZEALAND - BUT WAS IT THE LARGEST ADVANCE ?**

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Dated speleothems interdeposited with glacioclastic sediments in Aurora Cave beside Lake Te Anau in Fiordland, southwest New Zealand, indicate that a glacial advance at MIS-4 was far larger than those that succeeded it. We compliment this archive of late Quaternary chronology with paired 10Be and 26Al in-situ cosmogenic exposure ages from lateral moraine erratics deposited along the glacial valley trough of Lake Te Anau directly overlying the cave. Whereas the speleothem evidence identifies non-glacial periods, in-situ exposure ages register the timing of the close of the intervening glacial phases or stadials. Our new results conclusively supports the assertion, unlike that observed in the Northern Hemisphere, that over the past 100 ka of the Last Glaciation cycle, the largest glacial advance in New Zealand was during MIS-4.

Over the face of the Te Anau valley sides, the ebb and flow of past glaciers have crafted a sequence of lateral moraine terraces, that staircase back in time with increasing altitude from 203 m at lake level to 975 m. In all we dated 27 granitic erratics from 9 of the 11 terraces mapped. Correction factors to local production rates included valley slope, terrace geometry, vegetation cover and variations in paleogeomagnetic dipole strength.

Coupling the uranium-series data and exposure ages at Te Anau, a coherent and interesting picture of the regional glacial chronology is emerging. Preliminary results, as a function of decreasing altitude, indicate glacial advances in Fiordland at 75- 65 ka BP, 28-25 ka BP, 21-19 ka BP and 17-14 ka BP. The data indicate that the maximum ice advance of the Last Glacial cycle was at 75-65 ka BP and, importantly, not at 20-18 ka LGM as observed in the Northern Hemisphere. Of interest, the youngest exposure dated terrace is the lowest altitude lateral moraine (20 meters above lake level) and is dated at 14-17 ka, occurring 2-3 ka earlier than the Younger Dryas readvance. Taken together this comprehensive chronology and ice extent questions the assumed synchronicity and amplitude of global glacial advances at the millennial age scale.

### 5-2 BTH 68 Newnham, Rewi M.

**LATE QUATERNARY ENVIRONMENTAL CHANGE FROM LAKE OMAPERE, NORTHLAND, NEW ZEALAND**

NEWNHAM, Rewi M.<sup>1</sup>, LOWE, David J.<sup>2</sup>, GREEN, John D.<sup>2</sup>, TURNER, Gillian M.<sup>3</sup>, HARPER, Margaret A.<sup>3</sup>, MCGLONE, Matthew S.<sup>4</sup>, STOUT, Stephen<sup>2</sup>, HORIE, Shoji<sup>5</sup>, and FROGGATT, Paul C.<sup>3</sup>, (1) Dept. of Geography, Univ. of Plymouth, Plymouth, PL4 8AA, United Kingdom, rnewnham@plymouth.ac.uk, (2) School of Science & Technology, Univ of Waikato, Bag 3105, Hamilton, New Zealand, (3) Research School of Earth Sciences, Victoria Univ of Wellington, Box 600, Wellington, New Zealand, (4) Landcare Rsch, Box 69, Lincoln, New Zealand, (5) GeoForschungsZentrum, Telegrafenberg, D-14473, Potsdam, Germany  
Lake Omaperere is a large, shallow (2 m), eutrophic lake in northern New Zealand (35° S, 174° E) from which we obtained a discontinuous record of environmental change since ~80 cal ka by analysis of a 7-m core. Ages were obtained via tephrochronology, paleomagnetism and <sup>14</sup>C plus climato- and palynostratigraphy. Three of 14 tephras provided markers for correlating the record with other sequences and with marine isotope stages: T-13 (~74 cal ka) was deposited near MIS 5a-4 boundary, Rotoehu (Re) (~55 cal ka) was deposited early in MIS 3, and Kaharoa (Ka) (AD 1314 ± 12) marks late MIS 1. The initial (alkaline) lake formed ~80 cal ka, inundating peat and forest trees. It filled rapidly to levels ~1-2 m above that at present. The subsequent phase of variable but generally falling levels and increasing dystrophy may have been climatically controlled. The lake became swampy/dry early in MIS 3, soon after Re fell. Non-deposition (or non-preservation)

characterizes most of MIS 3, all of MIS 2, and probably most of MIS 1 until formation of the modern lake ~700 cal yr ago, or soon after, as indicated by the presence of Ka near the top of the core. Ka also provided a maximum date for Polynesian settlement, shown palynologically by initial forest clearance soon after its deposition. Except for the human era, forest appears to have been continuously dominant near L. Omaperere. *Nothofagus* (probably *N. truncata*) (beech) was much more common in Northland during the Last Glacial (LG) and its relative abundance vs. *Agathis* (kauri) pollen provides a better indicator of cooler vs. warmer intervals in the Quaternary than the ratio of tree to non-tree pollen. Moisture balance was probably more critical than temperature in controlling vegetation composition and distribution, particularly during MIS 2. Several tree species (*Halocarpus bidwillii*, *H. biformis*, *Phyllocladus alpinus*) occurred ~2° latitude farther north and at much lower altitudes than their current limits during cooler or drier phases of the LG, and a temperature depression of 4° C at various times in Northland during the LG is inferred from these range expansions. But the persistence of widespread forest cover suggests that L. Pleistocene climates of Northland were less severe than elsewhere in New Zealand, supporting evidence for a strong latitudinal temperature gradient across N.Z. during MIS 4-1.

### 5-3 BTH 69 Johnson, Beverly J.

**LATE QUATERNARY VEGETATION HISTORY OF THE KEEP RIVER NATIONAL PARK, NORTHERN TERRITORY, AUSTRALIA**

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A 30,000 year record of paleoenvironmental change has been derived from the stable isotope composition of the bulk organic carbon fraction and lipid biomarkers extracted from a core taken from a mound spring at the Keep River National Park, Northern Territory, Australia. The bulk sediment carbon isotope data represent a mix of C<sub>3</sub> and C<sub>4</sub> plants between 30,000 and 12,000 <sup>14</sup>C yr BP, (δ<sup>13</sup>C values range between -28 and -14‰) and nearly 100% C<sub>3</sub> plants between 9,000 <sup>14</sup>C yr BP and present (δ<sup>13</sup>C values approximate -28‰ for the time period).

The carbon isotope composition of the long chain fatty acids (δ<sup>13</sup>C<sub>LCFA</sub>) diagnostic of higher plants (C<sub>24</sub>, C<sub>26</sub>, C<sub>28</sub>) range between -25 and -27 ‰ from 30,000 to 18,000 <sup>14</sup>C yr BP, indicating that the region was dominated by C<sub>4</sub> plants (grasses, and possibly sedges). After 18,000 <sup>14</sup>C yr BP, the δ<sup>13</sup>C<sub>LCFA</sub> decrease to approximately -35 ‰ by 9,000 <sup>14</sup>C yr BP and remain constant to the present day, indicating that the region was composed of a 50-50 mix of C<sub>3</sub> and C<sub>4</sub> plants.

There is good agreement between the bulk sediment and compound specific isotope data between 30,000 and 9,000 <sup>14</sup>C yr BP; C<sub>4</sub> plants dominate the organic input to the site. During the Holocene, however, there is an apparent discrepancy between the bulk and compound specific isotope data that can be explained by a shift in depositional setting at the site. As the mound spring becomes established and elevated relative to the surrounding plains (beginning at 9,000 <sup>14</sup>C yrs BP), fewer materials can be washed in from the surrounding environment. The bulk sediment isotope data represent organic deposition at the mound-spring proper (i.e., 100% C<sub>3</sub>). The n-fatty acids can be transported via wind and/or water, and therefore represents a mix of local (i.e. C<sub>3</sub>) as well as distal (i.e., C<sub>4</sub>) plant sources.

The fatty acid distributions and the δ<sup>13</sup>C<sub>LCFA</sub> values indicate the establishment of a reliable source of water (i.e., the mound spring) at the site by the early Holocene. These fatty acid and isotopic data provide evidence for a shift from arid and/or cooler conditions during the Last Glacial Maximum (21,000 to 18,000 <sup>14</sup>C yr BP) (i.e., C<sub>4</sub> grass dominance) to consistently wetter conditions by the early Holocene (10,000 <sup>14</sup>C yr BP) (i.e., C<sub>3</sub> vegetation at the site surrounded by C<sub>4</sub> grass plains) in response to enhancement of the Australian summer monsoon.

### 5-4 BTH 70 Moss, Patrick Tobias

**AN ENVIRONMENTAL HISTORY OF NORTHEASTERN QUEENSLAND, AUSTRALIA FROM 250,000 TO 500,000 YEARS BP BASED ON THE ODP 820 MARINE CORE**

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The ODP 820 marine core has provided a continuous, though generalized record of vegetation, burning and climatic change for the humid tropics of northeastern Australia over the last 1.5 million years (Kershaw et al., 1993). A more detailed pollen and charcoal analysis has been undertaken for the last 250,000 years (oxygen isotope stages 8 to 1) (Moss, 1999, Moss and Kershaw, 2000) and compared with an equally detailed oxygen isotope record from the core. The palynological record provides evidence of cyclical environmental changes linked to Milankovitch periodicities, as well as 3 profound alterations in vegetation and burning linked to non-cyclical alterations (at 170,000 years BP, 135,000 to 130,000 years BP and 45,000 years BP). This refined analysis of the ODP 820 core is in the process of being extended from 250,000 to 500,000 years (oxygen isotope stages 8 to 13) in order to provide a firmer basis for explanation of the late Quaternary events in relation to regional tectonics and possibly associated changes in atmospheric and oceanic circulation patterns in the west Pacific.

Kershaw, A.P., McKenzie, G.M., McMinn, A., 1993. A Quaternary vegetation history of northeastern Queensland from pollen analysis of ODP site 820. Proceedings of the Ocean Drilling Program Scientific Results 133, 107-114. Moss, P.T., 1999. Late Quaternary environments of the humid tropics of northeastern Australia. unpublished Ph.D. thesis, Monash University, Australia. Moss, P.T., Kershaw, A.P., 2000. The last glacial cycle from the humid tropics of northeastern Australia: comparison of a terrestrial and marine record. Palaeogeography, Palaeoclimatology, Palaeoecology 155, 155-176.

### 5-5 BTH 71 Samarajalingam, Shanmuganandan

**PALEOCLIMATE AND GLOBAL CHANGE: A STUDY OF INDIAN MONSOON IN UNDERSTANDING CLIMATE CHANGE DYNAMICS AND MAJOR DIMENSIONS**

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The study of climate variations and related oceanic phenomena in the Asia-Pacific sector including the Indian, polar and subpolar Oceans is of immense importance to contribute toward establishing advanced prediction schemes. Numerical simulations using ocean and atmosphere models of various degrees of freedom as well as data analyses are particularly emphasized its significance in order to understand the basic processes generating those climate variations. The paleoclimate record makes it clear that abrupt climate shifts known to have occurred in the 20th century are only a subset of possible surprise climate system behaviors that have occurred in the more distant past and might be expected to occur in the future. The present study attempts to summarize the state-of-the-art and guide efforts to focus the climate predictability in relation to Indian

Monsoon as a result of abrupt climate change dynamics. The present study concentrates in analyzing the irregularities of the Indian monsoon that govern food production for billions of people, often in countries where the poorly developed infrastructure and lack of agricultural and financial reserves exacerbate the vulnerability to climate variability. The study with the help of paleoclimate data attempts to understand the climate change dynamics with reference to temperature precipitation and pressure variation and seasonal changes of the onset and late arrival of the in different time periods of the Indian monsoon and its variability in relation to ENSO events. An emphasis is also made to understand the climate change dynamics as a result of monsoon irregularities caused due to monsoon circulation, the imbalance in the rate and magnitude of seasonal heating and cooling over the land and ocean. The studies have also revealed that ENSO variations are linked to monsoon strength and also an prediction is made that ENSO warm phases which act as the connective system that usually determines the relationship between the monsoon convective base and Southern oscillation. The present with the help of the paleoclimate data and also with the help of case studies attempt to establish the findings related to climate change dynamics of Indian Monsoon. The study thus highlighted that the strength of the Monsoon in many regions were linked to ENSO variations.

### 5-6 BTH 72 Sarkar, A.

#### STABLE ISOTOPES OF ESTUARINE WATER AND OYSTER SHELLS FROM GANGES DELTA, INDIA: PALAEOENVIRONMENTAL IMPLICATIONS

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Stable isotope analyses of oyster species *Crassostrea cuttackensis* (exhibiting easily identifiable seasonal growth bands) vis-à-vis modern isotope hydrology of Ganges delta estuary indicate significant change in palaeoenvironment.  $18\text{O}/16\text{O}$  and  $13\text{C}/12\text{C}$  ratio in oyster are controlled by the local salinity, temperature and  $\delta^{13}\text{C}$  DIC of water where they inhabit.  $\delta^{18}\text{O}$  water and  $\delta^{13}\text{C}$  DIC of the estuarine water show positive correlation with salinity, indicating that both are controlled by the seasonal monsoon induced freshwater discharge into this estuarine system. Predicted  $\delta^{18}\text{O}$  values exhibit a seasonal spread of  $\sim 5.5\%$  while that of  $\delta^{13}\text{C}$  show a spread of  $\sim 16\%$ . The results show that the strong monsoon periods are characterised by depleted oxygen and carbon isotope values owing to the high river discharge and  $\text{CO}_2$  from decomposed terrestrial organic matter. Conversely the periods of bad monsoon exhibit enriched oxygen and carbon values.  $\delta^{18}\text{O}$  and  $\delta^{13}\text{C}$  data of both oyster and predicted equilibrium carbonates show positive correlation of similar slope indicating that salinity cum river discharge controlled the isotopic compositions of carbonates the same way during the oyster growth as it does today. Compared to predicted values of  $\sim 5.5\%$  the total range in oyster is less, about  $\sim 4.1\%$ . Also the oyster calcite shows enriched values both in maximum and minimum  $\delta^{18}\text{O}$  and  $\delta^{13}\text{C}$  indicates that riverine fresh water discharge changes salinity and  $\delta^{13}\text{C}$  DIC on seasonal scale. Predicted highly depleted  $\delta^{13}\text{C}$  values during the peak river discharge are not recorded in the oyster as their growth are stunted or even stopped during this extreme low salinity condition. The results indicate that systematic stable isotope analyses of fossil oyster beds from this area, deposited during the historical period, can be a promising tool for studying the eustatic and palaeomonsoon change over Indian subcontinent.

### 5-7 BTH 73 Tripathi, Jayant K.

#### ISOTOPIC ( $\text{Sr}^{87}/\text{Sr}^{86}$ AND $\text{Nd}^{143}/\text{Nd}^{144}$ ) EVIDENCE FOR A HIMALAYAN PROVENANCE TO THE THAR DESERT SEDIMENTS AND ITS IMPLICATION

TRIPATHI, Jayant K. I, BOCK, Barbara<sup>2</sup>, RAJAMANI, V<sup>1</sup>, and EISENHAEUER, A<sup>2</sup>, (1) School of Environmental Sciences, Jawaharlal Nehru Univ, New Delhi, 110067, India, jktrip@yahoo.com, (2) GEOMAR, Wischofstrasse, 1-3, D-24148 Kiel, Germany  
The origin of the Thar Desert, particularly the source of the desert sands, is a much-debated topic of the Quaternary geology of India. Remote sensing, archeological and paleohydrological studies show that this region was experiencing a humid climate and was drained by many Himalayan rivers in the Late Quaternary times. In the green forest countryside of this region flourished one of the greatest civilizations, i. e., the Indus Valley Civilization (3500-1500 B. C.) which subsequently vanished under a hostile arid climate. In order to understand the nature and source to the desert materials and the cause of desertification, the geochemistry (REE, Nd and Sr isotopes) of the sediments from north and northeastern part of the Thar desert and the floodplains of the present day Himalayan rivers (Ganges, Yamuna, Sutlej and Ghaggar) draining from different catchments of the Himalayas have been studied. We observed that the rivers draining the High Himalayas today have radiogenic sediments ( $87\text{Sr}/86\text{Sr} = 0.752715 - 0.789324$ ;  $143\text{Nd}/144\text{Nd} = 0.511682 - 0.511835$ ). However, the desert sediments are less radiogenic ( $87\text{Sr}/86\text{Sr} = 0.728984 - 0.735157$ ;  $143\text{Nd}/144\text{Nd} = 0.511825 - 0.511994$ ). Comparing with those of the various distinct lithotectonic units of Himalayan orogen, we infer that whereas the desert materials could have been derived from less radiogenic Sub-Himalayan Tertiary sediments, those of the alluvium were derived from High Himalayan Crystallines. Because the rivers draining the Sub-Himalayan ranges could have lacked perennial water sources (glacial), unlike those of the present day rivers draining through the Higher Himalayas, their flow must have been largely controlled by monsoon rainfall. Any change in the intensity and pattern of monsoon rainfall should have made these rivers initially ephemeral and finally extinct. Present day arid phase must have followed the humid phase, resulting in aeolian reworking of Sub-Himalayan river alluvium and desert formation.

### 5-8 BTH 74 Cai, Yanjun

#### VARIATION OF THE INDIAN MONSOON DURING THE PERIOD OF 50-11 KA: INFERRED FROM SPELEOTHEM RECORDS IN YUNNAN PROVINCE, SOUTHWESTERN CHINA

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Thirty-nine ICP-MS 230Th-234U dates show that three stalagmites, collected from two adjacent caves in Yunnan Province, SW China, were deposited between 50 and 11ka B.P. and that two of them grew contemporaneously between 18 and 15 ka B.P. Considering dating errors and resolution differences, the  $\delta^{18}\text{O}$  variation of two stalagmites are similar during the interval of contemporaneous growth. Moreover, R2 values between  $\delta^{18}\text{O}$  and  $\delta^{13}\text{C}$  for each stalagmite are low, showing no evidence for kinetic fractionation.

Meteorological records and  $\delta^{18}\text{O}$  analysis of precipitation reveal that monsoon circulation strongly affects the amount and isotopic composition of precipitation at the city of Kunming, Yunnan Province. Seepage water in the caves may be mainly recharged in the rainy season (May to Oct.), because more than 85% of annual precipitation falls during this period. The amount of rainfall during the rainy season anti-correlates with the  $\delta^{18}\text{O}$  values of the precipitation, while temperature does not correlate significantly with the  $\delta^{18}\text{O}$  values. The large range of the  $\delta^{18}\text{O}$  values suggests that rainfall amount—which is affected by the monsoon intensity—may be an important control. Nevertheless, we cannot exclude the effect of temperature since it affects the fractionation between deposited calcite and drip water.

The  $\delta^{18}\text{O}$  record shows the Indian Monsoon varied significantly on century to millennium time scales during the last glacial period, resembling cave Monsoon records further to the east and D-O cycles from Greenland ice cores. As opposed to records further east, the long-term trend does not appear to follow summer insolation at the cave site, suggesting that in this region, the Indian Monsoon may respond nonlinearly to insolation forcing when its intensity is affected by Eurasian snow cover and ice sheet extent. The close linkage between D-O events and  $\delta^{18}\text{O}$  variation indicates a positive correlation between high northern latitude temperature and moisture transmission from low to high northern latitudes. During the YD, our high resolution  $\delta^{18}\text{O}$  record has many high amplitude oscillations distinct from the long cold period recorded in Greenland. In comparison with other records during the YD, our record is consistent with the idea that fluctuation in precipitation within the YD chronozone is related to low-latitude forcing.

### 5-9 BTH 75 Jiang, Wenying

#### HOLOCENE MONSOON CHANGES INFERRED FROM LAKE SEDIMENT POLLEN AND ISOTOPE IN NORTHERN CHINA

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A 1.8m core collected in Lake Bayanchagan, northern China is analyzed for radiometric chronology, pollen and isotope content of authigenic, inorganic carbonate. The core provides a continuous Holocene record. Changes in stable carbon and Oxygen isotopic contents of authigenic carbonates and arboreal pollen percentage reveal significant changes in environmental conditions, induced by climate changes that might have been resulted from East Asian monsoon changes. Quantitative reconstruction of Holocene paleoclimate has been carried out using a model based on pollen data. An increase in arboreal pollen percentage at 9.7 ka BP coincides with a significantly negative shift in oxygen isotopic composition. The quantitative reconstruction shows the precipitation and the mean temperature of the coldest month may increase by  $\sim 50$ -100mm and  $\sim 2$ -4 degrees, respectively. A dry event happened at  $\sim 4.6$  ka BP characterized by a rapid decrease in arboreal pollen percentage, and changes of carbon and oxygen isotopic compositions towards more positive values. The precipitation and the mean temperature of the coldest month may decrease by  $\sim 100$ -200mm and  $\sim 3$ -5 degrees, respectively.

### 5-10 BTH 76 Zhou, Weijian

#### GEOLOGICAL EVIDENCE FOR SPATIAL VARIATION OF THE YOUNGER DRYAS EVENT

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The Younger Dryas chronozone, recognized in northern high latitude areas as a cold event between 11,000 and 10,000  $^{14}\text{C}$  yrs BP (12,900  $^{\circ}\text{C}$  11,600 cal. yr. BP), seems to manifest itself globally in different ways. Here, we examine well-dated stratigraphic sequences together with high-resolution proxy data plots from sites across our study area, the arid/semi-arid transition zone in northern China. This climatically sensitive area of China records a cold, dry Younger Dryas climate, which was punctuated by a brief period of summer monsoon precipitation. We have since found that similar climatic sequences have been reported from the Sahel and the equatorial region of Africa. Based on evidence from these sites, together with other published data, we postulate that precipitation during the Younger Dryas chronozone was indicative of a low-latitude driving force superimposed on the high latitude cold background. This rain belt rearrangement was most probably caused by an interaction between cold air advection and summer moisture transport across the tropical Pacific Ocean. Examination of high resolution proxies suggest short-term climate fluctuations indicative of a large scale teleconnection involving moist air transportation patterns from the tropics to higher latitudes, varying with ENSO and other tropical factors.

### 5-11 BTH 77 Oba, Tadamichi

#### TELE-CONNECTION BETWEEN EAST CHINA SEA AND GREENLAND

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A 33.65 m long IMAGES core with very high sedimentation rate (ca. 80cm/ka) from the northern part of the East China Sea was analyzed at 10 cm (about 125 years) intervals using oxygen-carbon isotope of Globigerinoides ruber (sense strict) and sea surface temperature (SST) estimates from alkenones. The general pattern of the oxygen isotope curve is similar to the standard oxygen isotope curve in open ocean and shows many light oxygen isotope peaks similar to Dansgaard-Oeschger (D-O) cycles observed in Greenland ice cores since the last 43 ka. The alkenone SST curve of the core resembles to the oxygen isotope curve. The SST at the core top is 24 degrees centigrade, which is close to the present mean SST in June at the core site. Whereas the SST at the LGM is about 5 degrees centigrade lower than present-day. The alkenone SST curve does not show high values at the light oxygen isotope peaks of the D-O cycles. This suggests that these light oxygen isotope peaks were formed at the warm (D-O) events when fresh water was supplied to the core site. The sea surface salinity reconstruction using the oxygen isotope and alkenone SST values suggests that the low salinity (31-32 psu) events are observed at the LGM, due to the progressive movement of the river mouths of the Yellow and Changjiang Rivers to the core site in response to the sea level drop. Similar salinity drops are also observed at the warm events of D-O cycles, due to the increased precipitation in East China. Tele-connection between East Asia and Greenland must be caused by the meander of the westerly during the cold and warm D-O cycles.

### 5-12 BTH 78 Zhang, De'er

#### ADVANCES IN THE STUDY OF RAINFALL VARIATIONS IN THE HISTORICAL PERIODS OF CHINA

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Our work succeeded in retrieving the events, reconstructing the sequences and extremes of historical precipitation, as shown below.

1) In recent years an attempt has been made to reduce grid-based anomaly fields from historical descriptions. With the aid of computers and the "A Compendium of Chinese Meteorological Records of the Last 3000 Years" as basic data, different values were assigned to related grid points according to the descriptions and through interpolation a rainfall anomaly field was computed.

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er-retrieved in a way that denotes grid anomalies by -1, 0 and +1 at a 1-year and a 1x1 lat./long. resolution. We have thus reduced tentatively the anomaly fields in 1501-1900 annual precipitation for the eastern part of China, attaining a total of 400 grid-based maps and intend to employ in addressing climate change and verifying output from numerical models.

2) Restudy of rainfall descriptions from the "Daily Weather Records" covered 1724-1904 made in Qing Dynasty for Beijing . The present work recalculated the retrievals and investigated its techniques, whereupon we propose an 8-factor stepwise regression scheme to "translate" the descriptions into seven categories of daily rainfall intensity, from which monthly precipitation totals are obtained in conformity with contemporary rainfall data. Thereby we get rainfall series on a seasonal and an annual basis in 1724-2000.

3) Retrieval of extremely dry and wet events in historical periods e.g., those of large-scale excessive precipitation on a continuous basis in 1552-1553, 1755-1757 and 1870-1872, and of extensive persistent droughts, in 1484-1485, 1527-1529, 1784-1787 and 1876-1878. It is worth noting that many of the historical extremes exceed in severity the counterparts to much greater extent that have merged in the past 50 years.

### 5-13 BTH 79 Zhou, Jie

QUATERNARY ENVIRONMENT ANALYZING IN CHINA WITH THEMATIC MAPPING  
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It is necessary and possible to provide some more clear images of Quaternary Paleo-environment in China based on newly researches in this field. Thematic maps of three special stages, that is, Holocene (6ka), Last Glacial Maximum (18ka), and Late Interglacial Stages (120ka) have been mapped by computer-aided mapping techniques. Natural environment elements such as glaciers, frozen earth, deserts, bio-climate zones, etc., have been considered as basic layers to constitute the maps. Analysis of these maps in terms of spatio-temporal relations of different environment elements in a single map and between maps shows that the formation and transformation process of Paleo- East Asia Monsoon impact greatly on spatial and temporal distribution on Quaternary deposits and other environment elements as well. Statistics shows that glaciers areas in the following four different stages, present time, Holocene (6ka), the Last Glacial Maximum (18ka), and the Late Interglacial Stage (120ka) are 59600km<sup>2</sup>, 50300km<sup>2</sup>, 296100km<sup>2</sup>, and 50100km<sup>2</sup>, while the corresponding desert area are 1533000 km<sup>2</sup>, 800400 km<sup>2</sup>, 2268600 km<sup>2</sup>, and 780300 km<sup>2</sup> respectively. The southmost spots of bio-climate between cold temperate zone and temperate zone, temperate zone and subtropical zone—subtropical zone and tropical zone in eastern monsoon area in China are 49.7N, 41.7N, 23.2N in Holocene (6ka), and 51.02N, 41.8N, 23.7N in Late Interglacial Stage (120ka). And 38.8N, 22.4N were southmost spots of bio-climate between cold temperate zone and temperate zone, whereas subtropical zone and tropical zone disappeared in mainland and shifted to South China Sea in Last Glacial Maximum (18ka), which reflect the large scale movements of the bio-climate zone with global climate and environment changes. Furthermore, backgrounds and factors of these paleo-environment changes is put forwards.

### 5-14 BTH 80 Feng, Weimin

MICROGASTROPOD TROPHIC STRUCTURE OF YONGSHU REEF, SCS SINCE THE LATEST PLEISTOCENE WITH BEARING ON PALEOENVIRONMENT

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Yongshu reef, South China Sea has been important subject for research on Quaternary paleoceanography of South China Sea in the last ten years. Reported here are microgastropods since late Pleistocene according to core1 of Yongshu reef. Research shows that there were four microgastropod communities, known respectively as microgastropod community of recent inner reef flat facies, that of lagoon slope facies, that of beach facies and that of inner reef flat facies on the basis of microgastropod diversity and trophic composition. Among them, the former three communities belong to the Holocene in addition to one in the latest Pleistocene. Research shows that the primary customers within every community are dominated by trophic category known as herbivores and gross primary customers always greatly exceed successive carnivore throughout the latest Pleistocene and the Holocene. Research also shows that microgastropod diversity and abundance in the Holocene are much richer than that in the latest Pleistocene, for example, microgastropods in the inner reef flat facies of the late Pleistocene only comprise 4 genera whereas that of Holocene 16 genera in the beach, 35 genera in the lagoon slope and 23 genera in the recent inner flat communities. It is therefore obvious that community of lagoon slope facies is the most developing stage of Holocene microgastropods and it can be further divided into three stages. In the early stage herbivores, carnivores—deposit-feeders and suspension-feeders appear, but with the deepening of waters the suspension-feeders disappeared and the deposit-feeders still developed to the middle stage, by comparison, equal to stage of high sea level of the middle Holocene, in which the trophic categories are the most abundant. In the late stage the deposition rate that abrupt increased may directly resulted in disappearance of a majority of deposit-feeders, but an herbivore *Tricola (Hiloa) variabilis* developed particularly at this stage. The suspension-feeders occurred mainly in the early stage of the lagoon slope and the late stage of the recent reef flat in which relatively strong water turbulence may exit. The research shows that trophic feeder categories are of significance in documenting environmental change of coral reef. Acknowledgement: Project (40176030) is supported by NNSFC.

### 5-15 BTH 81 Chen, Min-Te

CENTENNIAL TO MILLENNIAL SCALE HYDROGRAPHIC VARIATIONS IN THE NORTHERN AND SOUTHERN SOUTH CHINA SEA DURING THE PAST 10-70 KYR

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The South China Sea (SCS) is a place that is influenced by the East Asian Monsoon and Western Pacific Warm Pool (WPWP) systems. The SCS sediments are highly sensitive recorders of past climate in the tropical oceans as its marginal sea location causes it to accumulate sediments rapidly from both marine and terrestrial sources. Here we present a high-resolution sea surface temperature (SST) and salinity (SSAL) records from an IMAGES core MD972151, which is located at the southwestern SCS. The SSTs were estimated by revised planktic foraminifer fauna transfer function and alkenone methods. We calculated the SSAL by deconvoluting the planktic foraminifer  $\delta^{18}O$  record into components of temperature, salinity and ice volume components correction. In focusing the past 10-70 kyr variations, we used AMS 14C dating and also age-tuning the  $\delta^{18}O$  to match a Hulu cave stalagmite record from the mainland China. Within the uncertainty of our age controls, the MD972151 record reveals high-frequency SSAL variations that varied in accord with

Dansgaard/Oeschger cycles shown in the Hulu Cave stalagmite and the Greenland ice core (GISPII) records. The SSAL estimates were relatively higher during the major episodes of high-latitude cooling and were lower during major interstadials. The patterns of the SSAL estimates are echoed by the variations of a color reflectance proxy for terrestrial precipitation. The precipitation proxy was derived from the first derivative of visible light spectra of sediment surface color, which is indicative of the changing compositions of goethite relative to hematite (G/G+H). The precipitation index shows lower/or arid during the Heinrich-like cooling events, and higher/or moist in major interstadials. The records of SSAL and precipitation index variations provide data supporting the hypothesis calls upon the shift in the tropical Pacific ocean/atmosphere system analogous to modern El Niño–Southern Oscillation (ENSO) driving past climate change.

### 5-16 BTH 82 Lin, Hui-Ling

SEASONAL VARIATION OF PLANKTONIC FORAMINIFERAL ISOTOPIC COMPOSITION FROM THE SEDIMENT TRAPS IN THE SOUTH CHINA SEA

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Impurities of seasonal hydrographic change on the two common planktonic foraminiferal shells, *Globigerinoides sacculifer* and *Globigerinoides ruber*, were discussed based on specimens collected from the sediment traps deployed in the northern South China Sea. Generally the isotopic composition of *G. ruber* is more depleted than that of *G. sacculifer* for both  $\delta^{18}O$  and  $\delta^{13}C$ . The lowest  $\delta^{13}C$  values associated with relative heavy  $\delta^{18}O$  in January and March for both species are indicative of enriched nutrient contents in the surface water induced by winter monsoon. In addition, the  $\delta^{13}C$  of *G. ruber* shows a better (negative) relationship with corresponding particulate mass fluxes than *G. sacculifer*. *G. ruber* thus seems to be more sensitive than *G. sacculifer* in reflecting the sea surface nutrient conditions in terms of paleoceanographic application. The covariance between  $\delta^{18}O$  and  $\delta^{13}C$  values in *G. ruber*, however, is as two times more than *G. sacculifer* (with a  $\delta^{18}O/\delta^{13}C$  slope of -1.29 vs. -0.61). The relationship is different from what would be expected for most biogenic carbonates (0.25–0.33) caused by the enhanced kinetic fractionation at higher ambient carbonate ion concentrations  $CO_3^{2-}$ . Nevertheless, similar regression slopes of  $\delta^{18}O/\delta^{13}C$  ranging between -0.52–-0.6 are also derived based on *G. sacculifer* shells collected by plankton tows. It is possible that factors other than carbonate ion effect are responsible for negative correlation between  $\delta^{18}O$  and  $\delta^{13}C$  in this region. In comparison with downcore records, the  $\delta^{13}C$  compositions of traps samples are significantly lighter than those from core samples with comparable  $\delta^{18}O$  values. The shift of  $\delta^{13}C$  between trap and core samples should be the consequence of preservation (burial diagenesis).

### 5-17 BTH 83 Wang, Chung-Ho

THE MIXING OF WATER MASSES OFF SOUTHWEST COAST OF TAIWAN

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Water mass mixing in the continental shelf is one of important phenomena regarding the interaction among seawater, river and groundwater discharges. Water samples were collected along three transects off the southwest coast of Taiwan from different seasons in 2001 and 2002 to explore the details of water mass movement. Temperature (T), salinity (S) and oxygen isotope compositions ( $\delta^{18}O$ ) in the seawater samples all exhibited apparent seasonal variations. In the wet season, there were distinct gradients of T, S, and  $\delta^{18}O$  in illustrating the active mixing between seawater and river discharge in the surface layer. However, the surface gradients almost disappeared and seawater signal became dominant during the dry season due to very low output of river flow. The vertical profiles of T, S and  $\delta^{18}O$  also displayed seasonal variations for each sampling site. Evidence of Kuroshio was barely detected for remote stations at a depth of 150m in summer, but was found everywhere for a layer from 50m to 300m in the winter. Traces of groundwater discharge were observed along the Kaoping Canyon at depths of 400-600m and 1200m, respectively, in the wet season. Our findings can serve as valuable basis for the understanding the coastal oceanography and a further modeling work of seawater encroachment in the southwestern Taiwan.

### 5-18 BTH 84 Han, Hyuk-Soo

LATE QUATERNARY SEQUENCE STRATIGRAPHY AND DEPOSITIONAL ENVIRONMENTS THE SOUTHERN CONTINENTAL SHELF OF KOREA

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High-resolution seismic profiles and a number of sediment cores were analyzed to reconstruct the sequence stratigraphy of late Quaternary deposits in the southern continental shelf of Korea. The late Quaternary sequence above the unconformity can be divided into transgressive systems tract and highstand systems tract according to acoustic characteristics and external geometry. These systems tracts comprise five depositional systems which show a different seismic facies and lithofacies association. Between the transgressive surface and the maximum flooding surface, four depositional systems (incised-channel fill, transgressive estuarine/deltaic complex, transgressive sand sheet, and transgressive sand ridge) constitute the transgressive systems tract. Incised-valley fill depositional systems occur across the shelf from the present river mouth to the shelf margin. Transgressive sand sheet and sand ridge depositional systems are present over a wide area of mid-shelf, whereas transgressive estuarine/deltaic complex depositional systems occur on the inner shelf. The topmost depositional system (recent mud) above the maximum flooding surface represents the highstand systems tract formed during the recent highstand of sea-level.

### 5-19 BTH 85 Kanagawa, Kazuto

PALEOENVIRONMENTAL CHANGES SINCE THE LAST GLACIAL STAGE IN CENTRAL HOKKAIDO, JAPAN

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Hokkaido is situated at the northeastern edge of continental Eurasia, surrounded by the North Pacific, the Sea of Okhotsk, and the Sea of Japan. We present a brief report concerning the changes in vegetation on Hokkaido during the last glacial stage. At that time, high mountains

were the only areas in the Japanese islands that were covered with glaciers. Five moorland sites located along 43 degree N were studied with regard to their forest history, and the following results were obtained: 1. Some pyroclastic layers in the peat cores were correlated with pyroclastic ash deposits from the Tarumae volcano in Hokkaido, and their stratigraphy has already been established. 2. Site Yu2 is located at an altitude of 75 m, where there are 3 pollen zones in descending order from zone Yu2-A to zone Yu2-C. Yu2-A is characterized by *Picea* pollen, Yu2-B by *Quercus*, and Yu2-C by *Salix*. 3. Moor Ku1 is located at an altitude of 49 m, where there are 4 pollen zones in descending order from Ku-A to Ku-D. In these zones, *Tsuga*, which has already disappeared due to paleoenvironmental changes in this area, accounted for about 5% of total pollen continuously since the last glacial stage. 4. Moor Yb1 is located at an altitude of 305 m, where there are 5 pollen zones in descending order from Yb-A to Yb-E. After a warm period in the hypsithermal interval (ca. 6000 yBP), there was a short period during which *Quercus* increased and *Picea* decreased in Yb-C. Such a change is rare elsewhere in Hokkaido. 5. Yo1 is located at an altitude of 1820 m, at the summit of Mt. Yotei. There are 2 pollen zones, Yo-A to Yo-B, in descending order. Yo-A is characterized by *Pinus*, and Yo-B by *Betula*. The admission numbers are 4-30, 4-718, and 46-19. 6. Moor Su1 lies at an altitude of 35 m, where there are 2 pollen zones, Su-A to Su-B, in descending order. Su-A is characterized by *Quercus* and *Abies*, and Su-B by *Betula*. The surface sample in particular contains a lot of *Betula* and reduced amounts of conifer pollen. The bottom of Su-B is characterized by an increase of *Fagus* pollen from a depth of 58 cm. 7. The 14C date determined by accelerator mass spectrometry between Su-A and Su-B was 160±30 yr BP (NUTA2-1401). 8. The increase of *Salix* at Yu2-C may be due to human activity, whereas the increase of *Betula* at the surface may be due to global warming.

## 5-20 BTH 86 Hoshino, Fusa

### VEGETATIONAL HISTORY SINCE THE LAST GLACIAL STAGE AT NAKAYAMA MOOR, SOUTH-WESTERN HOKKAIDO, JAPAN

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Hokkaido is situated at the northeastern edge of continental Eurasia, surrounded by the North Pacific, the Sea of Okhotsk, and the Sea of Japan. We present a brief report concerning the changes in vegetation, deduced from the pollen record and 14C dating by accelerator mass spectrometry, at three sites along 43 degrees N, in subalpine Hokkaido since the last glacial stage. Fossil pollen from three cores taken at Loc.1 and Loc.2, which are both 870 m above sea level, and at Loc.3, which is 910 m above sea level, and now surrounded by the subarctic forest species *Picea glehnii*, revealed different vegetational histories. During the late glacial substage, mixed forest at Loc.2 composed mainly of *Picea*, *Larix gmelinii*, *Pinus pumila*, *Betula* and *Alnus* together with *Selaginella* selaginoides developed under a cold climate. Boreal coniferous forest characterized by *Picea* and *Betula* coexisting with a few aquatic plants developed after 10,830 yr BP. After 8935 yr BP, *Juglans* and *Quercus* increased. Aquatic plants such as *Nuphar* and *Juglans* increased relative to *Betula*. These aquatic plants grew until about 8,500 yr BP. *Quercus*, which grows in a warm climate associated with *Ilex*, persisted for a period of about 7500 years. Although *Picea* at Loc.1 increased after 1840 yr BP, at Loc.2 the *Picea* pollen count showed a sharp peak after 460 yr BP and then gradually decreased. From a depth of 0.2 m to the surface, there was a rapid increase of *Betula* and a decrease of *Quercus*. The surface appearance of *Quercus* is thought to have resulted from wind transport because at present *Quercus* forest does not grow in the vicinity. At Loc.2, the partial disappearance of the *Picea* forest that presently covers a wide area of the moors in the subalpine zone at 43 degrees N suggests that further global warming has continued. Evidence of *Betula* forest from the surface record at Loc.2 is considered to have resulted from human activity. The vegetational history at Loc.3 differs from that at both Loc.1 and Loc.2.

## 5-21 BTH 87 Alexeeva, Nadezhda V.

PLIOCENE AND PLEISTOCENE PALEOENVIRONMENTS OF THE TRANSBAIKAL AREA  
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During the Neogene the Transbaikal area was characterized by warm and humid climate with the predominance of the coniferous and broad-leaved forest and mesophytic vegetations (Logatchev et al., 1964; Belova, 1985). At the beginning of the Pliocene the climate changed towards cooler and arid. In the vegetations many thermophilic elements became reduce. However rather humid climate still existed to the Middle Pliocene and woodland predominated. It is evidenced by mammal associations and pollen flora known in Udunga locality of the region. The further tendency towards aridisation and cool condition is indicated by the mammal fauna of the following Chikoi complex which shows that the forest inhabitants are reduced significantly and savanna like forest steppe and steppe dwellers are flourished. At the Late Pliocene with the global cooling registered in the Baikal area at the age of 2.82-2.5 Ma (Karabanov et al., 1999; Prokopenko et al., 2001), the steppe inhabitants became dominant which evidenced by the tantsinian faunas. With the progressive cooling at the beginning of the Early Pleistocene, the climate continued to change towards arid and the significant reorganisation in faunal assemblages occurred. The most Pliocene taxa disappeared or replaced by advanced forms and the first appearance of lagurids, inhabitants of dry steppe, took place. At that time (1.75-1.4 Ma) another data of the cooling were recognized in the region (Karabanov et al., 1999) which led to the further aridisation. At the Middle Pleistocene in the fauna of Tologoi complex dry steppe and desert taxa became predominant. To the Late Pleistocene natural conditions of the region have changed towards more or less periglacial. The faunal analysis and ecological characteristic of main key taxa as well pollen data indicate that the alternation of the cold periglacial wormwood steppes and grass steppes with open woodlands took place in the area.

## 5-22 BTH 88 Granoszewski, Wojciech

HIGH-RESOLUTION POLLEN RECORDS FROM THE BOTTOM SEDIMENTS OF LAKE BAIKAL  
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Within the framework of ongoing EU Project CONTINENT, clayey sediments from 3 box cores and 2 piston cores were searched by pollen analysis to reconstruct climate signals during the Last Interglacial and Late Glacial and Holocene.

Late Glacial and Holocene pollen successions were taken from 3 stations: Vidrino Shoulder, Southern Basin (cores CON01-605-5 and CON01-605-3), Posolskoye High, Central Basin (CON01-606-3) and Continent Ridge, Northern Basin (CON01-603-5). All the pollen diagrams were visually subdivided into local pollen assemblage zones (L PAZ), which reflect vegetation changes in the regions of the Khमार-Daban Mts., the Selenga Delta, and the Barguzin Mts., respectively.

The general pattern of the vegetational changes in all the profiles is very similar and includes Late Glacial steppe-tundra plant communities with *Betula nana*, *Salix*, *Cyperaceae*, *Poaceae*, *Artemisia*, *Chenopodiaceae*, and many others, followed by strong expansion of *Alnus fruticosa*. The Holocene part of the succession began with an expansion of *Betula-Picea-Larix* forests accompanied by a strong spread of *Pteridium* and *Abies* followed by development of dark taiga communities with *Pinus sibirica*, *P. sylvestris*, *Picea*, and *Abies*. In the southernmost station, i.e. Vidrino, *P. sibirica* and *P. sylvestris* appeared as early as *Betula*, *Picea* and *Larix*. Later, these communities changed into forest which was more of the light taiga type, pointing to the climate becoming drier. L PAZ's and AMS <sup>14</sup>C-datings allowed for correlation of the cores and delineation of the Younger Dryas-Holocene transition.

Pollen analysis of piston core CON01-603-2 from Continent Ridge produced an interglacial pollen succession. Subsampling of the core for pollen analysis was performed following the magnetic susceptibility data. This pollen succession differs from the Holocene one from the same site (CON01-603-5) in having higher *Abies* and lower *Larix* percentages, which points to higher temperatures and precipitation. Moreover, this succession is covered by a glacial sequence, which spans the entry into glaciation and at least one warm interval of interstadial rank. Assuming no hiatus between the Holocene and the last interglacial this succession has to be considered the equivalent of the Eemian (=Kazantsevo) Interglacial.

## 5-23 BTH 89 Johnson, Beverly J.

### LIPID BIOMARKERS AND LATE QUATERNARY ORGANIC CARBON CYCLING AT LAKE ELIKCHAN, NORTHEAST SIBERIA

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Sedimentary cores from Elikchan Lake, northeast Siberia, provide a continuous sequence of deposition for at least the last ~60,000 years (Lozhkin and Anderson, 1996). Palynological analysis indicates several marked shifts between forest and tundra dominated vegetation between 30,000 and 60,000 years ago (Lozhkin and Anderson, 1996). Recently, lipid biomarker concentrations of modern plants, a plankton tow, and core sediments from Elikchan Lake have been investigated to better understand organic matter sources, deposition and diagenetic effects within the catchment. Modern plants and a plankton tow were collected in 2001 and a fresh sediment core was collected from Elikchan Lake in 2002.

Higher plant leaf wax n-fatty acids (i.e., C24, C26, and C28) were present to varying degrees in all modern plants examined, including thirteen terrestrial plants and three aquatic macrophytes, and were not present in the plankton tow material. These results suggest that leaf wax n-fatty acids alone cannot distinguish between terrestrial plant and aquatic macrophyte sources. In the core sediments, shorter chained (i.e., C14, C16, C18) and unsaturated (i.e., C18) n-fatty acids decreased relative to the leaf wax n-fatty acids at all but two depths. Relative increases in shorter chained n-fatty acids were seen at ~6,000 and ~12,000 years ago. Preservation of these relatively labile compounds may reflect an increase in preservation potential of organic matter in the basin or an increase in input of aquatic sources to the site at ~6,000 and ~12,000 years ago. C/N ratios of the bulk sediments decrease initially and stabilize within the upper ~100 cm, indicating little change in preservation potential at the site through the last 30,000 years. Therefore, the increases in shorter chained n-fatty acids at 6,000 and 12,000 years ago may reflect increases in aquatic primary productivity. The n-fatty acid concentration data will eventually be coupled with δ13C analysis and pollen data to further evaluate within basin shifts in carbon cycling correlated to climate change.

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## 5-24 BTH 90 Panyushkina, Irina P.

### ENVIRONMENTAL RECONSTRUCTION FROM TREE RINGS OF ARCHAEOLOGICAL TIMBERS IN THE ALTAI MOUNTAINS, RUSSIA

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Global reconstruction of climate change based on high-resolution multiproxy climate records is limited by geographical distribution of sites, especially for periods before AD 1000. Tree rings from living trees and subfossil wood were actively employed in climate reconstruction in the mountains of central Eurasia. There is the first attempt to estimate dendroclimatic potential of archaeological timbers from South Siberia. The goal of this study was to evaluate the climatic signal in tree rings from archaeological timbers of various ages and cultures in the Altai Mountains, Russia. We studied tree-ring widths of archaeological timbers from Siberian Scythians tombs (400-200 BC), Huns-Sarmatian burial mounds (AD 200-400) and Turks stone enclosures (AD 600-800) in high and low elevations of southeastern Altai. We crossdated tree rings and built 6 floating chronologies of larch (*Larix sibirica*). The 1574 years of the discontinuous chronologies spanned radiocarbon ages 325 BC to AD 650. Statistical properties and periodicity of tree-ring width variability of archaeological time series were compared with tree-ring series of living trees from the same region. A strong summer temperature signal was found in the Scythian tree rings from tombs at high elevation (2050-2345 m asl). The Scythian tree-ring chronology might be used as a master chronology of southeastern the Altai Mountains for crossdating and as a climatic proxy. The tree-ring variability of the Turks chronology (1600 m asl) showed insect outbreaks signal. Tree rings of Huns-Sarmatian wood (1600 m asl) are complacent and can not be used for an environmental reconstruction. The dendrochronological analysis indicates that the wood used for burial purpose was cut in surroundings forested sites. The most suitable wood for climatic reconstruction is from archaeological sites located at and above upper tree line. The study suggests that archaeological wood has a great potential for developing long-term climatic proxies from tree rings in the Altai Mountains.

## 5-25 BTH 91 Fernandez-Jalvo, Yolanda

QUATERNARY DEPOSITS AT THE LESSER CAUCASUS, THE ARMENIAN CORRIDOR  
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Recent discoveries in the Caucasus region indicate that hominids occupied this area over a period of nearly two million years. The earliest hominids outside Africa in Europe are known from the Georgian site of Dmanisi in the southern Caucasus (~1.8 Ma). Human remains from Mezmaiskaya Cave in the northern Caucasus, provide evidence that the European species, the Neanderthals, were present in Eurasia at a later date (~29000 years BP) and further east than previously considered. The Armenian Corridor connects the Levant with Europe and vice-versa. In order to increase our understanding of the Armenian Region and to investigate possible migration routes, we conducted reconnaissance fieldwork in Armenia and Karabagh during 1999-2002. The area investigated encompassed northern and western Armenia, as well as the region surrounding Azokh cave in southeastern Karabagh. In northern Armenia, localities were examined in the Javacheti mountain range where the Georgian site of Dmanisi is also situated. The Javacheti and Karabagh regions of the Armenian Corridor explored have great potential for the discovery of further hominid remains, stone tools and associated fauna. Amongst the cave sites surveyed in southeastern Karabagh, was the well-known Azokh cave, which yielded hominid remains identified as *H. heidelbergensis* in a previous excavation. Excavations at Azokh Cave were resumed in the summer of 2002 by a multidisciplinary and international research team. Sediments rich in fauna and stone tools, as well as additional entrances to the cave were revealed, and provide exciting information about the site and the region as a whole. This fieldwork was undertaken as part of a long-term collaboration agreement between The Armenian Academy of Sciences, The Yerevan Institute of Man, The Natural History Museum, The Institute of Archaeology of London, and Museo Nacional de Ciencias Naturales, Spain. Excavations at Azokh cave were carried out in collaboration with Artsakh State University, with the support of The Ministry of Culture of Karabagh. We are grateful to British Mediterranean Airways; The Harold Hyam Wingate Trust; The Natural History Museum, London; The British Academy, The Spanish Minister of Science and Technology; The Royal Society; and The University of London for their support.

## 5-26 BTH 92 Lavrushin, Yu A.

CATASTROPHICALLY LANDSCAPES CHANGES WITHIN NORTH ARID ZONE (PRECASPIAN) SINCE 13-11.5 KA AGO  
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Detail geological and palinology investigations ascertained complicated and fast paleolandscape changes within North Precaspian area during last 1500 year. There are three landscapes types during the end of Raunissian interglacial period. At the beginning Pine's forest with Picea and Betula predominated. The grass cover was produced by motley grass meadow. After that forest-steppe with small forest (Betula, Pinus) islands were emerged. Pine's forest landscape were the final stage of Raunissian interglacial.

Forest-steppe with forest (Betula, Pinus) island predominated during Early Drias; and there are Artemisia and Chenopodiaceae as a grass cover.

Forest landscapes with different wetting degree predominated during fist stage of Belling. Ther is next forest landscape's sequence: Pinus- Picea with Chenopodiicia grass, Pinus forest with Artemisia and spores, and Picea -Pinus and Pinus- Picea with Chenopodiaceae. Forest-steppe with Pinus and Birch islands predominated during the end of Belling, there is cereals-wormwood.

The desert was appeared in the beginning of Middle Drias, and changed into dry steppe with Artemisia and Chenopodiaceae and cereal steppe more late.

Different types of forest (Pinus, Pinus- Picea, Picea -Pinus with Betula) landscapes predominated during Allerod. The desert with Chenopodiaceae arised again in Late Drias.

Consequently, very fast catastrophic landscapes' changes took place during last 1500 years of Pleistocene. There are no any gray areas. Established landscape changes are correlated with climatic fluctuations and controlled by stable isotopes data. Radio carbon dating realized correlation with global climatic and stratigraphical units of Late Pleistocene (project 3.8. DSG RAS)

## 5-27 BTH 93 Menashe, Rachel

PLIO-PLEISTOCENE PALEOENVIRONMENTS IN THE NORTHWESTERN NEGEV, ISRAEL: INSIGHTS FROM TEL SHARUHEN- BESOR VALLEY

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The 50 m thick Plio-Pleistocene sequence exposed at Tel Sharuhen, which is located on the left bank of the Besor river, northwestern Negev, is composed of bedded eolian and fluvial sand units that were episodically exposed to pedogenesis. The characteristics of the sediments and the buried sandy calcic soils were influenced by the position of the southeastern Mediterranean coastline with respect to the study area. Paleomagnetism, indicative shallow marine fossils and luminescence dating methods indicate that this sequence was deposited between the late Pliocene and middle Pleistocene (340 ka), a time interval for which little information on the region exists. The paleoenvironment during this period was reconstructed using sedimentology analyses, soil stratigraphy, soil micromorphology, and  $\delta^{13}\text{C}$  and  $\delta^{18}\text{O}$  of soil carbonate nodules. The calcic soils indicate arid to semiarid climates, and the variations of  $\delta^{18}\text{O}$  in the sequence point to abrupt and/or gradual transitions between these two climates. Soil macro- and micro- morphology demonstrate that vegetation cover was sparse and comprised mainly grasses and bushes.  $\delta^{13}\text{C}$  values reveal a continuous synchronous existence of  $\text{C}_3$  and  $\text{C}_4$  vegetation in varying ratios. Inverse trends of light  $\delta^{18}\text{O}$  versus heavy  $\delta^{13}\text{C}$  values in the upper units are explained by increased water leaching through the sandy soil profile during more humid periods. Water percolation caused increased dissolution of inorganic carbonates from dust input, land snail shells and parent material, which contributed heavy  $\delta^{13}\text{C}$  values to the pedogenic carbonates. The sparse vegetation, even in a more humid climate, is attributed to the instability of environments in this near-coast sandy area caused by a strong-wind regime. It is concluded that wind is more crucial than precipitation for stabilization of sandy areas by vegetation. Therefore, in windy environments, during moister periods, light  $\delta^{18}\text{O}$  values together with heavy  $\delta^{13}\text{C}$  values in soil carbonates are expected. Slightly more arid conditions, typified by heavier  $\delta^{18}\text{O}$  but characterized by weaker winds and a more stable environment, will allow the development of soils with enhanced biogenic activity typified by lighter  $\delta^{13}\text{C}$  values.

## 5-28 BTH 94 Bateman, Mark D.

AEOLIANITE AND BARRIER DUNE CONSTRUCTION SPANNING THE LAST TWO GLACIAL-INTERGLACIAL CYCLES FROM THE SOUTHERN CAPE COAST, SOUTH AFRICA  
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The southern Cape region of South Africa has extensive coastal aeolianites and barrier dunes which offer the potential to increase our understanding of palaeoenvironments in an area of considerable climatic and oceanic sensitivity as well as of archaeological importance. Whilst previous reports their lack of chronostratigraphy has precluded an understanding of their relationship with Late Quaternary climatic and sea-level fluctuations. Sedimentological and geomorphological studies combined with an optical luminescence dating programme for sites on both Cape Agulhas and the Wilderness cordon dunes reveal aeolianite and barrier dune construction spanning at least the last two glacial-interglacial cycles. Aeolianite deposition has occurred on the Southern Cape coast at c. 68-75, 89-95, 104-122, 176-189 and >120 ka before the present. Using this and other published data coupled with known Late Quaternary sea level fluctuations and palaeoocastline configurations it is concluded that these depositional phases appear to be controlled by interglacial and subsequent interstadial sea-level high stands. These marine transgressions and regressions allowed on-shore carbonate rich sediment movement and subsequent aeolian reworking to occur at similar points in the landscape on a number of occasions. The lack of carbonates in more recent dunes (Oxygen isotope stage 1/2 and 4/5) are attributed not to leaching but due to changes to carbonate production in the sediment source area caused by increased terrigenous material and/or changes in the balance between the nutrient rich cold Benguela and warm Agulhas ocean currents.

## 5-29 BTH 95 Scott, Louis

CLIMATE CHANGE IN A SOUTHERN HEMISPHERE WINTER-RAIN REGION INFERRED FROM POLLEN ANALYSIS OF FOSSIL HYRAX DUNG ACCUMULATIONS IN THE PAKHUIS PASS, S.W. CAPE, SOUTH AFRICA

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Palynology in the Cape winter rain region, in comparison with that in the northern summer-rain region, can be applied to questions concerning the interaction between winter- and summer-rain regions. Pollen in stratified hyrax dung gives a millennial scale record of rocky-slope vegetation (fynbos) of the Pakhuis Pass area, South Western Cape over 20000 years. Regular changes in temperature and moisture conditions are reflected in fluctuations of pollen counts of Restionaceae, Asteraceae types, Cyperaceae, succulents and shrubs. Besides these changes the long term record shows that LGM vegetation was composed of mainly low shrubs (low-spine pollen of *Stoebe/Elytropappus* type) and "fynbos" (including *Ericaceae*, *Passerina*, *Cliffortia* and *Proteaceae*), while Holocene vegetation contained more scrub vegetation (including *Dodonaea* and *Olea*) with succulents and Asteraceae. Results support conclusions based on isotopes in hyrax diet (dung) (Scott and Vogel, 1999) that plants remained typical of a winter-rain environment during the whole study period. Although the boundary between the study area and the summer rain region to the north apparently did not move significantly a limited grass improvement shortly before 2 kyr may be related to a slight increase in summer-rain following the pattern of optimal conditions north of the study area. Over the long term, however, inferred moisture patterns are at times the opposite of that in proxy records to the north, e.g., showing moist conditions in the early Holocene and drier conditions in the Middle Holocene.

## 5-30 BTH 96 Carr, Andrew S.

LATE QUATERNARY ENVIRONMENTAL CHANGE ON THE AGULHAS PLAIN, WINTER RAINFALL ZONE, SOUTH AFRICA

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Despite its key position, at the interface of the temperate westerly and tropical climatic systems, the Quaternary environmental record in South Africa's winter rainfall zone is poorly resolved. Little is known of its relationship to the larger summer rainfall zone, particularly in terms of the synchronicity and direction of past climatic changes. At the southern most tip of Africa and the meeting point of the Agulhas and Benguela currents, the Agulhas Plain represents a winter rainfall zone area that was potentially very sensitive to Quaternary environmental change. Four pan/luette dune complexes have been investigated in this area and a chronology of luette deposition derived from 17 OSL age determinations has produced a record spanning the last 70 ka. The study has also involved the extraction of cores from littoral environments on the floor of Voelvlie pan, the aim being to utilise independent, but complementary proxy data sources from the same site; an "arid" or aeolian record derived from the luette dune and a "humid" record of pan water status from the core sediments.

Inadequate optical bleaching hampered attempts at OSL dating of sand units in the cores, but radiocarbon dating of fine grained, pollen rich units produced an age of c. 28 ka BP (uncal). It is suggested that these units are associated with pelagic environments and represent high water conditions. This radiocarbon age contrasts with a suite of OSL ages for the luette dune, which indicate two discreet phases of luette deposition (17 -23 Ka and c. 3 Ka). OSL ages obtained from nearby Soutpan and Rhenosterkop pan suggest luette deposition during OIS 4. A small fourth pan (Buffeljacht pan), c. 30 km further west also indicates luette deposition during the late Holocene. The disparate timing of luette deposition for sites within 30 km of each other may be explained by the contrasting geological and hydrological settings of the pans. However, it appears that much luette deposition on the Agulhas Plain has been associated with OIS 4 and 2 and thus hypothermal conditions. The orientation of these luette dunes, all on the eastern shores of the pans, indicates westerly formative winds and contrasts with the dominantly easterly winds of the modern dry season.

**5-31 BTH 97** Gaines, Sarah M.

THE MORPHOLOGY, SEDIMENTOLOGY AND PALEOENVIRONMENTAL SIGNIFICANCE OF TWO PAN-LUNETTE CLUSTERS IN THE SOUTH WESTERN CAPE OF SOUTH AFRICA  
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Two clusters of small pans and associated lunette dunes are distinct landscape features in the Swartland and Agulhas Plain regions of the southwestern Cape of South Africa. While occurring in geographic proximity within the winter rainfall region, each of the pan-lunette clusters is hosted by different substrates, subjected to different coastal climate regimes and exhibits different morphology, orientation of features, and sedimentological characteristics. Not only are geomorphic characteristics at variance between regions, but also the alignment of lunettes on the leeside of pans, parallel within the cluster, is at variance with predominant modern wind direction and seasonality of precipitation at both sites, although the difference is more pronounced at Agulhas. In order to elucidate the occurrence and formational processes of these features, a dual-scale approach was employed: a regional cartographic study coupled with detailed local sedimentological analyses. The geomorphic characteristics of these features were quantified using aerial photography and orthophotographic maps. Dry season paleo-wind direction was inferred from the regional analysis. Sedimentological and geochemical analyses were applied to investigate the pan-lunette sediments at Voelvlief, in the Agulhas cluster, and at Droevlei East, in the Swartland cluster, in order to clarify the processes responsible for their formation. The characteristics of sediments in both lunettes indicate a primary control by parent material with little post-depositional diagenesis. Sedimentological characteristics of many of the lunettes suggest differences in timing of formation; radiocarbon dates confirm this. Although dunes within each cluster appear to have been initiated at different times, the dune-building activity at Agulhas (8000 BP) was initiated, on average, prior to the activity in the Swartland (11800 BP). Without further chronological constraints to elucidate the timing of dune-building periods, the lunettes may be seen as a cumulative product of at least the past 8000 years of windy arid seasons. The comparative relationships of the pan and lunette features in the Swartland and Agulhas offer insights into the shifting palaeoenvironment of the winter rainfall region of South Africa.

**5-32 BTH 98** Umer, Mohammed

PALEOENVIRONMENTAL EVOLUTION OF SOUTH-EASTERN ETHIOPIAN HIGHLANDS (BALE MOUNTAINS) DURING THE LAST 13,000 YEARS

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Lakes in the main Ethiopian Rift Valley are now considered as one of the reference sites for paleoclimatic reconstruction in the tropics. They provide evidence for a regional pattern of lake high-stands between 10-5 kyr BP, interrupted by abrupt arid intervals resulting from global mechanisms. However, recent work indicates that some of the environmental changes were caused by non-climatic, local factors. Lakes and swamps at high altitudes have proved suitable for paleoclimatic reconstruction. Most Ethiopian mountains were affected by Pleistocene glaciation, which retreated after ~14 kyr BP. Earlier cores collected from the south Ethiopian mountains were either discontinuous, short or have provided low-resolution data. We recently investigated a new site in the Bale Mountains of Ethiopia, on the Southeastern Plateau east of the Main Ethiopian Rift Valley. In May 2001, we obtained a 15.82m core with a basal radiocarbon age of ~13 kyr BP from lake Garba Guratsch at 4000m. This core has the potential to provide the first high resolution, continuous record spanning the Late Glacial to the Holocene for the Ethiopian mountains.

Initial results of analysis of sediment, organic matter and pollen are presented here. The sediment consists of greenish-grey silt with layers of sand and gravel from the base to 9m (~13-10 kyr BP), and organic gyttja from 9m to the top (10-0 kyr BP). Total organic carbon is up to 3% in the lower clastic sediment and reaches 11% in the upper organic unit. Pollen analysis shows the dominance of Amaranthaceae/Chenopodiaceae, Poaceae and Artemisia in the Lateglacial sediment, perhaps indicating cold steppe vegetation on a deglaciated landscape. The high sedimentation rate between 11-10 kyr BP (5m in 1000 yrs) could be due to high sediment transport from a sparsely vegetated landscape around the lake. The rise in Ericaceae after 10 kyr BP, coincident with the deposition of organic gyttja, marks the beginning of the Holocene. This may indicate a warm and humid climate with stabilization of the slopes and soil development. The fall in Ericaceae and the rise in Podocarpus and Juniperus (now growing on the northern drier slope of the Bale mountains) above 4m in the core could relate to drying of the mid-Holocene climate. The rise in Plantago and the fall in Podocarpus above 2m may be evidence of human impact.

**5-33 BTH 99** Allen, Judy R.M.

A NEW RECORD OF MEDITERRANEAN PALAEOENVIRONMENTS DURING THE LAST INTERGLACIAL: PRELIMINARY RESULTS FROM LAGO GRANDE DI MONTICCHIO

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Lago Grande di Monticchio, a volcanic crater lake in southern Italy, has already been shown to have a unique palaeoenvironmental record of the last glacial period. New core material recovered in summer 2000, by a team from GFZ-Potsdam, has extended the sediment record to 102m in length (an additional 30m) and penetrated through the last interglacial and into deposits from the penultimate glacial (marine oxygen isotope stage 6).

Here we present a selection of preliminary results of the ongoing analyses of this new material. The approach used for the upper parts of this record (70m; 100ka) to construct an independent sedimentation rate chronology is being continued through the new material. Microscope examination of thin sections of the entire sequence will identify the varved sections which provide the basis for the many estimations of sedimentation rate which contribute to the final chronology. (AB, JM).

The outline pollen diagram and sedimentological data presented here show that the new profile covers the whole of the last interglacial including the transitions from the preceding and to the following glacial periods. Future work will provide detailed palaeovegetation and palaeoenvironmental reconstructions based on high temporal resolution palynological (at least 200yr), (JRMA, BH). The development and dynamics of the catchment will be deduced from sedimentological data at seasonal (micro-facies) to decadal resolution including geochemical profiling and magnetic susceptibility. (AB, JM, UF).

In the 30m of new material 54 tephra layers have so far been identified. Of particular regional importance is the layer correlated with the Ionian Sea tephra layer X6 (ca. 107ka); this occurs as a prominent layer and is suitable for Ar39/Ar40 dating. Other tephras will be further analysed and regionally correlated wherever possible. (SW).

**5-34 BTH 100** Diniz, Filomena Ursula

THE PARTICULAR ASPECT OF PLEISTOCENE POLLEN FLORA FROM THE WEST COAST OF PORTUGAL

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There are numerous deposits rich in organic matter outcrop in several places in the cliffs between Ferrel and Lagoa de Obidos on the west coast of Portugal. At this site pollen has been studied from 4 specific sections: Olhos de Água, Fincha Grande, Vale Benfeito and Vale de Janela. Palynological studies show that trees and herbs are poorly represented except for Pinus, Ericaceae and Myrica and at some levels Myrtus, Betula Quercus and Ilex. The Mediterranean facet is represented by Olea, Q. ilex-t., and Cistaceae. The diagram of Vale de Janela shows the progressive installation of arboreal vegetation without, however, complete forest cover. It could be an open vegetation in a coastal area affected by the relatively damp, windy climate. Pollen analysis of Fincha Grande has identified 40 taxa, with Quercus the most dominant in the upper part, replaced by Betula and then by Pinus. Saxifraga, a temperate or sub-Arctic element, is present at the top of the diagram and Lygeum a Poaceae from the Mediterranean steppes in the middle. At Vale Benfeito, Betula is well represented and Quercus is present at Olhos de Água. Based on pollen flora and radiocarbon dating (35,000 to 45,000 years BP) these sites have been dated as Pleistocene. Paleo-floristic data obtained is in agreement with the meridional location of these deposits on the Atlantic coast and indicates the buffer role played by the ocean. Observation of Myrica, Ilex, Olea, Quercus ilex-t would seem to indicate that this coastal zone was a sort of refuge, with heath and a foggy, Atlantic climate. There would also be areas protected by arboreal vegetation that formed a complex ecosystem clearly showing the particular aspects of Pleistocene flora in Portugal.

**5-35 BTH 101** Mäusbacher, Roland

LATE PLEISTOCENE AND HOLOCENE ENVIRONMENTAL CHANGES IN NW SPITSBERGEN – EVIDENCE FROM LAKE SEDIMENTS

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Late Pleistocene and Holocene Environmental Changes in NW Spitsbergen – evidence from lake sediments - Subbottom profiling and coring in the two proglacial lakes Varfluesjøen and Vogtvatnet (NW-Spitsbergen, Andréland) show a continuous record of lacustrine sediments underlain by marine sediments and finally till/breccia forming the base. The sediment source for the marine sedimentation in the lake basins is primarily found in the inner fjord areas of Wood- and Wijdefjord whereas the lacustrine sedimentation is fed by the local tributary.

According to 14C data, sedimentation in the lake basins starts around 12.0 ka BP in both investigated lakes. The separation of the lake basins from the Fjords, marked by the marine – lacustrine boundary in the sediments, happened around 9.7 ka BP in Varfluesjøen and around 7.9 ka BP in Vogtvatnet. This difference in time is explained by different elevations of the basin thresholds. According to this difference of the two near by situated lakes an approx. relative uplift rate of 1.7 cm/a can be calculated for this timespan for the northern Andréland area.

14C data show that the sedimentation in the lake basins starts after deglaciation at 12.0 ka BP. The sedimentary record shows in both lakes at least one prominent glacier readvance around 8.0 ka BP and several younger minor glacial fluctuations. Older Late Glacial readvances of the glaciers where not detected in the lake basins. Further marine incursions after separation from the fjordsystem where only detected in Vogtvatnet, indicating only minor changes in relative sea level since the Boreal.

**5-36 BTH 102** Junge, Frank W.

COMPARATIVE INVESTIGATIONS INTO THE UPPER EOCENE AND QUATERNARY PALAEOENVIRONMENT AND PALAEOCLIMATE BY GEOCHEMICAL STUDIES OF FLUVIAL SEDIMENTS AND INCORPORATED FOSSIL TREE TRUNKS (CENTRAL GERMANY)

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Fluvial deposits from the Eocene and the Quaternary in central Germany exhibit significant differences in terms of both their geochemical-mineralogical indicators (minerals, trace and main elements) and the geochemical parameters of the fossil wood they contain, such as the content of stable isotopes in wood cellulose. During the Eocene the climate was subtropical to humid; during the Quaternary it was humid to cold and arid. Whereas the substances contained and the geochemical "maturity" of the sediment reflect the prevailing type and degree of weathering processes, the isotope-geochemical parameters of the fossil wood are indirect indicators of the temperature and the level of CO<sub>2</sub> in the atmosphere. The weathering processes predominating in the humid, subtropical tertiary climate led to more intensive leaching processes and the extensive removal of chemically mobile elements. This resulted in sediments with high geochemical maturity containing enriched levels of SiO<sub>2</sub>, Corg, S and largely immobile trace elements (e.g. Zr, Y, Sn) mainly bound to the heavy mineral fraction. By contrast, the Quaternary sediments - which were mainly exposed to physically controlled weathering processes, contained feldspar and had a lower geochemical maturity - were characterized by higher levels of alkalis and alkaline earths. In the Upper Eocene river sediments in Germany, the wood cellulose of the numerous coniferous trees contains carbon with an isotope pattern (given as delta values in ‰ versus PDB) differing sharply from the isotope values of tree trunks from the Quaternary (Upper Eocene, central Germany: C-13 ca. -20‰; Late Glacial, southern Germany: ca. -24‰; Early Holocene, southern Germany: ca. -23‰; Early Holocene, central Germany: ca. -24‰; middle Holocene, northwest Europe: ca. -25‰; medieval time, northwest Europe: ca. -24‰) and Recent (central Germany: ca. -25‰; northwest Europe: ca. -26‰) periods. Compared to the Quaternary and Recent findings, the isotope data for the Upper Eocene document higher temperatures accompanied by the natural higher availability of atmospheric CO<sub>2</sub> for photosynthesis in trees. In addition to the geochemical findings in the fluvial sediments and the isotope data obtained from wood cellulose, the article also highlights additional conclusions on the palaeoflow directions derived from orientation on trunks deposited in the sediments.

## SESSION NO. 5

### 5-37 BTH 103 Eronen, Matti

A 7500-YEAR UNBROKEN SCOTS PINE TREE-RING CHRONOLOGY FOR FINNISH LAPLAND  
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Tree rings are of great importance as high-resolution proxies of past climate. A long well-established dendrochronological record from a climatologically sensitive area can provide valuable indications of the Holocene climatic variability. Here we report a c. 7500 years long continuous Scots pine tree-ring record from the treeline area of northern Fennoscandia. This record can be used for reconstructions of the interannual variability of past summer temperatures and potentially for studies of many past climatic and environmental variables. Scots pine (*Pinus sylvestris*, L.) immigrated to northern Finnish Lapland by 9.5 - 9 ka calBP and spread in favourable climatic conditions to a larger area than that occupied by pine forests today. The time of the maximum extent was between 7 and 4.5 ka calBP. A large number of subfossil pine trunks and stumps have been preserved in small lakes in Lapland in the present treeline area and also beyond it. An earlier work in Lapland resulted in several dozens of radiocarbon dates for subfossil pine wood. The dated sample discs could be used to tie the initial floating chronologies to the radiocarbon timescale. Cores from living trees and beams of old wooden buildings were also used. The intensive phase of the data collection and chronology building lasted about 10 years until the master curve was completed in 1999. The present pine tree-ring chronology extends from the present time to c. 5520 B.C. Several studies have shown that the tree rings of forest-limit pines in northern Fennoscandia are good indicators of past summer temperatures, the July ones being the predominant decisive factor for the radial growth of pine. The long pine tree-ring curve should therefore indicate interannual variations of summer temperatures in northern Fennoscandia. The annual resolution makes it possible to reconstruct a high-frequency record of temperature variability over thousands of years. However, it is much more difficult to extract information about low-frequency climatic variations from this data. This high-resolution proxy record covering a major part of the Holocene can be used now for many kinds of analyses, measurements and correlations with other proxies.

### 5-38 BTH 104 Jeraj, Marjeta

POLLEN EVIDENCE AND SIMULATED LATE GLACIAL AND HOLOCENE CLIMATE OF LJUBLJANA MOOR, SLOVENIA

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Pollen analyses from Bistra, southwestern Ljubljana Moor, Slovenia, and macrophysical climate models for Ljubljana Moor were compared in order to reconstruct the past environment, especially climatic changes in the last 14000 years and vegetation history during the Holocene.

Temperature and precipitation models suggest a substantial rise in January and July temperatures and a noticeable decrease in annual rainfall in the Late Glacial near Ljubljana Moor. These climatic changes may have had an important influence on the occurrence and development of mesophilic Holocene vegetation. In the beginning of the Holocene the cold-period *Pinus-Betula* stands, characteristic for the Late Glacial, were already to a large extent replaced by mixed-deciduous forests dominated by *Fagus*, as observed in the pollen record from Bistra. They became well established on the surrounding slopes, and after the appearance of *Abies* a predominant association of *Abieti-Fagetum* developed. In the pollen sequences from around 8000 until 6000 <sup>14</sup>C years BP, a thinning of beech-fir forest and temporary expansion of *Corylus* and *Alnus* are observed. The climate models for the same period suggest that the described changes in forest composition could be attributed to an increase in summer temperatures. Warmer summers were presumably less favorable for *Fagus*, which became dominant again around 5000 <sup>14</sup>C years BP, after summer temperatures started to drop significantly. The pollen record from Bistra also indicates that major changes in Holocene vegetation composition occurred towards the end of the Mid-Holocene. Changes in the surrounding vegetation such as an increase in herbs, especially Cyperaceae, presence of cereals, and a decrease in arboreal vegetation, are correlated with simulated cooler climatic conditions, but also reflect human impact on the landscape in the vicinity.

All in all, the pollen record from Bistra shows a good correlation with temperature models on the larger time scale. On the other hand, modeled rainfall indicates that precipitation did not have much effect on vegetation development around Ljubljana Moor after the Early Holocene. However, further comparative studies are needed to draw firmer conclusions.

### 5-39 BTH 105 Fodor, László

PLIOCENE-QUATERNARY LANDFORM EVOLUTION OF THE GODOLLO HILLS, CENTRAL HUNGARY: COMPETING AEOLIAN TO FLUVIAL DENUDATION, SEDIMENTATION AND TECTONIC FORCES

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The Gödöllő Hills are located east of Budapest, in the central part of the Pannonian Basin, Hungary. The upper 1 km is consisted of Upper Miocene to Pliocene, poorly lithified sand(stone), siltstone and claystone of lacustrine, delta or fluvial origin. These sediments are covered by Quaternary loess units with intercalated paleosols, dune and fluvial sand, silt and peat. We aimed to determine the geomorphologic evolution of the area and the role of tectonic control on landscape evolution, using geomorphic-geological mapping, digital elevation model, analysis of seismic reflection profiles. To establish chronostratigraphy, thermoluminescence dating, molluscs and rare vertebrate fossils were combined with paleosol stratigraphy. Morphology is characterised by a simple, parallel set of NW-SE trending, southeast flowing valleys and intervening flat-topped plateaus. Two effects may control this uniform direction. It can be due to a regional tilt of a Pliocene denudation surface, but wind erosion played an important role in valley formation. It is demonstrated by linear, broad valleys, by the occurrence of ventifacts and distribution of wind-blown sands. Moderately dipping, truncated intra-loess paleosol units, redeposited older Quaternary fragments, sliding surfaces show that the actual slope are close to older, gently dipping morphological surfaces. This suggest a relative longevity of the morphological elements; valleys, slopes and plateaus existed already at the time of earliest paleosol formations, before 400 ky. Seismic sections demonstrate that most valleys do not correspond to seismically resolvable faults. Morphology is rather controlled by the denudation processes or by lithological differences. However, some important disturbances in drainage correspond to strike-slip faulting or folding of underlying Upper Miocene rocks. Historical earthquakes might suggest ongoing activity of some structures. Crustal deformation could divert original fluvial network, but wind erosion, surface wash significantly lowered tectonic topography. Supported by the ISES Group, the Netherlands,

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### 5-40 BTH 106 Oches, Eric A.

GROUND-TEMPERATURE CONTROLS ON RACEMIZATION-DERIVED PALEOTEMPERATURE ESTIMATES FOR THE LAST GLACIATION IN CENTRAL EUROPE  
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Arrhenius parameters of amino acid racemization are derived for glutamic acid, aspartic acid, phenylalanine, and valine in the terrestrial gastropod genera *Succinea*, *Pupilla*, and *Trichia*. Measured D/L values and independent radiocarbon and luminescence age estimates are incorporated into kinetic models of racemization in order to calculate effective diagenetic temperatures for intervals of time during the late Pleistocene in the central Europe. Estimates based on initial glutamic acid Arrhenius parameters and measured D/L values in fossil *Succinea* shells collected from a loess profile at Nussloch, Germany (present mean annual air temperature=10 °C), suggest that the last glacial maximum (ca. 20 - 25 ka) temperature was -6 ± 12 °C, the period from 25 - 35 ka was -2 ± 11 °C, 35 - 60 ka estimated temperatures were 1 ± 12 °C, and the period corresponding to oxygen-isotope stage 3 (ca. 25 - 60 ka) was 0 ± 11 °C. Comparable effective temperature estimates are calculated based on alioisoleucine/isoleucine data, but aspartic acid results suggest significantly lower paleotemperatures. Ongoing refinement of racemization kinetics for amino acids measured in *Succinea*, *Pupilla*, and *Trichia* will lead to reduction in the error estimates and allow us to calculate late Pleistocene paleotemperatures at loess localities in Germany, Czech Republic, Hungary, and Serbia.

It should be noted that we are reporting calculated ground (paleo)temperatures, which are not directly comparable with mean annual air temperatures. The temperature that a shell experiences in the ground has a strong control on the rate of racemization of amino acids in the shell carbonate matrix. We have recently undertaken a program of installing ground temperature data loggers at depths from one to three meters throughout the study area. While these data are not yet available, multi-year ground temperature data will allow us to determine the relationship between temperatures at depth and surface air temperatures. These data will also enable us to correct our calculated effective diagenetic temperatures for changing burial depths and varying sedimentation rates as loess progressively accumulated.

### 5-41 BTH 107 Gibbard, Philip

LATER QUATERNARY HISTORY OF THE ENGLISH CHANNEL  
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Evidence for sea-level high and low-stand environments characterise both the terrestrial and shallow marine environments of the English Channel (La Manche). Well-preserved sequences of raised marine deposits are known from both the English and French sides of the Channel and they are particularly well preserved in the Normandy and Sussex areas. In Sussex at least 4 spatially- and temporally-discrete high sea level stand events have been demonstrated. Evidence for the oldest Pleistocene marine incursion into the Sussex coastal plain area is currently thought to date to 450-500 ka B.P. while the youngest incursion occurred during the last interglacial (Ipswichian, Eemian). While many of the sequences indicate deposition under conditions as warm as the present-day, sediments thought to date to the penultimate interglacial appear to have accumulated during cooler water conditions.

Elsewhere important sequences of fluvial sands and gravels are associated with many of the river valley, particularly including the Seine, Somme and former Solent River. However, despite a number of recent investigations focused on these different elements of the Channel system, it remains difficult to integrate the evidence from sea-level high and low-stand phases and consequently a precise history of the region remains to be determined.

Elucidation of the sequence of events in the Channel region has important implications for our understanding of regional palaeogeographies as well as the human colonisation of the islands of Great Britain. Furthermore the area contains important sequences that will contribute to our understanding of palaeoceanographic changes in the NE Atlantic area during the later Middle and Upper Pleistocene.

## SESSION NO. 6, 1:30 PM

Thursday, July 24, 2003

### T3. Quaternary Economic Deposits and Landscape Evolution in the Late Cenozoic (Posters) (Committee on Quaternary Economic Deposits)

#### Reno Hilton Resort and Conference Center, Pavilion

### 6-1 BTH 108 Kim, Ju Yong

GEOLOGICAL CHARACTERIZATION OF ADEQUATE INDUSTRIAL STONE RESOURCES OF SOUTH KOREA

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Industrial resources potential of the Quaternary geology is related to sand and gravel aggregates and dimension stones. In South Korea, a rapid economic development and infrastructure construction necessitate ever increasing amount of all types of industrial stone resources as constructional materials. Sand and gravel aggregate resources are supplied from fluvial area and shallow seabed in the western coastal and onshore-offshore areas of the peninsula. Geological characterization and modeling of the resources potential are performed to meet the need of adequate supply amount and quality control of the resources. Ever increasing extraction of the sand aggregates caused modification of landscape and human intervention to marine bio-resources and coastal and near shore geomorphological change. As to the dimension stone resources in Korea the most favorable quarries have been selected before extraction in order to develop the most efficient extraction strategy and localize the most prospecting site among any potential building stone

quarries. As a result of geological and geophysical prospection, Jurassic and Cretaceous biotite granite, or two-mica granite are most favourable stone resources for both quantity and quality. The geological and petrochemical and mechanical properties of these lithologic types, including specific gravity, absorption ratio, porosity, compressive strength, tensile strength and abrasive hardness, have been examined and controlled as indices for adequate bedrock quality for the last two decades. Lastly crushed stone as aggregates are now tested for their lithologic types to avoid deleterious alkali-cement reaction of raw stone materials. An environmental feasibility for mining stone resources have been evaluated mainly for these Jurassic and Cretaceous granites for economic extraction and development.

## 6-2 BTH 109 Gunnell, Yanni

### QUARRIED CALCRETE CAPPINGS: A WIDESPREAD LEGACY OF LATE CENOZOIC CLIMATE CHANGE ACROSS THE PRECAMBRIAN BASEMENT OF SEMI-ARID PENINSULAR INDIA

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Accumulations of calcium carbonate in weathering profiles are widespread in semi-arid lands where annual rainfall ranges between 600 and 400 mm/yr. Based on this understanding they have been used as paleoclimatic and paleoecological indicators. With a rainfall of 350 to 750 mm/yr, the land surface of South India located in the rainshadow of the Western Ghats exhibits a large number of sites where diverse forms and fabrics of calcrete occur almost exclusively on Precambrian silicate bedrock. These economic grade calcrete deposits involve employment in quarrying, transport, off-site production of lime and construction material for houses and dry stone walls.

We have mapped the distribution of calcareous and calcified soils across South India based on state-wise soil maps and on a study engaged in classifying, U-series dating and isotopically tracing the most massive occurrences of calcrete in the region. Depending on geomorphic setting we find that the quarried calcretes are either pedogenic or phreatic with complex petrographic histories of surface reworking. Their ages vary from early/mid-Pleistocene to Recent, and depending on geographical position with respect to paleomonsoon wind patterns they sometimes contain aeolian dust input with marine strontium signatures. Such diversity and wide distribution reflects the stability, in the rainshadow of the SW monsoon, of semi-arid Quaternary conditions oscillating around a rainfall average similar to that of the present but involving phases of fabric reworking.

Occurrences in the semi-arid zone of fossil Cenozoic laterite capped by calcrete further indicate that (1) the parent material of the calcrete is only occasionally the bedrock itself; (2) humid climates, which created the conditions for laterite development, preceded the drier conditions without any detected reversals to lateritizing conditions during the Quaternary; and (3) as a consequence of lasting climate change laterite has been eclipsed by calcrete as the chief economic surface deposit, although it is still a key resource for the production of free-stone bricks in the humid areas seaward of the Western Ghats. Quarrying industries of Quaternary calcrete and Cenozoic laterite place South India in a unique position amongst the many other laterite- and calcrete-capped regions of the Tropics.

## 6-3 BTH 110 Duk-Rodkin, Alejandra

### LATE CRETACEOUS TO LATE PLEISTOCENE DRAINAGE EVOLUTION OF COBAR UPLAND, N.S.W., AUSTRALIA

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Late Cretaceous to late Pleistocene drainage evolution of Cobar upland, N.S.W., Australia. The Cobar Basin, was formed in Devonian time. A major structural feature occupies the axes of a Cretaceous marine basin to the north. Deformation in Cobar includes overturned anticlines along faults trending generally north-northwest to south-southeast with diagonal secondary faults. Most faults and fractures in the region have been formed in the same direction. Even modern structural features are being formed by reactivation of the Devonian structural framework. The Devonian to Cretaceous sedimentation record has been denudated almost completely. A few remnants survived. Important mineralization was formed along these structures, Ag, Zc, Cu, Au between them.

An interior sea basin was formed (Eromanga) during the Cretaceous that lasted until late Cretaceous. This event triggered a new cycle of denudation and drainage down cutting. In the last 62 million years the Cobar landscape evolution is defined by diversion of drainage caused by tectonic reactivation along Devonian structures. Volcanic plugs were also formed along the same structures developed from mid to late Tertiary. Some of the basalts covered Tertiary conglomerates giving an estimate for the age of these deposits.

Cobar can be separated in two major regions where there is general migration of drainage to the south in the eastern area and to the north in the western area. Changes in drainage were established from Late Cretaceous to Pliocene time. Migration of drainage in the eastern area is indicative of uplift from north to south while the western area the opposite, from south to north. The two blocks moved around a pivot point located in the center of the basin. Drainage captured by regressive erosion was also present at the headwater of major diversions.

The Cobar drainage evolved from south-north in Late Cretaceous to progressively east-west trend in late Tertiary. Further, it evolved from a high drainage density associated with a much wetter climatic conditions to a drainage containing sporadic or intermittent water indicative of a drier and warmer conditions.

Paleo-channel deposits containing gold has been found. Changes in drainage patterns will be used for mineral exploration in the Cobar Basin.

## 6-4 BTH 111 Chan, Roslyn

### REGOLITH-LANDFORM PROCESSES AT NORTH PARKES CU-AU MINE, NSW, AUSTRALIA

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The Northparkes Mine is a porphyry Cu-Au mine in the Lachlan Fold Belt in central New South Wales, Australia. Detailed mine pit profile and drill hole descriptions and analyses, together with regolith-landform mapping, have revealed a palaeo-landscape with a greater relief (up to 30 m) than the present relief (mostly less than a few metres) developed on weathered bedrock, now largely buried by weathered sediments. Alluvial and colluvial sediments were deposited in palaeo-valleys and on top of palaeo-interfluvies in the northern Lachlan Fold Belt. The Northparkes palaeo-valleys are a few kilometres north of the Canobolas Divide, a major drainage divide initiated in the Late Cretaceous due to drainage incision of a regional Jurassic sediment palaeo-plain. The sediments at Northparkes can be inferred to be Cainozoic, as they include reworked Mesozoic quartzose alluvial sediments. The Northparkes palaeo-valleys may have become estab-

lished in exhumed north-trending, strike-aligned Jurassic palaeo-valleys. Regional studies indicate that much of the sediment is derived from colluvial slope sheet-wash or debris flows on valley sides, and low angle alluvial fans that coalesce to form alluvial plains. Many areas in the north Lachlan Fold Belt have deep leads where headwater tributaries may have eroded mineralised bedrock and supergene enriched saprolite, and then been buried by sediments. Aeolian sediments mixed in with residual or transported soils through pedogenic and transportation processes, may redistribute, mask or dilute mineralisation signatures, or alternately, add an exotic signal to an existing anomaly or otherwise barren ground. Interpretation of geochemical anomalies is difficult and requires detailed understanding of hydromorphic dispersion, physical transport, and chemical coprecipitation processes in relation to variable palaeo-climate and the evolving palaeo-topography. Application of background geochemical values of the weathered lithologies versus geochemical anomalies related to mineralisation at Northparkes has assisted in establishing geochemical thresholds and targeting mineralisation.

## 6-5 BTH 112 Patyk-Kara, Natalia G.

### LATE CENOZOIC PALEOCHANNEL MINERAL DEPOSITS OF THE TRANS-URALS PENEPLAIN

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Late Cenozoic landscapes of the south flank of the Trans-Urals peneplain shaped in response to inherited planation and low erosion in terms of gradual replacement of warm humid conditions by semi-arid conditions in Miocene and by alteration of cold semi-humid and semi-arid conditions during the Pliocene-Quaternary. The area of peneplain is characterized by branched paleo-drainage, among which the Miocene and Pliocene-Early Quaternary paleo-ravines and paleo-valleys are the most saved. Paleochannel deposits of different origin are connected to them – from distal placer deposits of precious stones (corundum), crystal and piezo-quartz, gold to infiltration deposits on the complex epigenetic geochemical barrier (reduction, hydrolysis, sorption, etc.) – uranium and satellite metals. This epigenetic mineralization is alocal and can be spatially coincided with different-type placer mineralization within paleochannels of the 1st-3rd orders. Sanarka River basin with its Neogene-Quaternary paleochannels is one of area where the coincidence of placer and epigenetic mineralization can be well observed. Within boundaries of the Trans-Urals peneplain more ancient (Mesozoic) gold and uranium paleochannel are also known.

## 6-6 BTH 113 Levson, Victor M.

### EARLY PLEISTOCENE AND LATE TERTIARY PALEOCHANNELS IN THE CANADIAN CORDILLERA AND ADJACENT PLAINS: DISCOVERY, RECONSTRUCTION AND ECONOMIC IMPLICATIONS

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Fluvial paleochannels occur in a variety of geological settings in the Canadian Cordillera and adjacent plains. Due to widespread glaciation in these regions, drainage patterns have been repeatedly altered and paleochannel systems are often completely obscured by overlying glacial deposits. These include till, glaciolacustrine sediments and glacioluvial deposits that locally are up to 100's of metres thick. In plateau areas within the mountains and in the plains east of the mountain front, the paleochannels often occur within flat to gently rolling terrain and commonly they have little or no surface expression.

A variety of tools have been used to detect these hidden channels including interpretation of satellite data, resistivity surveys, high-resolution aeromagnetics, seismic profiling, ground penetrating radar, and borehole evaluation. The advantages and disadvantages of these different methods will be discussed using case study data from several areas in British Columbia. The first step in identifying the channels is to locate the main paleovalleys by reconstructing the bedrock topography. These valleys are wide and deep and therefore more readily detected by remote sensing. Smaller tributary valleys are relatively difficult to map but often are more significant from economic perspectives, partly because their contained deposits occur closer to surface and have thinner overburden. Mapping of the smaller tributaries requires high resolution data and ultimately borehole data must be used.

Gravel deposits within these ancient paleochannels are relatively mature compared to modern fluvial systems and consequently they provide high quality aggregates and, in some gold provinces, they are excellent placer targets. They also are important aquifers and recently have become of interest for their hydrocarbon (shallow gas) potential. A number of paleochannels east of the Rocky Mountains are the focus of recent shallow gas plays. The channels are buried by thick sequences of Middle to Late Pleistocene, glaciolacustrine deposits and clay tills which act as cap rocks. Glaciers that advanced westward up the regional slope, dammed rivers draining eastward off the Rockies and eventually deposited a cap of clay-rich till derived from local shale bedrock.

## 6-7 BTH 114 Naumova, Oksana B.

### THE QUATERNARY PERIGLACIAL ALLUVIUM OF THE KAMA RIVER BASIN AS A POLYCOMPONENT RAW MATERIAL (SAND AND GRAVEL, GOLD, PGE, DIAMONDS)

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Quaternary alluvium of the Kama drainage basin is a multi-component mineral deposit that contains construction materials (sands and gravels) and accessory components, such as gold, diamonds, platinum. During the Quaternary the region formed a part of a vast periglacial zone. It was distinguished by a number of special features, including a specific structural position (close to the platform/folded mountains boundary); differentiated neotectonic movements of considerable range complicated by salt tectonics; highly diversified composition of source rocks; limited influence of the main centers of ice spreading. By the Quaternary, valleys of the Kama and its tributaries were already fully developed geomorphic systems with a series and Neogene terraces. Most of the rivers were not directly fed on glacial meltwater. The periglacial alluvium of the Kama is well sorted and represents a valuable construction material. Besides, it contains gold, platinum and precious minerals which were supplied to the Quaternary fluvial deposits through a series of intermediate hosts – terrigenous rocks of Tertiary and Mesozoic age. Another source of gold and platinum could be fault zones attributable to the Meso-Cenozoic stage of tectonic and magmatic processes reactivation on the East European Plain. The most efficient way to develop fluvial sand and gravel deposits in the Kama drainage basin is to recover separately gravel and sand (specially sorted), and then - to extract collective concentrate of precious minerals (gold, platinum and other placer-forming components).

## SESSION NO. 6

### 6-8 BTH 115 Bobrowsky, Peter T.

#### GROUND PENETRATING RADAR AND GIS IN FLUVIAL PLACER EXPLORATION, MAPLE CREEK, GUYANA

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A total of 44 km of ground penetrating radar (GPR) survey line was collected at the Vanessa Ventures Ltd.'s Maple Creek diamond and gold placer property in Guyana, South America. Reconnaissance exploration indicated that a buried diamondiferous and gold-bearing deposit exists adjacent to and underlying Maple Creek. To date, traditional placer exploration has not embraced many of the technological advances successfully proven in other aspects of geoscience. In particular, new geophysical techniques integrated with GIS allow construction of a three-dimensional sub-surface model and provide an exceptional tool for assisting in placer exploration.

Despite the technical challenges of conducting a GPR survey in the dense jungle, the data collected provided high quality imagery of a buried valley. The quartz-rich sediment allowed for exceptional depth penetration (>70 m) and high resolution imaging of the architecture of the fluvial valley fill sediments. The processed survey lines clearly imaged a number of discrete radar elements. These radar elements can be related to fluvial architectural elements and therefore, provide laterally extensive cross-sections of the valley fill sediments and the bounding surfaces. The most notable bounding surface is the 6th order bedrock-sediment interface that defines the paleo-bedrock surface. Utilizing GIS software, a three-dimensional model of the paleo-topography was constructed. Another regionally extensive surface is imaged near the top of the profiles and represents either a weathering contact or the sequence boundary between the fluvial valley fill sediments and ubiquitous surface sand. Other examples of architectural elements present in the GPR profiles are channels, barforms, as well as downstream and lateral-accretion macroforms. Extensive trenching in the study area confirmed many of the major reflectors and provided direct observation of some of the fill elements.

The processed survey lines, in conjunction with GIS imaging software enabled the construction of a three-dimensional model, recreating the bedrock topography and therefore delineating and imaging the paleo-valley. Armed with an accurate model of the paleo-topography, channel morphology, and an understanding the local stratigraphy, information such as resource estimates, exploration targets, and mine plans are possible.

### 6-9 BTH 116 Arias, Jaime

#### ON THE ORIGIN OF SALTPETER, NORTHERN CHILE COAST

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Chile's nitrate origin has been debated since Darwin visited Tarapaca deposits in 1835; deposits cover 6,500 Km<sup>2</sup> of arid Atacama Desert, between Pisagua and Taltal.

N<sub>2</sub> forms 70% of Earth's atmosphere and is fixed by algae and bacteria before plants use; oceanic algae fix it in unknown amounts. NO<sub>3</sub>-(aq.) and NH<sub>4</sub>+(aq.) are main species in the N-O-H system Eh-pH stability diagram (25°C, 1 bar) and most common species in water; significant N<sub>2</sub> water-solubility favors N accumulation in algae; NH<sub>4</sub>+ forms by algae decay; thus, nitrogen cycles in and out of algae biomass.

Nitrate deposits result from decay of marine algae concentrations living above the 9 Km-deep Peru-Chile trench, due to N, K, P plant nutrients cycling by sea currents and seawater uplift in the trench's reduced gravity field; collapse waves from the +20m. high sea-rise, form abundant sea-spray, taken inland by SW winds; these facts link algae's N<sub>2</sub> biological uptake and accumulation with NH<sub>4</sub>+ rich sea-spray from algae decay, which when risen over the 2,000m-high Coast Range into the desert's high solar radiation atmosphere undergoes photochemical oxidation of NH<sub>4</sub>+ to NO<sub>3</sub>-.

Nitrates accumulate on land both through marine-fog precipitation, and sea-spray oxidation/desiccation and gravitational settling of airborne NaNO<sub>3</sub>, KNO<sub>3</sub>, NaCl, Na<sub>2</sub>SO<sub>4</sub>, I, in the hot/dry desert atmosphere. El Niño/La Niña extreme aridity/torrential rain cycles favor nitrates accumulation through both aridity and water solution/remobilization/transportation onto slopes and into basins; capillary solution movement forms layers of nitrates; pure nitrate forms rare veins.

Nitrate deposits, as irregular strata >1m. thick, average 8% NaNO<sub>3</sub> (range 3% - >13% NaNO<sub>3</sub>; mining cut-off grade is 7%). Nitrate ore reserves are estimated at 6,800x10<sup>6</sup> tons (equivalent to 54x10<sup>6</sup> tons NaNO<sub>3</sub>); accumulation rate would be 32.1 ton NaNO<sub>3</sub>/year (or 88 milligrams/m<sup>2</sup>/day) if it started in the Miocene, 17m.y. ago (extreme aridity onset); exploitation rate today is 106 tons NaNO<sub>3</sub>/year; 200x10<sup>6</sup> tons may have been exploited since 1809. Nitrates are non-renewable, since accumulation rate is very slow; efficient use of nitrate fertilizers could help reduce nitrates exhaustion risk.

Studies of natural nitrate formation processes and accumulation rate measurements would help define more efficient resource uses.

### 6-10 BTH 117 Chan, Roslyn

#### REGOLITH GEOCHEMISTRY, MINERALOGY, REGOLITH MAPPING, GEOMORPHOLOGY

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The Cooperative Research Centre for Landscape Environments and Mineral Exploration (CRC LEME) is made up of researchers from Australian universities, Commonwealth and State Government geoscientific and environmental agencies, and private industry. CRC LEME aims to develop a greater understanding of Australia's regolith terrain when applied to mineral exploration and environmental management. CRC LEME has ongoing projects throughout Australia, and this poster highlights some of the aspects of the projects within the State of New South Wales (NSW) that pertain to mineral exploration. Regolith, encompassing soils, sediments and weathered bedrock, mantles most of Australia, with significant depths (50-200 m) over much of the continent. In NSW CRC LEME's mineral exploration projects are within the geological fold belts or on their perimeters with surrounding basins. Areas are selected so as to study various aspects of the distribution of regolith materials, their present and palaeo landscape position, their processes of formation, and their geochemical and mineralogical character. By placing the geochemical and mineralogical attributes in context of the evolving regolith architecture of an area, background versus anomalous values can be understood. In situ geochemical anomalies can be distinguished from transported anomalies, and the source of transported anomalies may be able to be inferred by interpreting palaeo groundwater flow in terms of a landscape evolution model. Certain regolith materials can concentrate minerals, eg. calcrete concentrates gold in the semi arid areas of NSW, and so are used as sampling media to target mineralisation. Studies of regolith profiles help to identify bedrock lithology, distinguish bedrock alteration from weathering, distinguish primary mineralisation from secondary mineralisation, and identify associated pathfinder elements.

### 6-11 BTH 118 Li, ZHongfeng

#### STUDY OF LAND USE CHANGE IN YULIN PREFECTURE

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This paper takes Yulin prefecture as an example. Yulin prefecture is located in the Northern-most part of Shaanxi province, between 36°57' and 39°34' N and 107°28' and 111°15' E; It covers an area of 43578km<sup>2</sup>, accounting for 22% of the total Shaanxi province. Climate type is temperate and temperate semi-arid continental monsoon climate. Mean annual air temperature is about 10°C. Mean annual precipitation is 400mm, with most of the rainfall occurring in July and August, only little falls between November and January and has large annual and seasonal amplitudes. In spatial the rainfall decreases from Southeast toward Northwest. Located in the transitional zone from agricultural to husbandry areas. Yulin prefecture not only has its special spatial pattern in physical geography, but also has typical characteristics of fragile ecosystem and differentiation rule in ecology. Located in transition area of Loess Plateau and Mu Us desert, Yulin prefecture has the problem of serious soil erosion and water shortage. It is selected as a typical area for the ecosystem assessment of western China project. Depending on 1986 and 2000 TM images and other data, we achieved the land-use change data after interpretation. This paper analyzed the situation of land-use change in temporal and spatial aspects with the GIS and statistic methods. Then this paper analyzed the situation of landscape change with FRAGSTATS 3.3, the most famous landscape structure analysis program. Various landscape metrics are calculated at class and landscape levels. The results show that: in recent 14 years the un-used land decreased by 1305.56 km<sup>2</sup>, cultivated land increased by 567.11 km<sup>2</sup>, forest land and grassland increased by 99.6km<sup>2</sup> and 616.79km<sup>2</sup> respectively. The change rate of un-used and construction land is most high. There is obvious area differentiation in land-use change. In the direction of land-use change the conversion from un-used land to grassland and from grassland to forest and cultivated land is prominent. The results also show that the landscape structure changed dramatically during the past 15 years. The land conservation works well in recent years.

### 6-12 BTH 119 Smirmov, Alexander N.

#### FOSSIL IVORY – A SPECIFIC PLACER OCCURRENCES OF RUSSIA'S ARCTIC

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Specific environments that existed in northern Siberia in the Late Pleistocene and predetermined the expansion of the mammoth fauna serve as a critical factor in subsequent formation of placer-type accumulations of specific of biogenetic raw material – fossil ivory (tusks). Technological and decorative features of fossil ivory are practically similar to contemporary one. Despite the exogenous origin, unusual sizes and morphology of monoblocks of fossil ivory, its accumulations in recent sediments conform in their formation and location to the main laws of placer formation. The northern regions of the Republic of Sakha (Yakutia), including coastal plains, shelf, and islands, are the main area where most of the pay ivory deposits are located. They are closely related to areas of distribution of specific aeolian-cryogenic ice-bearing loess-like sediments of the so called 'Edoma Suite' ('muck'), which appears as an unique primary collector of fossil ivory. The most significant ivory placers suitable for commercial operation under present conditions represent contemporary residual coastal and littoral deposits located on beach and mud flats along termo-abrasion cliffs. Residual ivory occurrences on river beaches are of lesser importance. Summary annual mining of high-quality fossil ivory from placers may reach 5-10 t. Reserves of coastal and littoral placer ivory accumulations are renewed after operation; that is the most important condition for the long-term production of fossil ivory from placer deposits. In connection with the short life of exposed fossil ivory accumulations, the periodical monitoring of productive deposits and concurrent ivory collection without environments disturbing are to be appropriate.

## SESSION NO. 7, 1:30 PM

Thursday, July 24, 2003

### T11. Paleohydrology and Global Change (Posters) (GLOCOPH)

#### Reno Hilton Resort and Conference Center, Pavilion

### 7-1 BTH 120 Gregory, Ken

#### PROGRESS IN PALAEOHYDROLOGY

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Issues and challenges in palaeohydrology are introduced in Palaeohydrology: Understanding global change (Gregory and Benito, 2003). Once the research foundations for environmental processes and Quaternary Environmental Change were established, interrelationships were explored and palaeohydrology is just one new hybrid research field generated at research frontiers where disciplinary boundaries intersect. Palaeohydrology research will continue to progress arising from the growth of palaeohydrology demonstrated in the literature data base (PHEIMS) and from subjects at Glocoph conferences; the definition of palaeohydrology which has broadened as a concomitant of rapid growth of sub branches, demonstrating the potential of palaeoflood hydrology, and the need for a more basin-based palaeohydrology; regional variations in palaeohydrology which are needed for specific global areas as the scale and rate of Late Pleistocene hydrological processes do not always have present analogues; and the potential of palaeohydrology in relation to global change is significant not only for downscaling spatially but also recognizing that the data analyzed has to be downscaled temporally.

When considering global change and recognizing that adjustments in water resources will be regional or local, potential contributions of palaeohydrology include coupling of Global Climate Change Models to hydrological models and the necessary forcing mechanisms; derivation of data to complement periods of continuous hydrological records relating to water balance, hydrological extremes, water quality; mechanics of temporal change, including the significance of thresholds; spatial contrasts identifying differences between world zones, within zones and within basins, and their synchronicity; and construction of new models of a retroductive kind. Growth areas include short term hydrological events because it has been appreciated that the most dramatic changes during glacials were succeeded by large and sometimes abrupt, natural climatic oscillations during the Holocene. A project bringing together research from six organisations with ICSU support is focusing on past hydrological events related to global change.

**7-2 BTH 121 Starkel, Leszek****THEMES ARISING FROM PALEOHYDROLOGICAL RESEARCH IN HIGH LATITUDES AND THE TEMPERATE ZONE**

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The most extensive continental areas of the northern hemisphere drained by large river basins are located in the temperate zone and in high latitudes. These areas experienced substantial change in water circulation at the turn from the last cold stage to the Holocene. During the cold stage water storage occurred in large ice sheets as well as in the foreland areas together with permafrost and seasonal storage in snow in areas of continental climate. Depending on the pattern of drainage systems large ice dammed lakes were formed.

During the Lateglacial and the early Holocene major transformations in water storage and drainage pattern occurred. Rapidly retreating ice sheets and permafrost left new topography over which lake basins with surficial storage were developed, then being subsequently modified with the gradual formation of a new drainage pattern, expansion of bogs and overgrowing of lakes. In continental climate areas permafrost still dominates. With extension of forest communities rivers changed their regime and their channels shifted from a braided to a meandering pattern.

The cooler and wetter phases, clearly evident during the Holocene coinciding with decreases in solar activity and with high frequencies of volcanic eruptions, are characterised by higher frequencies of extreme floods and their clustering. Rivers responded to these conditions by straightening and braiding of their channels, especially in mountain headwater catchments, where lowering of vertical climatic vegetation belts is also observed.

Special attention should be concentrated on human intervention, which initially caused an acceleration of runoff, increase of sediment load and aggradation, but later in the last century various human activities directly provoked opposite tendencies.

**7-3 BTH 122 Thomas, Michael F****LATE QUATERNARY PALEOHYDROLOGY IN THE TROPICS AND SUB-TROPICS**

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Sparse records and correct interpretation of proxy data are major issues. Paleolake studies often ignore catchment conditions and groundwater flows; pollen spectra may not characterize vegetation patterns, and aridity is masked at wetland sites; ocean sediments are ambiguous about catchment behavior, and submarine fans of major rivers integrate fluvial response across many ecological zones. Use of terrestrial sediments to infer climate change implies that climate forcing determines fluvial behavior, but tectonic forcing, inherited morphology, complex response and human impacts are complications. Large drainage systems (Amazon, Congo, Nile) create major problems for sampling.

Quaternary sediments indicate prolonged deposition during Zone 3 continuing until 27ka. Forest changes and reduced rainfall became severe at the LGM. Fans, braided rivers and ephemeral tributaries that left few deposits, are recorded from Amazonia, Congo, E and W Africa, India and N Australia: 27/23-15/14ka. Recovery of climate was diachronous after 17ka. In Africa, lake overflows and floods occurred at 13.5ka and 11ka. Sedimentation increased x2 in the Ganges delta at 11ka. In W Africa channels were scoured, and gravels deposited after 15ka, in NE Australia fans entrenched after 14ka. From 11-8ka humid climates and rainforest were widely established and meandering channels replaced braided rivers as flow regimes stabilised. The YD and mid-Holocene aridity affected lakes and rivers, but no change to fluvial style is evident.

Major issues include: 1/ the regionalisation of climate change and fluvial response across the tropics; 2/ the differential and diachronous response between equatorial and arid areas (severity of LGM, progress of wetter post-glacial, Holocene climates, collapse of rainfall in the mid-Holocene); 3/ the nature and timing of the fluvial response to hydrologic change on different timescales. Although lake levels and palaeofloods often indicate immediate responses to water inputs, the evolution of floodplains is more complex, requiring millennia of changing climate and land cover. But the major impact of Quaternary climates on stream and slope hydrology in the tropics is confirmed, and is fundamental to the evaluation of short-term changes in fluvial and hillslope systems.

**7-4 BTH 123 Benito, Gerardo****KEY ISSUES ON CONTEMPORARY PALEOHYDROLOGY**

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Contributions from contemporary palaeohydrology derive from establishing: (1) quantitative palaeohydrological indicators of global change and improving the precision of dating fluvial deposits; both required to obtain high resolution paleoclimatic and environmental records from stratigraphic sequences; (2) potential responses of palaeohydrological systems to large-amplitude (millennial scale), rapid (decadal to centennial) global change, demonstrating the utility of palaeohydrology in determining high-resolution global change records. Key palaeohydrological research investigations are based upon sediment-based research and process-based studies in addition to analysis of landform assemblages. Sediment-based interpretations from studies of alluvial plain sequences, demonstrate changes in the discharge-load relationships over long time periods (0.1-1 ka), and provide sedimentary evidence of individual events, such as floods. The other trend, of process-based palaeohydrological research, focuses on studies which provide better understanding of components of the hydrological cycle including the water balance components, river discharge (mean and flood discharge), surface-groundwater exchange, sediment transport, and rates of erosion and sedimentation in channels and on floodplains. Analysis of basin components, including palaeochannels, lakes and vegetation (pollen), provide the data necessary to estimate hydrological fluxes and to develop models of the hydrological cycle and water balance of the past. Palaeoflood hydrology provides a good example of synergy between sediment and process based research, together with modelling of flood hydraulic conditions. Contributions to global change science (Gregory and Benito, 2003) require further palaeohydrological quantification to improve understanding of relations between climate and hydrological changes as a basis for application in climate models.

**7-5 BTH 124 Baker, Victor R.****PALEOFLOOD HYDROLOGY AND EXTENDED DISCHARGE RECORDS**

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There have been remarkable recent advances in studies of the effects of ancient floods on natural recording systems, allowing the extension of discharge records over the past 10,000 years. Although the term "palaeoflood hydrology" was not even introduced until 1982, various methods of palaeoflood analysis now have worldwide application. Extensive and detailed palaeoflood hydrological investigations have been performed in the United States, China, Australia, India, Spain, Israel, Japan and South Africa. Palaeoflood hydrology is the study of past or ancient flow events that occurred before direct measurement by modern hydrological techniques. This subject has

experienced a revolution in its development in recent years. There are now numerous techniques of very high accuracy for the estimation of past flood discharges that effectively extend stream-gage record of floods to time scales of several thousand years. Reconnaissance work shows the potential for much more application in South America, southern and central Europe, northern Africa and southwestern Asia. Although long historical records and palaeoflood data do have the necessary record lengths to test the hypothesis of increasing extreme flooding, these aspects of science have received minimal attention and minimal funding, thereby contributing to the current non-scientific, nontestable paradigm of global extreme flood assessment. A very preliminary survey of historical and palaeoflood records suggests the following (though the database is woefully inadequate to defend these conclusions in a rigorous manner): (1) very large floods (those exceeding some threshold value) seem to cluster on time scales of decades and centuries, (2) there are some regions, particularly in arid regions and the tropics, where the most recent century shows a cluster of extreme flood magnitudes, and (3) the floods of recent years do not generally exceed the magnitudes of those in the current cluster, or those of past clusters, and much larger floods are usually indicated in the past. These conclusions are sufficiently controversial and important enough to warrant the expenditure of more resources on the collection of relevant historical and palaeoflood data.

**7-6 BTH 125 Passmore, David G.****FLUVIAL MORPHOLOGY AND SEDIMENTS: ARCHIVES OF PAST FLUVIAL SYSTEM RESPONSE TO GLOBAL CHANGE**

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For many decades it has been known that rivers respond to a number of stimuli or forcing functions which act over a variety of temporal and spatial scales (e.g. Schumm and Lichty, 1965). Over the longer term (i.e. 10<sup>3</sup>-10<sup>6</sup> years) geology and climate may play the dominant role in fluvial system behaviour, generating basin-wide sediment-landform assemblages. Changes in these variables exert control over sediment and water supply and thus often promote system adjustment. Runoff and sediment supply, however, vary also over the shorter-term (i.e. 10<sup>1</sup> - 10<sup>2</sup> years) as a result of sediment exhaustion and starvation, and changes in flood frequency and magnitude. In the context of immediate future global change it is perhaps these latter mechanisms that appear to be of most obvious concern however, in many areas, particularly the mid-latitudes, basins sculptured by Pleistocene glaciation may still contain rivers adjusting to longer-term processes.

One approach to understanding how rivers might respond to any given future change scenario is to look at the record of past long-term behaviour. These changes are archived within the sediment-landform assemblages of the river basin and their investigation requires consideration of both the morphological and sedimentological attributes of this archive. Unfortunately establishing the relative importance of forcing functions acting at different time and spatial scales within the fluvial sedimentary record can be extremely difficult, especially as the changes observed within the sedimentary record are often very similar. This paper will illustrate how recent advances in methodology, and in particular the increasing availability of geochronology, may help to decipher these records with higher temporal resolution, allowing more accurate models of fluvial system behaviour to be erected, especially with respect to establishing cause-effect relationships. Such models can provide valuable insight into the future consequences of global change on individual river system behaviour.

**7-7 BTH 126 Knox, James C.****LARGE UPPER MISSISSIPPI RIVER FLOODS AND CLIMATE CHANGE OVER THE PAST 7000 YEARS**

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Sedimentological properties of UMR (upper Mississippi River) Holocene alluvium indicate large floods during the last 7000 years have occurred in a very episodic fashion that is strongly linked to relatively modest climate changes. There has been a tendency for floods to be smaller and more variable during prolonged warm episodes compared to floods being larger and less variable during prolonged cool episodes. Thus, a general tendency for moderate to relatively large floods between about 7000 and 5500 years ago, followed by an episode of smaller floods between about 5500 and 3300 years ago, then returning to generally larger floods after about 3000 years ago is broadly coincident with modest shifts in local effective climate conditions from cool/moist to warm/dry and back to cool/moist during the same times. However, on shorter timescales, there also has been a strong tendency for increased occurrences of very large floods during the beginning phases of times characterized by rapid climate change. Particularly noteworthy are occurrences of large floods about 4700, 2500-2200, 1800-1500, 1280, 1000-750, and 550-400 calendar years B.P., all times that independent climatic proxies indicate as periods of change. The anomalous high frequency of large floods on the UMR since about 1950 have occurred during a period of rapid global warming, and the association appears similar to anomalous frequencies of large floods evident in the geologic record of past periods when global warming was also apparent. The strong sensitivity to climate change supports a view that planning and policy decisions related to anticipated future flooding conditions should reflect scenarios of potential future climates rather than assuming randomness in climatic and hydrologic time series as is commonly done at present. Research was supported by the National Science Foundation (ATM-0112614).

**7-8 BTH 127 Menounos, Brian****MILLENNIAL-SCALE PATTERNS OF STREAMFLOW VARIABILITY INFERRED FROM ANNUALLY LAMINATED LAKE SEDIMENTS, COAST MOUNTAINS, CANADA**

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We recovered five percussion cores ranging in length from 2.1 to 3.5 m from Cheakamus Lake (50°N, 123°W), British Columbia, to determine if the lake's annually laminated (varved) sediments contain proxy information on changes in the hydrologic regime during the late Holocene. Cheakamus Lake is an oligotrophic lake draining a moderately (25 percent) glacierized watershed in the southern Coast Mountain, approximately 100 km north of Vancouver. Recovered sediments are inorganic, finely laminated, clayey silts. The moderate correlation ( $r=0.75$ ;  $n=41$ ) between laminae thickness and annual flood magnitude obtained from a nearby gauging station suggests that the laminae represent clastic varves. Their thickness ( $2.97 \pm 2.6$ mm;  $n=947$ ) and excellent preservation allowed us to subdivide the varves into six major types. Comparison between varve type and annual hydrographs over the period of instrumentation allows us to attribute the six varve types to (a) snowmelt flooding, (b) autumn flooding, (c) two major inflow events, (d) three major inflow events, (e) more than three major inflow events, and (f) periods of sustained glacial runoff. Varves attributed to glacial runoff (type f) and late autumn floods (type b) are dominant. Markov chain analysis indicates that varve types (b) and (f) exhibit serial dependence and are most common at ca. AD1300-1320, AD1380-1410, AD1470-1500, AD1710-1730, AD1880-1906, and

AD1916-1945. From Northern Hemispheric reconstructions of air temperatures, we conclude that these periods coincide with decades that are warmer than the long-term average. In contrast, varves interpreted to form predominantly during early season floods appear to be randomly distributed through time. These results confirm the importance of sediment production and transfers during the summer and autumn runoff season in the Coast Mountains over the past 1000 years.

## 7-9 BTH 128 Sauchyn, David J.

ARIDITY ON THE CANADIAN PLAINS: PAST RECORDS AND FUTURE FORECASTS  
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The Prairie Ecozone is the only major region of Canada where drought is a landscape hazard; aridity is closely linked to soil erosion and degradation. Future management of prairie ecosystems and soil landscapes will therefore require an improved understanding of past and future trends and variability in regional aridity. We used instrumental and paleoclimatic records to define a regional baseline for prairie aridity, to evaluate the utility of modern climate normals (i.e. 1961-1990) as a benchmark for future climatic change, and to provide a historical and paleoclimatic context for a range of GCM forecasts of regional aridity spanning the next 80 years. The Canadian GCM forecasts the least increase in precipitation and the largest increase in temperature and therefore an approximately 50% increase in the area of subhumid climate and a significant area of semiarid climate by the 2050s. Tree rings and diatom-inferred lake salinity record prolonged arid events and show that modern climate normals are not representative of the full range of potential climatic conditions, even in the absence of global warming. The climate of the 20th century was anomalous in terms of the absence of sustained drought and the climate normal period of 1961-1990 may have been among the most benign of the past 750 years. Because both lake and tree-ring analyses recorded an abrupt amelioration of climatic conditions near the start of the instrumental record, we suggest that the immediate impacts of future global warming may be to return the prairie environment to past conditions in which persistent aridity was recorded for intervals of decades or longer.

## 7-11 BTH 130 Iriondo, Martin

A STABLE CANYON EXCAVATED IN THE BOTTOM OF A LARGE RIVER OF SOUTH AMERICA  
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The Uruguay is one of the large rivers in South America. It links along 1,838 km the tropical Brazilian meset with the temperate lowlands in Argentina and Uruguay. An exceptional feature in the river channel is a deep and narrow canyon or trench excavated in the bottom of the channel. This feature has been followed by the authors from the Cretaceous basaltic upper basin up to the mouth located in Quaternary littoral deposits. The canyon is permanently submerged, except in two short segments (where the trench is visible in low waters).

In the upper basin, the canyon is 3 to 7 times deeper than the river channel and the wide varies between 1/3 to 1/8 of the total channel width. The section is well defined with sub-vertical flanks and flat bottom incised in basalt. The trench forms irregular curves which are shorter than the present fluvial meanders. In a 3 km long the canyon is 12 m deep an emerges forming the well known Moconá falls. In the middle basin (between 500 to 800 km from the sea), the river crosses a hilly landscape of Cenozoic sediments and rocks. The canyon there is 30 m wide and 10-15 m deep in a channel 1 km wide and 1-3 m deep.

The lower segment of the river (150 km long) is subject to the littoral dynamics. The fluvial water level is between 1 to 2 m.a.s.l. The river is extremely wide (5 up to 12 km) and shallow (less than 3 m deep) along the 100 km upstream its mouth. The canyon is sharply incised in Quaternary sediments at the middle of the stream. The depth is 10-18 m with extreme values up to 25 m and the wide reaches 200-800 m. That is 1/20 of the total width. Discontinuous trenches up to 20 m depth and 4-6 km long appears at the left of the continuous canyon.

The key point of this issue is that the canyon is not an inactive fossil feature, but it is an active part of the present fluvial dynamics. That is explained by the fact that the bed load reaches 5 million Tn/yr and that volume is transported to the ocean without infilling the narrow trench. We estimate that the canyon was originally generated during a dry climate in the Lower Quaternary.

## 7-12 BTH 131 Behling, Hermann

ENVIRONMENTAL CHANGES IN HIGHLAND VALLEY HEAD AREAS DURING THE LATE PLEISTOCENE OF SANTA CATARINA STATE, SOUTHERN BRAZIL

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Pedostratigraphic units have been studied in the North of Santa Catarina State, Southern Brazil. The study area is situated on a plateau at about 1,000 meters elevation. According to Köppen's nomenclature the local climate is of the "Cfb" type. Although degraded, multi-layer *Araucaria* forests and *Campos* (grassland) compose the dominant vegetation today. Hills and valleys dominate geomorphology, under the structural influence of the area's Eo-Paleozoic basement. Two sites have been studied, near the interior border of the "Serra do Mar" mountain ranges. The sites are located in valley heads, above smooth Quaternary floodplains.

Thick histic paleosoils and peat bogs developed over Bw cambic horizons during the Quaternary. These soils alternate with colluvial strata, indicating pulses of erosion and sedimentation. Older layers are lenticular, while the younger develop cut and fill structures.

In one site, radiocarbon ages for the histic horizons suggest the development of paleosoils around 19,130 years BP  $\pm$  110 and 15,260 years BP  $\pm$  80. Colluvial lenses covered the last glacial maximum soil while the younger soil was dissected by gullies. This sedimentary pattern was interpreted as evidence for a change in environmental conditions.

At the second site a peat bog buried under 4.5 meters of colluvium had been described. Radiocarbon ages for the 150 cm long peat section gives >50,000 years BP for its base and 49,300 years BP  $\pm$  6,970 for its top. Pollen analytical studies on that peat indicate the predominance of *Campos* with small areas of forest during the glacial period record. Subtropical *Araucaria* forests probably occurred as gallery forest in the valleys. *Araucaria angustifolia* itself was not presented in that record. Pollen composition of the samples suggests two periods of stable conditions. The higher representation of *Podocarpus* trees during the younger period (0-

45cm) suggests a climate colder than that of the older period, where trees of *Weinmannia* were stronger represented.

Radiocarbon dates for the Late Pleistocene record of the sites are correlative to marine isotopic stages 2 and 3. Morphogenesis and pedogenesis alternate along this period. Drier climate seems to have been dominant during the period, although an excess of precipitation over evaporation is needed to explain the development of water logged soils.

## 7-13 BTH 132 Sheffer, Nathan A.

USING PALEOFLOOD HYDROLOGY FOR THE RECONSTRUCTION OF PALEOCLIMATE IN EUROPE

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In a specific drainage basin paleoflood research enables understanding of the long-term flood occurrences. Combining paleoflood records from several basins within a hydroclimatic region promotes understanding of regional climate variations in terms of the occurrences of extreme storms. Records from wider climatic zones may be helpful in constructing the larger paleoclimate. An attempt to reconstruct a regional paleoflood chronology was initiated in the southern Massif Central, France. It reveals a consistency in flood occurrences in the Ardèche and the Gardon Rivers (2450 km<sup>2</sup> and 1900 km<sup>2</sup>, respectively). These rivers drain the Cévennes region of the Massif Central and are confluences of the Rhône River. Their largest floods occur during the autumn from storms associated with moisture transported to the north from the Mediterranean. When compared with earlier and later times, more frequent large/extreme floods characterized the Little Ice Age (LIA). During the ~2000 years preceding the LIA there were no extreme floods in the Ardèche River. This 2000 years long gap followed by a frequency increase of large floods during the LIA was also identified in paleohydrological studies in the eastern Spanish Pyrenees and in Italy; all affected by the same flood producing mechanism. This temporal pattern over such a wide region may indicate that flood occurrences are not merely random in time, but follow trends controlled by the larger climate. Expanding such studies in space and time may provide a better understanding of the extremes embedded in paleoclimates.

## 7-14 BTH 133 Benito, Gerardo

A 3000 YEAR RECORD OF EXTREME FLOODS IN THE LLOBREGAT BASIN, NORTH EAST SPAIN

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Slackwater palaeoflood deposits were found along two reaches of the Llobregat River at Pont de Vilomara and Monistrol de Montserrat. A total of 56 individual flood units have been preserved in rock alcoves located on the valley margins of these bedrock gorge reaches. The highest elevation modern slackwater flood deposits, from the 1971 flood, indicate that the instrumental gauging station records underestimate the magnitude of extreme flood events. At Pont de Vilomara a discharge estimate of 2300 m<sup>3</sup>s<sup>-1</sup> was obtained from slackwater flood deposits from the 1971 event, compared to a discharge of 1500 m<sup>3</sup>s<sup>-1</sup> recorded at the gauge station. In terms of flood risk estimation the relative magnitude of the 1971 flood, the largest modern event, in comparison to earlier flood events is of particular relevance. The Llobregat palaeoflood record shows the occurrence of at least 8 palaeofloods of greater magnitude than the 1971 flood, these being radiocarbon dated to two distinct periods: a) the Late Bronze Age (ca. 2700 yrs BP and b) the Little Ice Age (ca. 16-17th centuries AD). The minimum discharge estimates of these extreme palaeofloods are 3700 m<sup>3</sup>s<sup>-1</sup> at Pont de Vilomara and 4680 m<sup>3</sup>s<sup>-1</sup> at Monistrol de Montserrat, respectively 38% and 46.5% greater than the discharge of the 1971 event at these reaches. The data indicate that the most extreme Llobregat palaeofloods exceeded in magnitude the largest floods observed in the instrumental record and provide valuable additional information for flood risk assessment.

## 7-15 BTH 134 Klimek, Kazimierz

SUBFOSSIL BRAIDED RIVER PATTERN AS AN INDICATOR OF EXTREME SHORT TERM EVENTS, SUDETES MOUNTAINS, CENTRAL EUROPE

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The Sudetes are a mid-mountain range located in the temperate climatic zone of Central Europe. Deep valley sides are covered with thick mantles of periglacial regolith. Migrating cyclones cause intensive rainstorms and floods. Geomorphological and sedimentological traces of previous large floods have been found in the upper course of the Bila Opava valley floor, which drains the eastern slope of the Hruby Jeseník massif, 1000-1400 m a. s. l. Big boulders deposited here form a typical braided pattern overgrown with old spruce forest; the braided river pattern consist of a group of boulder palaeo-bars, the majority of which formed as longitudinal central bars with lee slopes running diagonally to the valley axis. Tree-ring increment analysis indicates that the oldest spruces growing on this braided river pattern may be more than 75 years old so that, allowing for the time required for the formation of the initial soil and the succession of pioneer vegetation, the spruces succeeded here around the turn of the 20th century. The majority of precipitation is linked here to synoptic situations, when cyclones from southern and western direction create favorable conditions for continuous heavy precipitation. Such heavy rainfalls trigger large floods, which occurred several times in the turn of the 20th century in the vicinity of the Hruby Jeseník massif. The largest flood, in July 1903, was caused by a precipitations amount not previously recorded; on 9 July 1903 the rain gauges in the northern part of the massif received 200-240 mm of precipitation which generated a flood wave sufficient to transport and deposits very coarse material, forming the braided river pattern. The periglacial regolith covering the steep, deforested slopes of the valley were the source of the coarse-grained clastic material supplied to the Bila Opava river bed.

## 7-16 BTH 135 Magyari, Árpád

NEOTECTONIC CONTROL ON HOLOCENE RIVER DYNAMIC CHANGES IN THE KÖRÖS BASIN (E-PANNONIAN BASIN, HUNGARY): FROM UPLIFT TO SUBSIDENCE

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The latest phase of the multi-storey development of the Neogene Pannonian Basin in Central Europe comprises a still active compressional basin inversion (5 to 0 Ma). This resulted in significant uplift of most of the marginal parts and local subsidence of some depressions. Neotectonic

field and literature data showed, that in addition to climate changes, tectonic activity had an important control on avulsion and changes in river dynamics of the recent fluvial systems. The study area is situated in the eastern part of the Pannonian Basin, and represents a key-setting of a transitional zone from uplift to subsidence. The recent rivers display a transverse pattern, draining the Apuseni Mountains in Romania, and transport sediment to the west to the Körös Basin which is an actively subsiding depression. The present study focuses on changes in river course pattern of the transverse river system based on the analyses of airborne photographs. The reconstruction of the most important morphological features (channels, levees, terraces, marshes) showed, that the area can be subdivided into three E-W striking zones: (1) on the north large, well developed meanders are found, (2) the central part is characterised by a dense pattern of small-scale former meanders, (3) on the south, a braided pattern can be seen. A detailed analysis of seismic profiles, supported by digital elevation models, geological cross-sections, and neotectonic field data showed, that NE-SW to E-W striking faults, connected with basement highs correspond to the above described zones, characterised by different morphological patterns. A preliminary conclusion is that tectonics was an important allogenic control on the development of river dynamics that manifested in the form of alternating meandering and braided patterns.

#### 7-17 BTH 136 Jain, Vikrant

HYDROLOGICAL VARIABILITY AND LANDSCAPE EVOLUTION IN ALLUVIAL RIVER SYSTEM: AN EXAMPLE FROM THE GANGA PLAINS, INDIA

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Hydrological controls on landscape evolution of a river basin provide an understanding of river response to climate change. In the present contribution, landscape variability in one of the largest alluvial plains in the world, the Ganga plains, is analysed from hydrological data related to channel transport capacity and sediment load.

The Ganga river originates from the Higher Himalaya and drains the alluvial plains of northern and eastern India for a total length of 1900 km. Numerous tributaries join the Ganga on its journey to the Bay of Bengal, generating a system of coalescing alluvial plains. The rivers draining the western part of the Ganga plains are incised and stable, and are characterized by infrequent overbank flooding. In contrast, the rivers draining the eastern part are aggrading and exhibit frequent channel migration and extensive overbank flooding. In the eastern part, the Kosi river has shifted 110 km westward in the last 200 years across its alluvial megafan. Studies on an eastern interfan river system, the Bagmati, have shown 8 major avulsions in the last 230 years, indicating a decadal scale of avulsion. These avulsion processes are related to high sediment load in the river channel and local neotectonic movements.

These observations suggest geomorphic diversity within the Ganga plains, and this is correlated with sediment supply-transport capacity relationship, which in turn is governed by upstream controls. Rivers in the western plains are characterized by higher specific stream power (40-43 W/m<sup>2</sup>) and lower sediment load (60-637 tkm<sup>-2</sup>yr<sup>-1</sup>), whereas rivers in the eastern part are characterized by lower specific stream power (6.36-20 W/m<sup>2</sup>) and higher sediment load (647-2774 tkm<sup>-2</sup>yr<sup>-1</sup>). Higher specific stream power with respect to sediment load in western rivers is responsible for channel incision, whereas higher sediment supply against less specific stream power in eastern rivers is responsible for aggradation process. Further, high sediment supply in eastern rivers is related with higher rainfall and uplift rate in the hinterland area, and high susceptibility of erosional processes to rainfall. In summary, upstream processes in the basin area are responsible for geomorphic diversity within the basin.

#### 7-18 BTH 137 Carling, Paul

EXTREME FLOOD HISTORY OF OB LUANG GORGE, THAILAND. CLIMATIC OR LAND USE CHANGE?

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Differentiating the effects of climatic and land use change in the hydrological record is challenging. Palaeoflood hydrology, the study of past extreme floods, offers a useful investigative approach providing insights to this challenge, and the range and sophistication of tools available to the hydrologist in the form of data collection and statistical analysis possibilities, has improved. This paper analyses some extreme flood evidence of Ob Luang Gorge, Mae Chaem River, Thailand. Aside from being a unique contribution from a poorly-studied geographic region, the Mae Chaem catchment offers the potential to test hypotheses regarding the interaction of monsoonal climate and land use change through its considerable palaeoflood evidence. A variety of Palaeoflood Stage Indicators (PSIs), including debris deposits in caves and tributary mouths, were dated and an hydraulic model constructed to simulate the flood events that formed these deposits. Dendrochronological specimens available as PSIs were used to extend the instrumented climatic record. This was analysed using database-mechanistic, spectral, fractal and wavelet techniques to detect monsoonal shifts. This analysis was then integrated with the PSI hydraulic model, and an 'exceedance threshold' approach taken to assessing flood frequency and likelihood. Confidence and Uncertainty are discussed, and inferences and interpretation of flood evidence and history are made.

#### 7-19 BTH 138 Kubo, Sumiko

THE LOWER MEKONG RIVER PLAIN IN CAMBODIA: LANDFORMS AND DEPOSITS  
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The Lower Mekong River Plain contains Cambodian Plain and Mekong Delta in Vietnam. The Great Lake or Lake Tonle Sap occurs in Cambodian Plain. The lake is connected with the Mekong via the Tonle Sap River. The Tonle Sap River meets with the Mekong at Phnom Penh, and the Bassac diverts from the Mekong there. Based on the interpretation of aerial photos and satellite images with field reconnaissance, geomorphologic features of the plain are summarized as follows: 1) surrounding uplands, 2) gentle fan in the western area, 3) natural levees and back marshes along the Mekong, 4) relatively flat lowland along the Tonle Sap river, and 5) human-induced feature of Colmatage system developing along the Mekong at Phnom Penh. These features are closely related with flood characters. Geomorphologic features of this area were confirmed to cause different flood characters during the major floods in 2000, 2001 and 2002: no inundation occurred in 1) uplands and 2) a gentle fan, 3) almost all back marshes were inundated along the Mekong while natural levees were not, 4) flood water covered along the Tonle Sap river, and 5) relatively light flood damages along the Bassac. Subsurface deposits of the plain are also examined with bore-hole logs and augering. More than 100-m thick Quaternary deposits occur in the central part, while less than 20 m in Phnom Penh city reflecting bedrock topography.

#### 7-20 BTH 139 Kemp, Justine

32,000-34,000 OSL AGES FOR LARGE, SINUOUS LATE PLEISTOCENE CHANNELS IN THE LACHLAN VALLEY, SOUTHEASTERN AUSTRALIA

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OSL techniques have been used to obtain the first dates on large, sinuous, Late Pleistocene channels in the Lachlan Valley, southeastern Australia. The Lachlan is a 700 km long tributary of the Murray Basin. Its palaeochannels are associated with two major alluvial terraces, which grade into extensive alluvial plains downstream from Forbes. Late Pleistocene channels of the Ulgutherie Fluvial System are characterised by sinuous, regular and scrolled meanders, with wider and shallower channels than the present-day, irregularly meandering, suspended-load river. Reconstructed channel cross-sections are 6 times larger than the average for the present Lachlan River, and bankfull discharges based on channel geometry formulations were estimated to be 4 to 7 times larger. Two OSL dates from channel sand and overlying source-bordering dune sand indicate that these channels were fully established by 34,000 yr BP and geomorphic evidence suggests the system may have declined soon afterwards. This conclusion is consistent with regional lake-level and geomorphic evidence of cool, pluvial conditions, followed by an arid glacial maximum.

### SESSION NO. 8, 1:30 PM

Thursday, July 24, 2003

## T27. Geophysical Investigations of Quaternary Sediments (Posters)

Reno Hilton Resort and Conference Center, Pavilion

#### 8-1 BTH 140 Roberts, Michael C.

LITHOLOGIC CONTROL FOR GPR PROFILES IN A BEACH-RIDGE DEPOSITIONAL ENVIRONMENT

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Ground penetrating radar (GPR) profiling was used to delineate the subsurface architecture and radar facies of a prograding beach-ridge system on the flank of the Fraser River delta, southwestern British Columbia, Canada. To correlate the radar reflection patterns, facies boundaries and radar discontinuities with lithological evidence, vibracoring in fine sediments, and flight augering in gravels was carried out. Vibracoring (7 cm core) in the beach ridges yielded continuous cores but depths of penetration were limited by the occurrence of gravel and typically halted at 2 m. Flight augers (15 cm diameter), on the other hand, were drilled through the total thickness of the beach-ridge system into the underlying tidal-flat sediments. The drawback of flight auger samples for detailed sedimentological analysis is that lithologic detail can be partially or completely destroyed by the rotation of the flights during drilling. To complement the drilling data and provide additional parameters to correlate radar signatures with lithology, cone penetration test (CPT) logs were obtained. These logs provide continuous records of sediment resistance to penetration by a steel rod (tip resistance in MN/m<sup>2</sup>) and variations in pore water pressure (m) within the beach sediments so penetrated. These logs, widely used in engineering, can be used to more finely interpret the correlative links between lithology and GPR images of the beach ridges.

#### 8-2 BTH 141 Wilkins, David

GPR AND GIS USE IN DOCUMENTING A DISTINCTIVE MODE OF STAR DUNE DEVELOPMENT

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Research reports that most star dunes occur in clusters or chains and commonly develop from modification of linear or crescentic dunes within a multidirectional wind regime (e.g., Nielsen and Kocurek, 1987; Lancaster, 1989). Our research suggests another mode for star dune development involving the response of transverse dunes to a highly-localized modification of a unidirectional wind regime, resulting in a single, isolated star dune. The Coral Pink Sand Dunes, located in southern Utah, is the site of an ongoing investigation into factors influencing dunefield development.

This research presents the results of GPR transects around an isolated star dune, and the GIS-aided analysis of changes in dunefield organization between 1960 and 1997. Comparison of aerial photographs of the dunefield, acquired in 1960 and 1997, reveal the star dune developed over this period. The early photos show a semi-regular arrangement of transverse dune crests and dune spacing. The later photos show that, in the interim period, the most upwind transverse dune (aka First Dune) became impeded on a bedrock knob and was modified into a barchan-like crescentic dune. Immediately downwind, previously existing transverse dunes responded to the change in wind regime and merged to form a star dune. Interpretation of GIS-mapped dune crests in the two photos suggests the dunefield became less organized for about a kilometer downwind of the star dune, also thought to be a response to modified windflow.

GPR data (100 MHz, 1.0-meter offset, 0.5-meter step) were collected from transects bracketing the star dune and First Dune and provide radar imagery of the sedimentary structure and underlying bedrock of the star dune and First Dune. Processing of the GPR data consisted of a few basic steps, including dewowing and bandpass filtering, migration, and topographic correction. Image acquisition was excellent with up to 20 meter depths recorded.

The presence of high-angle cross-strata in the radar stratigraphy supports the transverse dune parentage of First Dune and the primary limbs of the star dune. This is in contrast to other models of star dune development which report the most common deposits from star dunes to be low- to moderate-angle cross-strata (Nielsen and Kocurek, 1987).

**8-3 BTH 142 Gyllencreutz, Richard**

HOLOCENE SEDIMENTATION FROM HIGH-RESOLUTION CHIRP SONAR DATA AND IMAGES CORE MD99-2286 IN NORTHEASTERN SKAGERRAK

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The Skagerrak is the deepest part of the otherwise relatively shallow North Sea. The North Atlantic Current mainly governs the circulation and subsequent sedimentation in Skagerrak, with important contributions from the Jutland Current and Baltic Sea outflow. In northeastern Skagerrak, mixed currents form an anti-clockwise gyre and the average current speed is greatly reduced allowing fine-grained sediment to fall out at high rates. This makes the Skagerrak the major sink for fine-grained matter in the North Sea and a key area for our understanding of the late Quaternary oceanographic and climatic history of the North Sea region with adjacent land areas. In previous seismic studies of the Skagerrak and the Norwegian Trench, the uppermost seismic unit is regarded to be of Holocene age, and has been reported as acoustically transparent, with no or few internal reflectors.

A high-resolution chirp sonar survey in north eastern Skagerrak was made in 1998, and in this area the CALYPSO core MD99-2286 was retrieved within the International Marine Past Global Changes Study (IMAGES) program during leg 3 with R/V Marion Dufresne in 1999. Marine sediments in the 32.4 m long piston core MD99-2286, provides a continuous and detailed paleoceanographic and paleoenvironmental record of the last 12,000 years in the Skagerrak.

A detailed view of the Holocene stratigraphy in northeastern Skagerrak is presented by reconstructing a 3D stratigraphic model from high-resolution chirp sonar data, multibeam bathymetry data from the Geological Survey of Norway, and sediment physical properties of core MD99-2286. On the chirp sonar profiles, four stratigraphic units are distinguished. The lowermost unit, unit D, is characterised by strong reflectors draping the subjacent bedrock, and is interpreted as glacial marine sediments. The top three units, units A, B and C, comprise a thick seismically laminated blanketing sequence, and are interpreted as postglacial marine mud. Tentative correlation to core MD99-2286 based on p-wave velocity data and radiocarbon dating suggest that the Pleistocene/Holocene boundary (11,500 calendar years BP) is located in the lower part of unit C, above the glacial marine sediments of unit D.

**8-4 BTH 143 Peters, G.**

INTEGRATION OF SURFACE GEOPHYSICS AND PALEOSEISMOLOGICAL STUDIES, UPPER RHINEGRABEN, GERMANY

PETERS, G.<sup>1</sup>, CONNOLLY, P.T.<sup>1</sup>, BUCHMANN, T.<sup>1</sup>, REINECKER, J.<sup>1</sup>, WENZEL, F.<sup>1</sup>, REISS, S.<sup>2</sup>, and HUESGES, S.<sup>3</sup>, (1) Geophysical Institute, University of Karlsruhe, Karlsruhe, Germany, Gwendolyn.Peters@gpi.uni-karlsruhe.de, (2) Geological Institute, Univ of Hamburg, Germany, (3) GGM, Radolfzell, Germany

The geophysical investigations presented have been carried out to support paleoseismic studies in the Northern Upper Rhinegraben (NURG). To date, we have focused on the paleoseismic potential of the western border fault (WBF) north of the city of Worms. The fault has been documented from reflection seismic surveys and coring but recent/paleoseismic surface faulting has not been previously identified. The seismicity of this part of the NURG is low. However, geological data, geodetic measurements and geomorphological studies provide good indicators of active tectonics along the WBF. In order to identify near surface faults we applied geophysical techniques such as ground penetrating radar (GPR), electrical profiling and high resolution reflection seismics. For GPR we principally used the 200MHz antenna of a GSSI SIR system, electrical profiling was done using a Wenner array with 2m electrode spacing and reflection seismics used a 50kg drop weight and 1 to 2m geophone spacing. We selected a trench site where all measurements revealed near surface structures and where geological data and geomorphological indications were most promising for active faulting. In the first trench a highly faulted zone in Wuermian alluvial loess occurs. Electrical profiling show a contrast in resistivity and GPR measurements reveal steeply dipping reflectors at the fault zone. In contrast, no significant fault exists in the second trench, only 30m away which has the upper 3m dominated by Holocene paleosols. Measurements at this site reveal subhorizontal dipping of sedimentary units. The applied measurements exhibit good correlation with the observed structures and lithologies in the trenches and enable calibration of measurements. For identification of the location and depth of fault structures the use of shallow geophysics has been very fruitful when integrated with geomorphological analysis, geodetic and geological data of the NURG.

**8-5 BTH 144 O'Neal, Michael L.**

THE USE OF GROUND PENETRATING RADAR IN QUATERNARY SEA LEVEL STUDIES: AN OVERVIEW FROM THREE INVESTIGATIONS IN THE DELAWARE AND CHESAPEAKE BAYS, USA

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Ground penetrating radar (GPR) has proved to be an invaluable tool in investigations of Quaternary coastal stratigraphy in the siliciclastic sediments of the mid-Atlantic coastal plain of North America. In this region, the identification of highstand deposits of individual Pleistocene sea-level events is often difficult. Numerous highstand sequences are superposed, both vertically and laterally, in the subsurface of the modern coastal environment. Natural and artificial subsurface exposures are rare, and the geomorphic expression of these ancient deposits is often subtle. Identification of distinct highstand deposits from cores and boreholes is also difficult due to lithologic similarities between deposits, and the scarcity of suitable dating materials.

GPR has been successfully used in thin successions of exposed estuary-margin sediments in the region, to delineate unconformity-bound, climate-induced highstand deposits from distinct sea-level events in the mid to late Pleistocene. Radar records revealing the internal structure of these deposits have allowed for sequence-stratigraphic interpretations, with the identification of transgressive, highstand and regressive systems tracts. The separation of multiple minor sea-level fluctuations, within an overall sea-level event (oxygen isotope stage), has also been possible.

The lithology and sedimentary structures recognized in these high-resolution records have been used to interpret varied coastal depositional environments and geomorphic structures. Bay bottom, nearshore, foreshore, dune and backbarrier lagoon/marsh environments have been imaged, as well as nearshore bar, foreshore bar, barrier-island beach and shoreline escarpment structures. Buried paleovalleys of rivers and tidal creeks imaged with GPR establish cross-cutting relationships with adjacent highstand deposits, and provide a contrasting lowstand record in Quaternary sea level studies.

Examples of published and new data from three investigations on the exposed margins of the Delaware and Chesapeake Bay estuaries in New Jersey and Maryland are presented.

**SESSION NO. 9, 8:00 AM**

Friday, July 25, 2003

**S1. Earth System Models, Palaeo-observations, and Past Global Changes****Reno Hilton Resort and Conference Center, Carson 1&2****9-1 8:10 AM Hewitt, Chris D.**

COUPLED OCEAN-ATMOSPHERE MODELLING OF THE CLIMATE AT THE LAST GLACIAL MAXIMUM

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Coupled ocean-atmosphere-sea ice general circulation models (OAGCMs) are the state-of-the-art models for projecting future climate. Such models are now being used to simulate the climate of the last glacial maximum (LGM) in order to increase our understanding of climate change, and to test and evaluate the models by comparison with palaeoenvironmental data sets.

I will describe one such OAGCM simulation in some detail, using the HadCM3 OAGCM developed at the Met Office's Hadley Centre. I will also describe the current state of coupled modelling of the LGM by describing other recent coupled model LGM experiments, making some intercomparisons of the different model results.

Such an intercomparison will also be of use for planning the second phase of the Palaeoclimate Modelling Intercomparison Project (PMIP), which plans to examine how coupled OAGCMs perform when forced with the same boundary conditions.

**9-2 8:30 AM Weinelt, Mara**

MARGO: MULTIPROXY APPROACH FOR THE RECONSTRUCTION OF THE GLACIAL OCEAN SURFACE

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Four years after the EPILOG (Environmental Processes of an Ice Age: Land, Ocean and Glaciers) project was launched as an IMAGES/PAGES initiative, MARGO has initiated the compilation of core-top, Late Holocene, and LGM data sets for geochemical and microfossil-based sea-surface temperature (SST) proxies with global coverage. The MARGO project, an international assembly of paleoceanographers and paleoclimatologists contributing with own data or expertise ([www.pangaea.de/projects/MARGO](http://www.pangaea.de/projects/MARGO)), has formulated recommendations and action plans that should stimulate the compilation of large data sets for global-scale proxy calibration as well as for Late Holocene and LGM SST reconstructions and the organisation of corresponding archives in one concerted effort. The data sets considered are diatom, radiolaria, foraminifera and dinoflagellate counts, alkenone unsaturation ratios, and Mg/Ca records of foraminifera that are available to date. It is furthermore intended to compare SST estimates with a global data set of oxygen isotope values from planktonic foraminifera. The MARGO aims are twofold: The first is to define the general items for the content and structure of a global synthesis that are valid for all the different proxies. The second addresses issues particularly related to each of the proxy methods, and to the choice of different mapping methods as well as to the use of ocean temperature atlas data for calibration with core-top SST estimates. In parallel MARGO started to build up a new data archive in the PANGAEA-WDC MARE data bank. The archive now contains about 20 individual data sets that range from individual core data to basin-wide compilations for the LGM time slice. Also core-top data sets for regional or global calibration of different proxies will be archived. This presentation will report on the status of the MARGO archive and provide general information and guidelines for data submission and/or retrieval in the future.

**9-3 8:50 AM Peltier, William R.**

A REFINED MODEL OF THE LAST DEGLACIATION EVENT OF THE CURRENT ICE-AGE: ICE-5G  
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During the decade that has passed since publication of the ICE-4G model of Wurm-Wisconsin deglaciation, a significant quantity of high quality new data has been compiled which requires that this model be refined. These new data include critical observations of the LGM margins of the ice sheet that extended from the Barents Sea across Novaya Zemlya into the present Kara Sea, observations that have been compiled by the European QUEEN Group. Of equal importance have been the constraints on the LGM form of the Greenland Ice Sheet based upon the work of the European EISMINT project. Although of relatively minor global impact, the new work that has been completed in Britain to provide direct trim-line based estimates of the thickness of the LGM Scottish Ice Sheet has also been extremely informative. Of paramount importance, however, is most probably the new observations that have been forthcoming based upon absolute gravity and VLBI observations that are requiring a massive re-organization of the topography of the Laurentide Ice Sheet (LIS) itself. These observations have required us to recognize that the LGM form of the LIS was multi-domed rather than consisting of a single dome centred over Hudson Bay. In the ICE-5G reconstruction to be described in this paper, the Hudson Bay is covered by relatively thin ice, the time averaged thickness of which is controlled by the intense ice stream that flowed through Hudson Strait. This multi-domed form has now been predicted on a priori grounds using a modern three-dimensional thermo-mechanical model of ice sheet evolution.

**9-4 9:10 AM Khodri, Myriam****MODELLING THE CLIMATE EVOLUTION FROM THE LAST INTERGLACIAL TO THE START OF THE LAST GLACIATION**

KHODRI, Myriam<sup>1</sup>, RAMSTEIN, Gilles<sup>2</sup>, KAGEYAMA, Masa<sup>2</sup>, DYPLESSY, Jean-Claude<sup>2</sup>, GANOPOLSKI, Andrey<sup>3</sup>, and PAILLARD, Didier<sup>4</sup>, (1) Oceanography, Lamont-Doherty Earth Observatory of Columbia Univ, 61 Route 9W, Palisades, NY 10964-8000, khodri@ldeo.columbia.edu, (2) LSCE, CE Saclay, DSM/Orme des Merisiers/Bat. 709, Gif Sur Yvette, 91191, France, (3) Potsdam Institute for Climate Impact Rsch (PIK), P.O.Box 601203, Potsdam, 14412, Germany, (4) LSCE (CEA-CNRS), Centre d'Etudes de Saclay, Orme des Merisiers, Gif-sur-Yvette, 91191, France

How seasonal and latitudinal variations of the incident solar radiation initiate internal feedbacks that produce a shift from an interglacial to a glacial mode is still a matter of debate. Until now, the last interglacial-glacial transition has been discussed either through interpretation of proxy records or through modelling studies. Studies based on Atmospheric General Circulation Models forced by modern sea surface temperatures (SSTs) or coupled to mixed layer ocean have not been successful in simulating perennial snow cover, while accounting for ocean and vegetation feedbacks has produced results in better agreement with proxy records. Nevertheless, beyond the Milankovitch theory that argues for an orbitally induced shift from an interglacial to a glacial climate, the available proxy records give important clues that have still not been fully explored through modelling studies. Recent work from North Atlantic sediment cores clearly identifies a cooling step correlated to a significant change in deep water circulation around 115 ky BP i.e. at the last interglacial-glacial transition [Shackleton et al., 2002; Chapman et al., 1999; Adkins et al., 1997; Hall et al., 1998]. There is more evidence, from both land and marine records, for an "intra-Eemian" cooling event in the high latitudes of the Northern Hemisphere around 120 ky BP [Maslin et al., 2001; Cortijo et al., 1999; Sanchez-Goi et al., 1999; Tzedakis et al., 2002; Shemesh et al., 2001; Rioual et al., 2001]. The lag between insolation forcing and northern high latitudes cooling extrema at 120 ky BP emphasizes the necessity of exploring the mechanisms responsible for the changes occurring through the last interglacial and their implication for the last glacial inception. We propose to explore this issue by combining an Earth system Model of Intermediate Complexity (EMIC), a coupled ocean-atmosphere GCM (OAGCM), and the comparison to paleoclimatic data. Using the insolation forcing alone, the EMIC model produces a first order response of SSTs and thermohaline circulation evolution which agrees with the available geological data. However, by comparing the OAGCM and the EMIC results we show that the orbitally induced shift from an interglacial to a pre-glacial climate is highly sensitive to the high northern latitudes moisture budget.

**9-5 9:30 AM Valdes, Paul J****VEGETATION-OCEAN-ATMOSPHERE CLIMATE INTERACTIONS DURING THE LAST 21,000 YEARS**

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We use a set of "snapshot" climate model simulations to investigate climate change during the last glacial interglacial cycle. The model simulations use the Hadley centre atmospheric model (HadAM3) coupled to a simple slab ocean model with prescribed (and unchanging) ocean heat flux convergence. This ocean model is unable to represent changes in the ocean circulation and thus part of any differences between model and data can be interpreted as indicating the importance of ocean circulation changes. The model is forced by changes in carbon dioxide, methane, ice sheets, and orbital parameters, and simulations are performed for every 1000 years from the LGM to present day. An additional set of simulations coupled the climate model to a biogeographical model (BIOME4) so that the role of vegetation changes can be quantified.

Broadly, the set of model simulations compare favourably to data, except during the glacial interglacial transition (i.e. from approximately 15 - 10 kyr BP) where the model is unable to represent the Bolling-Allerod or Younger Dryas. This suggests that the ocean circulation changes are important for the onset of the Bolling-Allerod as well as the Younger-Dryas.

During the Holocene, vegetation feedback can be very important. The model results are compared to new data compiled from several databases of pollen sites on the European continent. A pit-based modern analogue method has been used to reconstruct various climatic parameters from this data-set for the last 12,000 years at high frequency (up to every 100 years), including mean temperature of the coldest month and annual precipitation. We use this data to evaluate the model simulations for Europe. In general, the model-data comparison suggests that the large-scale patterns are being reproduced by the model but that much regional detail is missing. We will discuss the reasons for these discrepancies.

**9-6 9:50 AM Edwards, Mary E.****PALEODATA-MODEL COMPARISONS OF ARCTIC VEGETATION RESPONSE TO CLIMATE AT 6 AND 21 KA**

EDWARDS, Mary E.<sup>1</sup>, BIGELOW, Nancy H.<sup>2</sup>, KAPLAN, Jed O.<sup>3</sup>, BRUBAKER, Linda B.<sup>4</sup>, HARRISON, Sandy P.<sup>3</sup>, and PRENTICE, I. Colin<sup>3</sup>, (1) Dept. of Geography, Univ of Southampton, Highfield, Southampton, SO17 1BJ, United Kingdom, M.E.Edwards@soton.ac.uk, (2) Univ of Alaska - Fairbanks, (3) Max Planck Institute for Biogeochemistry, (4) Univ of Washington

Arctic vegetation responds strongly to climatic factors such as growing season warmth and moisture availability. We investigated the response of vegetation to past climate using a data-model comparison approach. We developed a circumpolar classification, based on the abundances of plant functional types, of five tundra and seven forest vegetation types. This drove a 'biomization' procedure, which converts pollen assemblages to vegetation cover, for arctic pollen data for 0, 6, and 21 ka. An equilibrium biogeochemistry - biogeography model (BIOME 4), which uses the same vegetation classification driven by climatology, was coupled with GCM paleo-simulations for 6 and 21 ka.

Biomized and simulated vegetation for 0 ka match mapped data well in most sectors. Data for 21 ka show grass-forb tundra and prostrate/dwarf-shrub tundra dominating unglaciated Alaska and east-central Siberia; forest and shrub tundra cover is greatly reduced. At 21 ka, the models tend to generate too much precipitation, with only one simulating conditions dry enough to capture the full observed reduction of shrub tundra. At 6 ka, both data and model simulations show that the northward extension of treeline related to insolation forcing of warm summers is muted and asymmetric, with advances in central Siberia but no advance in Beringia. The asymmetry is attributed to Siberia's greater continentality and to sea-ice dynamics. In northeast Canada, a southward shift in treeline recorded by the data is counter to a simulated northward shift; the discrepancy is likely due to the absence in the models of residual Laurentide ice and the simulation of an associated regional cooling.

**9-7 10:30 AM Maher, Barbara A.****PALAEORAINFALL THROUGH THE HOLOCENE IN THE WESTERN CHINESE LOESS PLATEAU: A HIGH-RESOLUTION RECORD AND A TEST OF PMIP HINDCASTING FOR THE MID-HOLOCENE PERIOD**

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Formation of strongly magnetic iron oxides in well-drained, buffered, unpolluted soils appears to be controlled by climate, and especially rainfall. If robust, this magnetism/rainfall couple can be used to estimate past, monsoonal rainfall from buried soils, particularly the multiple soils of the Quaternary loess/soil sequences of Central Asia. However, dispute has existed regarding the role of climate versus dust flux for the magnetic properties of modern loessic soils. Kukla and colleagues proposed that the major process responsible for the Chinese loess/soil magnetic contrasts is magnetic 'dilution', controlled by a constant 'rain-out' of fine-grained magnetite from the atmosphere and a varying rate of accumulation of weakly magnetic windblown dust. According to this model, soils have higher magnetic concentrations due to reduced sedimentation rates and loess units have lower magnetic concentrations due to increased sedimentation rates. Given the scarcity of proxies for robust and quantitative reconstruction of palaeoclimate, essential for testing of climate model postdictions and predictions, and the significance of Asian monsoon variations in this highly-populated region, it is critical to test the validity of these two contrasting interpretations and thence the reliability of the proposed magnetism/rainfall link. Two sets of tests are discussed here: spatial and temporal. Having applied these tests, the magnetism/rainfall link is then used to make quantitative reconstruction of rainfall variations through the Holocene for the western Chinese Loess Plateau, and thereby in turn to test the rainfall hindcasting of the different PMIP models for the mid-Holocene period.

**9-8 10:50 AM Otto-Bliesner, Bette L.****EL NIÑO AND ITS TROPICAL TELECONNECTIONS DURING THE HOLOCENE AND LAST GLACIAL MAXIMUM**

OTTO-BLIESNER, Bette L.<sup>1</sup>, BRADY, Esther C.<sup>1</sup>, LIU, Z.<sup>2</sup>, SHIN, Sang-Ik<sup>2</sup>, and SHIELDS, Christine<sup>1</sup>, (1) Climate and Global Dynamics Division, National Ctr for Atmospheric Rsch, PO Box 3000, Boulder, CO 80307, otto@ucar.edu, (2) Center for Climatic Research, Univ of Wisconsin, 1225 W. Dayton St, Madison, WI 53706

The mean state of the tropical Pacific and its interannual variability during the Holocene and Last Glacial Maximum are investigated using multi-century simulations with the NCAR Climate System Model (CSM). The CSM is a global coupled atmosphere-ocean-sea ice model.

Better-resolved ocean sediment records for the eastern Pacific cold tongue and the western Pacific warm pool have challenged past interpretations of the east-west sea surface temperature (SST) gradient and degree of SST cooling during the Holocene and Last Glacial Maximum. The CSM reproduces the recently published data on changes of the mean state of the tropical Pacific. For the Holocene, the model results show a sharpening of the zonal SST gradient across the tropical Pacific (more cooling in the central and eastern Pacific than the western Pacific) and increased upwelling in the central Pacific. For the Last Glacial Maximum, differential cooling across the tropical Pacific results in a reduced zonal SST gradient.

Proxy data suggest that the intensity and frequency of ENSO was decreased compared to modern during the Holocene. The CSM predicts weaker El Niños/La Niñas compared to present for 11,000-3500 years ago and stronger El Niños/La Niñas for the Last Glacial Maximum. During the Holocene, there are more occurrences of small and less occurrences of large El Niños and La Niñas. Changes in intensities for the Last Glacial Maximum are traced to a sharpening of the tropical thermocline as a result of cooling at Southern Hemisphere middle and high latitudes. Changes in intensities for 11,000-3500 years ago are traced to strengthening of zonal wind stresses across the tropical Pacific Ocean by the stronger summer Asian monsoon and weakening of the tropical thermocline. Thus, for the Holocene and the Last Glacial Maximum, changes in both the atmospheric and oceanic mean climate conditions outside the tropical Pacific region need to be considered for understanding changes in ENSO SST variability. In addition, to understand proxy evidence of weaker precipitation variability in the Pacific region requires a determination of both changes in El Niño/La Niña and changes in the atmospheric circulation and hydrologic cycle.

**9-9 11:10 AM Bartlein, Patrick J.****COMPARISONS OF PALEOENVIRONMENTAL OBSERVATIONS AND PALEOCLIMATIC SIMULATIONS: PRINCIPAL RESULTS AND STRATEGIES FOR THE NEXT ITERATION**

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The records of past climatic variations preserved by paleoclimatic indicators (or "proxy data") document the behavior of the climate system over time and space, and also provide the only means for testing climate models under configurations of the climate system different from those at present. The first iterations of data-model comparisons, represented by PMIP and earlier less comprehensive projects, demonstrated convincingly that (a) the general approach of simulating regional variations of climate using global models is a sound one, (b) the general trends of climate since the last glacial maximum are well accounted for by a relatively simple conceptual model that invokes changes in insolation, ice volume, and atmospheric composition as the primary drivers, and (c) regional discordances between simulations and observations are most likely due to the absences of feedback and interactions among various components of the climate system not well represented in those earlier models.

In the next iteration of data-model comparison, in particular PMIP Phase II in which fully coupled ocean-atmosphere-vegetation models will be used, the focus will shift from evaluating the ability of models to simulate the mean state of climate at key times, to their ability to simulate variability changes as well as abrupt changes. The optimal evaluation of such models would involve global networks of well-dated, multi-dimensional, multi-proxy records, of sufficient spatial density to resolve regional patterns, and temporal frequency to diagnose interdecadal and interannual modes of climatic variability. However, such networks do not exist, nor are they likely to anytime soon. Consequently, we envision an alternative strategy with two elements: (1) the use of multiannual-to-decadal resolution records from lake and marine sediments and ice cores, which are available over growing networks (while employing also annually resolved records where (and when) available to characterize interannual variability), (2) the reanalysis of the lower temporal resolution but global networks of paleoecological and hydrological data in light of observations that such records necessarily contain the influence of climate variability, which may be retrieved through the application of suitable dynamic models of vegetation and hydrology.