of $\delta^{18}O$ variations over much of MIS 5 and 6. Precise ^{230}Th dating has replicated the chronology of the samples within error. The higher resolution data set confirms the timing of Termination II, placing it at 128.9 ± 0.9 ka, BP. The bulk of this transition ($\sim 1.7^{o}/_{oo}$) took place within 60 years, with the total range of the transition being $\sim 3^{o}/_{oo}$. A major issue is climate stability during interglacial periods. There were some early indications of major instability of the Last Interglacial climate (GRIP members, 1993, Nature 364, 203-207). Whereas our record shows no evidence for instability with glacial-interglacial $\delta^{18}O$ amplitudes, there is clear evidence for abrupt $\sim 1^{o}/_{oo}$ shifts with periods on the order of several hundred years during the Last Interglacial (supporting some earlier work, An and Porter, 1997, Geology 25, 603-606). Similar to the features found by Dykoski et al. (this meeting) during the Holocene in the Hulu/Dongge record (see also Bond et al., 2001, Science 294, 2130-2136), these shifts cover approximately of the amplitude of millennial-scale events during the Last Glacial Period in China (Wang et al., 2001, Science 294, 2345-2348). Thus, it appears that abrupt centennial or millennial-scale changes are a general feature of interglacial periods, albeit with significantly smaller amplitudes than events during glacial periods.

PP32A-0280 1330h POSTER

Paleoceanographic Change off Central Japan Since the Last 150 ka Recorded in an IMAGES Core.

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A long core (45.82 m length) was recovered from 2,224 m water depths off the central Japan during the IMAGES cruise in 2001. A multi-disciplinary study was carried out on this core by analyzing the following: color, grain size, mineral composition, paleomagnetism, d18O, d13C Opal, CaCO3, species of diatoms, coccolithophorids, radiolaria, planktonic foraminifera and benthic foraminifera, CaCO3 preservation, Uk37O, TOC, C/N, d13CTOC, d15NTOC, biomakers and pollen. The following main results were obtained. The d18O curve of benthic foraminifera is very similar to the standard oxygen isotope curve, suggesting continuous deposition over the last 150 ka. All warm water indices yielded by the four microfossil assemblages (diatoms, coccolith, radiolaria, planktonic foraminifera) show temperature decreases during the MIS 2 and 6, and increases during the MIS 5, although their correlation coefficients with each other are not always high (between 0.5 and 0,6). The Alkenon and oxygen isotope-derived temperature s (19?C) at the core top agree with the modern SST in this region. The isotope SST at the MIS 2 and 6 were 12-13?C, which are seen today about 4.5 degree latitude north than the core site. Similar migrations in SST are inferred from the coiling ratio of Neogloboquadrina pachyderma. The C/N ratio, d13CTOC and d15NTOC indicate that the TOC is mainly of marine origin, although terrestrial origin slightly increases during the MIS 6. The curve of the warm pollen index is similar to the d18O curve of G. bulloides, except for the MIS 6 and 5e when the land temperature changes inferred from the pollen curve precede the d18O curve. Variabilites in detritus transport and onland vegetation suggest higher precipitation on the central Japan during MIS 1 and the later half of MIS 5. Highest precipitation occurring during MIS 5 is attributed to be increased temperature contrast between air and sea surface due to significant drop of air temperature along the Pacific margin of the central Japan.

PP32A-0281 1330h POSTER

Sensitivity of Paleoreconstructions to Measurement Accuracy of the Glacier Borehole Temperature and Ice Core Geochemical Data

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This study is aimed to analyze sensitivity of various approaches to the past surface temperature reconstructions based on the glacier borehole temperature-depth profiles and the ice-core geochemical data. Except test study we compare results of inversions for Antarctica sites: South Pole, Vostok, and Siple Dome. The reconstructions are based on the solutions of the well and ill-posed inverse problems.

PP32B MCC: Level 1 Wednesday 1330h

Terrestrial and Lacustrine Records of Past Climate Posters *(joint with A, C, GC)*

Presiding: **B Brandsdʹottir,** Science Institute, University of Iceland

PP32B-0282 1330h POSTER

Obsidian hydration profiles and dating

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Obsidian hydration dating (or more generally, glass hydration dating) has been investigated as a method to determine the age of archeological samples (e.g., Lee et al., 1974; Freidman and Long, 1976; Anovitz et al., 1999; Liritzis and Diakostamatiou, 2002; Riciputi et al., 2002). This presentation attempts to lay the theoretical foundation for understanding glass hydration. Treating hydration as diffusion into a semi-infinite medium, a theoretical foundation requires an understanding of the following: (1) water concentration at the surface (water solubility in glass and whether equilibrium is reached); (2) water diffusion in glass; (3) diffusion behavior for periodically changing temperature and periodic boundary condition; (4) possible dissolution of obsidian in water, and (5) the effect of long-term trends in temperature (global warming) and humidity (such as drying or uplift of the region, etc.). Previous experimental data and models are extrapolated to room temperature on water speciation, solubility and diffusivity. Such information is compared with that extracted from measured obsidian hydration profiles. The effect of periodic T and surface conditions on diffusion is analytically examined. We conclude: (i) molecular H2O is the dominant species at room T; (ii) the surface water concentration in obsidian hydration is roughly consistent with extrapolated water solubility at room T and a humidity of 1; (iii) high-T water diffusion data cannot be extrapolated to room T (Leschik et al., 2003); and (iv) the most reliable part of a hydration profile is at depth greater than 0.6 micrometers. Because the total hydration depth is proportional to the square root of the integration of diffusivity with respect to time, it is sensitive to not only age (for dating), but also to the variation of diffusivity, which depends on mean annual T and humidity. Only when the annual mean diffusivity is constant, and when there was no dissolution of obsidian, would it be reliable to determine the age. On the other hand, the sensitivity of the diffusivity and hence the hydration depth to climate conditions (especially humidity) means that obsidian hydration profiles may be a good climate indicator if age of obsidian can be independently determined by, e.g., C-14 dating (Riciputi et al., 2002).

PP32B-0283 1330h POSTER

Behaviour of Structural Carbonate Stable Carbon and Oxygen Isotope Compositions in Bioapatite During Burning of Bone

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Bioapatite, the principal inorganic phase comprising bone, commonly contains a small fraction of carbonate, which has been substituted into the phosphate structure during bone formation. The isotopic compositions of both the phosphate oxygen and the structural carbonate oxygen are now commonly used in palaeoclimatological and bioarchaeological investigations. The potential for post-mortem alteration of these isotopic compositions, therefore, is of interest, with the behaviour of structural carbonate being of most concern. In bioarchaeological studies, alteration of bone isotopic compositions has the potential to occur not only during low-temperature processes associated with burial but also during food preparation involving heating (burning, boiling). Here, we examine the stable isotopic behaviour of structural carbonate oxygen and carbon, and coexisting phosphate oxygen during the burning of bone. Freshly deceased (6<8 months) white-tailed deer leg bones (*Odocoileus virginianus*) were collected from Pinery Provincial Park, Ontario, Canada. Each long bone was sectioned and incrementally heated from 25 to 900°C, in 25° intervals. The samples were then ground to a standardized grain-size (45<63μm), and changes in bioapatite crystallinity (CI) were determined using powder X-ray diffraction (pXRD), and Fourier transform infra-red spectroscopy (FTIR). Combined differential thermal and thermogravimetric analyses (DTA/TG) were used to evaluate weight loss and associated reactions during heating. Stable carbon isotope compositions of the bioapatite remain relatively constant ($\pm 1^{o}/_{oo}$) during heating to 650°C. A $4^{o}/_{oo}$ increase in stable carbon isotopic composition then occurs between 650-750°C, accompanied by an increase in CI, followed by a $10^{o}/_{oo}$ decline at temperatures above 800°C, as carbonate carbon is lost. Carbonate and phosphate oxygen isotopic compositions are correlated over the entire heating range, with carbonate being enriched relative to phosphate by about 8-$10^{o}/_{oo}$ below 500°C, 5-$6^{o}/_{oo}$ between 500-700°C, and 8-$10^{o}/_{oo}$ above 700°C. CI and oxygen isotopic compositions of carbonate and phosphate are not well correlated. Only modest CI changes are recorded from 25-675°C, compared with much larger changes in oxygen isotopic composition, especially above 300°C. On average, original isotopic compositions are largely preserved for both phosphate ($\pm 1^{o}/_{oo}$) and carbonate ($\pm 2^{o}/_{oo}$) oxygen at <300°C. At higher temperatures, however, both phosphate and carbonate oxygen in the bioapatite are systematically depleted of oxygen-18 relative to original values.

PP32B-0284 1330h POSTER

Pleistocene Glaciations on the Northwestern Tibet

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As a result of its immense size and high elevation, the Tibetan plateau plays a major role in affecting global climatic changes, and in particular the Asian monsoon system. Consequently knowledge of its glacial evolution during the Quaternary is an essential parameter. However, the chronology and extent of Quaternary glaciations on the Tibetan plateau is still in debate. Based on ice cores and other geological settings from the Tibetan plateau, it is inferred that temperatures during LGM were depressed by 6-9 °C. Kuhle (1998) proposed an extensive ice sheet on the Tibetan plateau during LGM, whereas others believe that, because of extreme aridity, the ELA depression in the western and interior sections is less than 300m. Thus, given that a large fraction of the Tibetan plateau surface would be below the ELA during LGM times, the extent of the proposed ice sheet would presumably be limited. We determined in situ cosmogenic nuclides Be-10 and Al-26 in young volcano samples located in Ashikule basin, western Kunlun Shan. The eruption ages of the samples are 130±40ka, 340±10ka and 780±140ka, dated by the K-Ar method. The exposure ages of the samples are, however, 70±7ka, 150±7ka, 160±8ka, respectively. All samples analyzed possess lava flowing textures, which suggests no erosion since eruption. Field observations indicate no sediment nor vegetation on the samples. Thus, the age differences most likely reflect ice and snow cover on the samples. The current ELA in western Kunlun Shan is about 6000m, whereas the samples are located at an elevation of 4800m. This implies that ELA depression in the western part of the Tibetan plateau was most likely larger than 1200m during LGM. If the interior of Tibetan plateau has a similar ELA depression, a large part of Tibetan plateau surface would be above the ELA during LGM. Therefore, Pleistocene ice coverage on the Tibetan plateau may be more extensive than previously recognized. Kuhle (1998) Quaternary International 45/46,71-108.

PP32B-0285 1330h POSTER

Cosmogenic Dating of Moraines of the Local Last Glacial Maximum in the Tropical Andes

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We have used cosmogenic dating (^{10}Be) to identify moraines of the local last glacial maximum along two east-west transects in the tropical Andes: the Junin region of central Peru (∼11°S 76°W) and the Cordillera Real of western Bolivia (∼16.3°S 68.2°W). The ^{10}Be ages from boulders on moraines in our study areas suggest that the local last glacial maximum occurred ca. 30,000 ^{10}Be yr BP (before the inferred peak of Northern Hemisphere glaciation at ca. 21,000 calendar yr BP) and that deglaciation was well underway by 20,000 ^{10}Be yr BP. Recessional moraines were deposited between about 20,000 and 15,000 ^{10}Be yr BP. Published ^{14}C dates from the Cordillera Real indicate that glaciers were within their present limits by about 11,000 calendar yr BP. Asymmetry in the east-west glacial extent and amount of snowline depression was relatively minor in the Junin region, but was more pronounced in the Cordillera Real. In the Junin region, terminal moraines of the local last glacial maximum lie at ∼4150-4200 m on the east side of the cordillera and at ∼4250-4400 m on the west side. In the Cordillera Real, lateral moraines of the local last glacial maximum lie at ∼4600 m on the southwest side of the cordillera (Milluni Valley), while a late-glacial (ca. 12,000 ^{10}Be yr BP) terminal moraine lies at ∼3800 m on the northeast side of the cordillera (Zongo Valley). Snowline depression during the local last glacial maximum in the Andes was ∼200-600 m on both sides of the eastern cordillera in the Junin region and on the southwest (Altiplano) side of the Cordillera Real, but closer to ∼900-1000 m on the northeast side of the Cordillera Real. The asymmetry likely arose from differences in precipitation (which comes mainly from the east) and from variations in shading, amount of supraglacial material, and topography between the deeply incised eastern valleys and the relatively broad, shallow valleys descending to high-altitude plateau surfaces on the west sides.

PP32B-0286 1330h POSTER

Glacial Features on the Northern Insular Margin of Iceland

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The iceberg scoured insular margin of Iceland is incised by several major fjords which mark the pathways of major outlet glaciers during recent glaciations. New Simrad EM300 multibeam bathymetric and Chirp sonar data from the northern insular margin have revealed glacial and glaciotectonic formations some of which, to our knowledge, have not been previously recognized. The iceberg scoured bank areas are mostly devoid of loose sediments which has accumulated within the fjords. Glacial erosion along the Kolbeinsey Ridge indicates that the Iceland ice cap extended beond 67°N during the last glacial maximum. Multiple marginal moraines exist at 400–500 m depth within a 3–6 km wide, U-shaped valley along the western margin of the ridge (at 66°55'N). The region east of the ridge is dominated by large volcanic complexes which bear the marks of glacial erosion, however, volcanic deposits from postglacial eruptions have blanketed all glacial features in this region. Scoured bedrock surfaces and eskers reflect the direction of two major outlet glaciers, into Skagafjördur-Skagafjardardjúp and Eyjafjördur-Eyjafjardaráll. The region between 66°20'N and 66°35'N in Eyjafjardaráll is dominated by a system of a Λ-shaped highly reflective (till?) ridges, which are characteristically up to 1 km long and 300–500 m wide and open towards the presumed glacial flow. The northernmost ridges strike NNE-SSW, parallel to a 10 km long lateral moraine, which most likely separated the two main outlet glaciers in this region, i.e. from Skagafjördur and Eyjafjördur. Further south, they change direction gradually, along with the fjord curvature. The Λ-shaped ridges most likely represent glaciotectonic features formed during repeated glacier advances. They are not drumlins as drumlins generally increase in volume up-glacier but the ridges down-glacier. Instead they represent some sort of composite ridges intervening depressions conforming to the general shape of the glacier margin that produced them. A highly crevassed, advancing glacier snout could generate such formations from bulldozed basal till, making these ridges a new? form of lateral crevasse-squeeze ridges or push moraines. Both transverse and lateral basal crevasse-fill ridges have been observed with surging glacier margins in Iceland but none with similar pattern as those within Eyjafjardaráll.

PP32B-0287 1330h POSTER

Successful Completion of Pre-Site Survey for Deep Drilling at El'gygytgyn Crater Lake

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Lake El'gygytgyn, located in central Chukotka, NE Russia, is a 3.6 million year old impact crater lake with a diameter of 12 km and a water depth of 170 m. The sedimentary record of the lake has become a major focus of multi-disciplinary multi-national paleoclimatic research and is now a potential target for deep drilling. A full-length sediment core would yield a complete record of Arctic climate evolution, back one million years prior to the first major glaciation of the Northern Hemisphere. Geomorphological evidence from the catchment suggests that the crater was never glaciated during the entire Late Cenozoic. A 13.0 m long sediment core retrieved from the deepest part of the lake in 1998 revealed a basal age of approx. 300 ka, confirmed the lack of glacial erosion, and underlined the sensitivity of this lacustrine environment to reflect high resolution climatic change. The first single channel seismic survey carried out in 2000 discovered undisturbed and well-stratified sediments to a depth of 160 m below the lake floor. Refraction data from sonobuoys indicated the top of the impact breccia at about 360 m subbottom. An ICDP workshop held in 2001 recognised the unique potential of the lake for both paleoclimate and impact-related research and suggested more site survey work. This final pre-site survey expedition took place from April to September 2003. Modern process studies of the lake hydrology, limnology, meteorology, and sedimentology took place over this entire period to better understand the various proxies we are using to decipher the paleoclimate record of the sediment fill. Geomorphic and permafrost studies of lake and river terrace stratigraphies contribute to our understanding of climate dependent landscape evolution. A 16 m long sediment core from the central part of the lake presumably extents the existing record towards more than 400 ka BP. The matching of proxies from this core and the core recovered in 1998 illustrates the lateral continuity of the record for recording regional and global events. Additional cores from the shelf and slope reflect lake-level changes, and the impact of debris flows on sediment redeposition in parts of the lake during Late Quaternary times. In total 8 multi-channel seismic profiles were shot using a 26 cubic inch GI-gun and a 280 m long streamer with 15 channels and 130 m offset. These data will form the major basis for site selection for deep drilling. Single-channel field results indicate bedrock surface at a depth of approximately 350 m subbottom and confirmed the existence of a central uplift structure in the northwestern portion of the lake. 160 km of new 3.5 kHz profiles completed the high-resolution sediment echosounding survey. In addition, a magnetic survey was carried out on the lake and in the catchment to localise impact-related magnetic anomalies. A dense net of new echosounding data will be used to finalise a high-resolution 3-d topographic model of the lake floor and the catchment.

PP32B-0288 1330h POSTER

Sedimentary Indicators of Significant Late Pleistocene - Early Holocene Lake-Level Fluctuation: Preliminary Results From Flathead Lake, Montana

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Flathead Lake is a large (550km^2) open lake system, locally >100m deep, occupying an active half-graben in NW-Montana. During the summer of 2003, we recovered eleven piston cores from the central and southern portions of the lake. Core locations were selected on the basis of available sub-bottom 3.5 kHz seismic reflection data and designed to yield the most information about Pleistocene and Holocene lake-level history. Particularly elucidating are seismic data and three cores (FL-03-14K, FL-03-15K, FL-03-16K) obtained along a north-south transect within Big Arm Bay in the western part of the lake in water depths of 17m. Seismic data along this transect indicate the presence of a fundamental unconformity that likely relates to a significant fluctuation in lake level. Sub-unconformity reflectors in the shallowest part of the transect are clearly truncated. The unconformity itself is onlapped by overlying reflectors. Down depositional dip, the degree of sub-unconformity erosion and post-unconformity onlap diminishes to a point at which the surface appears to be conformable. Core FL-03-14K recovered from the furthest updip position along the line of transect, contains a condensed section of gray-brown fine sand and silt in the uppermost part of the core overlying tan Pleistocene(?) mud (∼5m). Core FL-03-15K, recovered midway along the line of transect, consists mostly of dark brown-gray mud (0cm-613.5cm) with a tan clay and silt section towards the bottom (613.5cm-777cm). Core FL-03-16K, recovered furthest down-dip, contains very gassy dark gray-brown mud (0cm-740cm) with a very well pronounced, ∼1 cm thick ash layer (Glacier Peak ash, 13,375 cal.y.b.p.) at a depth of 650cm below the sediment-water interface. We interpret the transition from gray-brown mud to tan silt and clay to represent the unconformity imaged on our seismic data and to record the change from a glacially influenced lake system to the post-glacial open lake system present today. This unconformity, along with the condensed section in core FL-03-14K, provides information about an early post-glacial lake-level lowstand, during which the surface of the lake was about 15m below the modern lake level. Additionally we recovered cores from the center of Flathead Lake (cores FL-03-19 and FL-03-26K) and the east side of the lake (core FL-03-22K) respectively. Core FL-03-26K was collected in water depths of about 50m and provides an undisturbed record of Pleistocene and Holocene Lake sedimentation. A color change from brown-gray mud to tan clay and silt at a depth of 570cm below the sediment-water interface records the transition from glacial to interglacial conditions. Well-displayed rhythmic sedimentation containing centimeter-thick laminae with darker, coarser grained (very fine sand) layers and lighter colored silt and clay layers occupy the lower 460cm of this core (570cm-1030cm). A similar record has been recovered in core FL-03-22K in the deepest part of the lake (93m). The uppermost 150cm of this core consists of heavily degassing gray-brown mud with sulfide rich dark (black) layers. At a depth of 635cm below the sediment-water interface, we observed another sharp contact between the interglacial brown-gray mud and the tan glacial clay and silt sedimentation. The lower part (635cm-868cm) of core FL-03-22K contained nicely developed rhythmites, similar to those observed in core FL-03-26K.

PP32B-0289 1330h POSTER

Biomarker Records of Lake Albano (central Italy) and Lake Constance (southern Germany)- Implications for environmental change in the Holocene and Younger Dryas

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Steroids, triterpenoids and n-alkanes from a 13 m Holocene sediment core from Lake Albano and a 7 m Late Pleistocene/Holocene core from Lake Constance (13,000 to 650 years BP) as well as pigments, pollen and stable isotopes from benthic ostracodes, are used to reconstruct climatic changes and human impact on the lake systems and their catchments. Dinosterol, isoarborinol, hopanoids, and tetrahymanol in Lake Albano sediments indicate changes in the biological assemblages and enhanced lake mixing and thus stronger wind activity at around 6,500 and 3,800 years BP. A development from forest to a more open landscape in the Lake Albano catchment from 5,000 years BP is suggested by a decrease of n-alkanes derived from deciduous trees (C27 and C29). N-alkanes, friedelin and amyrenones show a close correspondence with the percentage of broadleaf-tree pollen, indicating deforestation after 5,000 and 6,500 years BP,. High concentrations of land-plant derived β-sitosterol in Lake Constance sediments during the Younger Dryas indicate erosive input due to sparse vegetation. The increase of β-sitosterol after 7,000 years BP suggests terrigenous input as a result of enhanced precipitation. Dinosterol distribution traces a period of high productivity between 11,600 and 7,000 years BP. Tetrahymanol, a biomarker for ciliates and possibly an indicator for water column stratification, shows relatively high concentrations at approximately 9,000 years BP. This coincides with a 4 $^{o}/_{oo}$ shift to more negative values of δ 13C in the ostracode L. mirabilis, suggesting hydromechanic changes in Lake Constance.

PP32B-0290 1330h POSTER

Limnologic Comparison of Two Small, Varved Lakes Based on Seismic-Reflection Data

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Seismic-reflection data are not commonly collected in the course of paleolimnological studies of small lakes, yet these data potentially contain considerable limnological information. In this study we compare high-resolution (Chirp) seismic-reflection data from two small glacial lakes in the northwestern United States, lakes that contain varved (annually laminated) sediments. Foy Lake (1.1 km^2, 42 m deep), near Kalispell, Montana, is an oligotrophic lake in calcareous till and bedrock. It contains late Holocene varves whose summer layers are formed by precipitation of calcium carbonate, underlain by non-varved sediments. The seismic data indicate that biogenic methane occurs sporadically in the sediments, commonly accumulating at the level of the Mazama tephra, and in some cases forming mud lumps, or gas escape structures. Despite the occurrence of gas, the seismic profiles commonly image the varved upper sediments, as well as the Mazama tephra and underlying non-varved units. The data are especially useful for defining the depositional patterns of these units. Gillette Lake (0.19 km^2, 26 m deep) in Stevens County, Washington, is a mesotrophic lake in non-calcareous till and bedrock. It contains non-calcareous varves whose summer layer consists mostly of diatom remains. The sediments are highly organic and charged with biogenic methane, to the point where sections of cored sediment float. Acoustic signals were reflected from the lake floor, but were completely scattered from below the sediment surface in all but shallow (<5 m) water. Despite this, the seismic profiles were still useful for defining the lake floor morphology in the course of selecting coring sites. The high-resolution geophysical data reveal properties of the two lacustrine sediment sequences that are entirely consistent with limnological and sedimentological data. The main limnological differences between the two are related to their productivity and trophic status, and to the composition of the underlying sediments and bedrock.

PP32B-0291 1330h POSTER

Tropical Storm Allison (2001) Recorded in Oxygen Isotopic Composition of Shells of Living Ostracoda

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The oxygen isotopic composition of rain from tropical cyclones is distinctly lower than that of normal rain in the tropics or subtropics (GRL, Lawrence and Gedzelman, 1996). Therefore when heavy rains fall in lowland coastal areas the surface waters show a sharp decrease in oxygen isotope values that persists for a few weeks (Chem. Geol., Lawrence 1998). In early June of 2001 Tropical Storm Allison dropped on the order of 600 mm of rain in the area around Houston, Texas. The oxygen isotopic composition of surface waters in east Houston dropped to -11.4 per mil and slowly returned to a more normal summertime value of -2 per mil over a three week period. Water samples were collected on June 6, 10, 13, 17 and 26. Attempts were made to collect samples of living Ostracoda on these dates. On June 17 and 26 samples of living Cypridopsis and Potamocypris were found and collected. The carbonate shells of these specimens were analyzed for their oxygen isotope values. The distinct difference observed in the oxygen isotopic composition of the surface waters on the two dates was mirrored in the analyzed shells of the Ostracoda. These results suggest that in fresh water shallow lake environments sediment cores containing shells of Ostracoda may provide a record of tropical cyclone activity over the last several thousands of years.

PP32B-0292 1330h POSTER

Compound Specific D/H Analysis of Late Holocene Lacustrine Sediments in Sub-Tropical North America: Implications for Reconstructing Atmospheric Circulation Patterns and Hydrologic Conditions.

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The hydrogen (D/H) isotopic composition of individual organic compounds has the potential to provide high-resolution reconstructions of paleoclimatic and hydrologic conditions (e.g. atmospheric circulation patterns, relative humidity, etc) in continental environments. Modern calibration studies have shown that specific fatty acids are unique to algae (C-16) and terrestrial (C-28) materials, and that δD(C16) is more depleted than δD(C28). In lacustrine systems, the δD(C16) is a direct reflection of the isotopic composition of the source water it was synthesized in which, is determined by atmospheric circulation patters that governs latitudinal sources and seasonal amounts of precipitation. The δD(C28), on the other hand, reflects an isotopic enrichment of source waters resulting from evaporative processes experienced by most terrestrial vegetation. The magnitude of isotopic offset between the algae and terrestrial markers, ($\Delta\delta$D(C16-C28)), takes into consideration variations in the source waters and, hence, reflects only the relative intensity of evaporative processes or the conditions of relative humidity. Together, δD(C16) and $\Delta\delta$D(C16-C28) from lacustrine archives can serve as proxies for the reconstruction of climatic conditions in continental settings. Lake Tulane, located in Central Florida, is a subtropical, groundwater-fed acidic lake with a high sedimentation rate and well-preserved organic matter. Its small catchment area allows for synchronous deposition of terrestrial and algal materials into the sedimentary record. Variability in the δD(C16) , reflecting source water changes, and variability in the $\Delta\delta$D(C16-C28) has been observed in a sedimentary record from Lake Tulane representing the last 80kyr. On glacial-interglacial time scales, sea level is the dominant control on regional relative humidity in Florida and the long-term record of $\Delta\delta$D(C16-C28). This study focuses on reconstructing higher resolution continental climate change on decadal to interannual time scales with emphasis on specific climatic events such as the Little Ice Age and Medieval Warm Period. Over this interval sea level is largely invariant and we can attribute changes in δD(C16) to changing atmospheric circulation patterns (source waters), and the variance in $\Delta\delta$D(C16-C28) to fluctuations in the P/E ratios (relative humidity). These parameters provide a new set of proxies that can reconstruct hydrologic and atmospheric conditions in the geologic past.

PP32B-0293 1330h POSTER

Assessment of Modern Climate Baselines for Paleoclimatic Reconstructions and Model Testing in North America

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Paleoclimatologic studies usually employ a "modern" climatic data set as the baseline against which to measure the differences between past climates and those of today. Weather records for the past century indicate that climate has not been stationary, and thus the selection of the baseline time-interval from the past hundred years will affect the interpreted paleoclimatic results. In addition, the spatial resolution of the baseline data set, coupled with the manner in which elevation is considered, may also affect these results. Our work thus far has employed a 1951-1980 climatic baseline on a 25-km equal-area grid of North America for which climatic variables have been interpolated from the records of approximately 8000 climate stations (Bartlein and Lipsitz, 1994). We compare reconstructions using the 25-km equal-area data set with reconstructions using a higher resolution 10-km equal-area data set of climatic variables interpolated from the Climate Research Unit (East Anglia, UK; Mitchell et al., 2003) 30-minute TS 2.0 data set. This 10-km data set provides coverage for the 20th century and thus permits the assessment of the effects of using different baseline time-intervals on paleoclimatic reconstructions and model validation exercises. Although the continental-scale patterns are similar among the 25-km data set and the various 10-km data sets, there are measurable differences, especially in regard to moisture variables, in the past and present climate reconstructions generated using these different climate baselines.

PP32B-0294 1330h POSTER

Development of Modern Analogue and Mutual Overlap Techniques for Paleoclimatic Reconstructions and Model Validation from Plant Macrofossil Assemblages in North America

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Plant macrofossils provide a unique resource in paleoclimatology: They can usually be identified to the species level, can be directly dated by radiocarbon analysis, and can be related to modern living relatives whose ranges are usually well-known. Fossil packrat middens provide a spatially and temporally rich data set of well-dated species-level plant macrofossil assemblages covering the last glacial period and the Holocene in western North America. Other plant macrofossil assemblages are available from permanently wet (e.g., lakes, mires) and permanently dry (e.g., cave sediments) deposits. To provide the basis for exploring the paleoclimatic implications of these macrofossil assemblages we have investigated the present-day relations between climatic parameters and the distributions of more than 600 woody plant species across North America, based on a 25-km grid of climatic, bioclimatic, and species distribution data. We used this data set to explore the efficacy of climatic estimation from plant assemblages based on the "modern analogue" comparison between the target plant assemblage and all other plant assemblages in the modern data set using the Jaccard similarity coefficient. The estimates produced by these methods were then compared with the range of permissible climates for each assemblage based on the mutual overlap approach. Our explorations suggest that the "modern analogue" method provides meaningful climatic estimates in most regions, if the number of species in the target assemblage is large enough. Although it is pleasing to obtain a single value for each climatic parameter associated with a given macrofossil assemblage, it is also potentially misleading in that the range of permissible climates for the assemblage may be large, particularly under atmospheric carbon dioxide concentrations different from those of today. The mutual overlap approach may provide a more realistic view of the past and may be better suited for data - model comparisons.

PP32B-0295 1330h POSTER

A High Resolution, Absolute-Dated Holocene and Deglacial Asian Monsoon Record From Dongge Cave, China

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Previous work on speleothems from Hulu Cave, China, demonstrated a link between last glacial period and deglacial East Asian monsoon intensity and millennial-scale events in the North Atlantic as well as orbitally induced insolation variations (Wang et al., 2001, Science, 294, 2345-2348). The East Asian monsoon originates from the tropical Pacific thereby connecting this specific site in the tropics to the processes creating these millennial-scale events. Recently these events have been observed to extend into the Holocene (Bond et al., 2001, Science, 278, 1257-1266), challenging the idea of fairly stable climatic conditions observed in Greenland ice cores during the Holocene. Here we present a continuous record of the Asian monsoon over the last 16,000 years from stalagmite calcite to further extend the link between Asian monsoon intensity and millennial-scale events into the Holocene. This time range overlaps the Hulu stalagmites by ~6,000 years and a strong correlation is observed between the two records suggesting the same mechanisms affecting the East Asian monsoon affect a broader region of the Asian monsoon system. 808 oxygen isotopic measurements providing information on shifts in monsoon precipitation are combined with a chronology from 45 precise ^{230}Th dates. Monsoon intensity increased dramatically (~3$^{o}/_{oo}$) during the start of the Holocene (~11.5 ka) and remained high for ~6 ka. In the middle-late Holocene, two abrupt positive shifts in δ^{18}O occur at 5457±75 years (0.75$^{o}/_{oo}$ in 170 y) and 3614±50 years (1.1$^{o}/_{oo}$ in 15 y) corresponding to a stepwise decrease in Asian monsoon intensity at these times. In addition, several other smaller intervals of decreased Asian monsoon activity occur suggesting millennial-scale features are present in the Holocene. Whereas one period of decreased activity occurs at 8085 years BP within error of the "8200-year event" seen in Greenland ice cores, similar events (~1.1$^{o}/_{oo}$) are present throughout the record. Therefore the "8200 year event" is not clearly evident in the monsoon record. Spectral analyses of the δ^{18}O record show significant peaks at 205- and 88- year cycles, which are also present in records of solar activity (Stuiver and Braziunas, 1993, Holocene, 3, 289-305), suggesting monsoon variation is influenced by solar forcing. However, there are numerous significant peaks at periods not present in the solar spectra. Thus, there are additional features besides insolation and solar variations, which affect the Asian monsoon.

PP32B-0296 1330h POSTER

Initial ^{230}Th and isotopic compositions of U and Th in a Holocene stalagmite from Ninh Binh, Vietnam

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The application of the ^{238}U-^{234}U-^{230}Th disequilibrium dating technique to cave carbonates has provided access to a valuable source of Quaternary environmental information. For some speleothems, however, the initial Th associated with the incorporation of detrital materials into the growing carbonate matrix can bias the true ages, which play a pivotal role in the paleo-sciences. Isochron techniques and development diagrams (Cheng et al., 2000, G.C.A., **64**, 2401-2416) were used on a stalagmite with unusually high thorium concentrations of 5-130 ppm and low uranium concentration of 100-300 ppb, collected from Ninh Binh, Vietnam, in order to evaluate the initial ^{230}Th values, ^{230}Th/^{232}Th ratios and ages. Uranium and thorium concentrations and isotopic compositions for forty subsamples collected from eight horizons of this 4600-yr old speleothem were analyzed by ICP-MS techniques (Shen et al., 2002, Chem. Geology, **185**, 165-178). Results from the application of isochron techniques were: (1) 50-90% of the ^{230}Th was deposited initially and must be subtracted from measured ^{230}Th in order to obtain accurate ages; (2) in some cases, discordant ages were obtained among subsamples on the same horizon if the same initial of ^{230}Th/^{232}Th was used for correction; (3) there was some variability in the initial ^{230}Th/^{232}Th values for different layers. These observations indicate that there are many Th sources with different concentrations and ^{230}Th/^{232}Th ratios introduced into growing layers during crystallization. Accordingly, the initial values of ^{230}Th/^{232}Th ratios vary between and within horizons. Such heterogeneous coprecipitation of detrital materials places some limits on the utility of simple two-dimensional isochron approaches to speleothems with large and complicated Th contamination, which enhances the uncertainty of estimated ages. If the development diagram technique is also employed, the initial values of ^{230}Th/^{232}Th ratios are more tightly constrained, varying from 17 to 26 ppm. However, even this sample, with very high thorium levels, yields ages that are generally consistent with AMS-^{14}C ages of this stalagmite, which has only a trivial dead carbon problem. Therefore, speleothems with moderate Th-levels can likely be dated precisely using the approaches that we outlined here.

PP32B-0297 1330h POSTER

Reconstruction of Late Quaternary Climate in Central Europe - A Comparison of Stable Isotope and Trace Element Variations in Speleothems From Different Cave Systems in Germany.

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Speleothems (stalagmites, stalactites, flowstones) are important archives for Late Quaternary continental climatic and paleo-environmental reconstruction. Speleothems form when calcium carbonate precipitates from solutions seeping into caves hosted e.g. in limestone or dolomite complexes. Information of past climate variability and changes in local environmental conditions can be obtained from signatures of the stable isotopes of oxygen and carbon as well as trace element pattern recorded in speleothems. Reconstruction of paleo-temperature and past environmental conditions from stable isotopes, however, require isotopic equilibrium between the drip water and the precipitating calcium carbonate. Results from Dietzel et al. (1992) and Johnson and Ingram (2001) indicate that the formation of modern travertine and speleothem calcite occurs under isotopic equilibrium. Factors that influence the stable oxygen and carbon isotope composition during speleothem precipitation include e.g. the moisture source and precipitation, photosynthetic pathways, the bedrock proportion, and the drip rate. This often leads to a situation with several variables. However, a specific interpretation is possible when dealing with environments where only one of the factors is dominant, or specific settings are assumed to be invariant, or further proxies like trace element variations help to define the frame conditions during speleothem formation. Concentrations of trace elements (e.g. Sr, Mg) which are co-precipitated with calcite are related to changes in the composition of the solution and strongly depend on the dissolution/precipitation dynamics along drip water flow paths. In a multiproxy approach they are a valuable tool for the interpretation of the recorded stable isotope variations. We present first results from different cave systems located in the Swabian Alps and the Harz Mountains (Germany). Our study includes a high-resolution multiproxy approach, using U/Th-TIMS data, stable oxygen/carbon isotope data, and geochemical compositions of speleothems, covering ages from the Late Pleistocene to the Early Holocene. The results are compared to geochemical data from host rocks, soil zones, cave sediments, drip water compositions, and recent calcium carbonate precipitates. Understanding the response of a cave system to the actual climatic, hydrologic and environmental regimen is a main requirement for the interpretation of "paleo-information" conserved in speleothems in order to lead to a coherent picture of past continental climate dynamics.

References: Dietzel M., Usdowski E., and Hoefs J., (1992): Applied Geochemistry 7: 177-184. Johnson, K.R. and Ingram, B.L. (2001): Abstract volume, 4th Internat. Symp. On Applied Isotope Geochemistry, Pacific Groove, USA: 70-72.

PP32B-0298 1330h POSTER

Changes in Atmospheric 14C Between 55 and 42 ky BP Recorded in a Stalagmite From Socotra Island, Indian Ocean

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A record of atmospheric radiocarbon (14C) variations for a part of the last glacial period was obtained from a 1.7 m long stalagmite, M1-2, from Socotra Island in the Indian Ocean. The stalagmite radiocarbon values were corrected for 14C-free carbon added by water-rock interaction (dead carbon fraction), by using del 13C values of the calcite as a constraint. An age-depth model was developed from 25 high-precision U/Th measurements. The base of the stalagmite dates to 54.7 ky BP and it stopped growing around 42.2 ky BP. The difference between U/Th and 14C ages shows a smooth, steady increase from about 5,000 years at the base of the stalagmite to about 8,000 years at its top. Correspondingly, Delta 14C values increase from 500 per mil to about 1300 per mil, which indicates that concentrations of atmospheric 14C steadily increased between 55 and 42 yr BP. The record from Socotra Island does

not show the large and rapid D14C changes previously recorded in a stalagmite from the Bahamas (Beck et al, Science 2001). The D14C values estimated from M1-2 are significantly higher than those estimated from a marine 14C record (foraminifera) from Cariaco Basin for the same time period (Hughen et al. in prep). In the latter, D14C values decrease to near 0 at about 44 ky BP. The most likely reason for this discrepancy are the two different time scales used; the Cariaco Basin is matched to the GISP2 timescale, which is approximately 5000 years younger than indicated by the stalagmite U/Th chronology (Burns et al, Science 2003). When the Cariaco basin record is adjusted to the M1-2 timescale, the D14C values for both datasets are similar.

PP32B-0299 1330h POSTER

Late Quaternary Vegetation History and Paleoclimate of the U.S.A.-Mexico Borderlands Region From Two New Packrat Midden Series

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Two new packrat midden (Neotoma spp.) chronologies reveal glacial to interglacial changes in vegetation and climate in the Playas and San Simon Valleys in the U.S.A.-Mexico Borderlands. The Borderlands, where the states of Arizona and New Mexico intersect with each other and the Mexican states of Chihuahua and Sonora, are characterized by several northwest-southeast trending and tilted fault-block ranges separated by closed topographic basins. These basins now contain ephemeral playas, but held pluvial lakes (Animas, Cloverdale, Cochise, Goodsight, Hachita, Palomas, Playas) during the Pleistocene and lesser lakes sporadically in the Holocene. Plant macrofossil and pollen assemblages from middens indicate vegetation along pluvial lake margins consisted of open pinyon-juniper communities dominated by Pinus edulis, Juniperus scopulorum, Juniperus cf. coahuilensis and a rich understory of C4 annuals and grasses. Although both lake and pinyon-juniper expansion across the lowlands have been attributed to greater winter precipitation, the summer-flowering understory, characteristic of modern desert grassland in the Borderlands, indicates at least moderate summer precipitation during the late glacial. The U.S.A.-Borderlands may have been the only area in the western half of the coterminous United States to "green-up" in July and August, and may have offered seasonal refuge from the dry fire season to the north. Late glacial summer precipitation in the Borderlands may explain the concentration of megafauna and paleoindian sites dating from this period in the area. A transition to a warmer, drier climate is inferred from the extirpation of Pinus edulis from the lowlands of the Playas and San Simon Valleys by 10,300 14C yr B.P. The disappearance of pinyon and change to more xeric oak-juniper communities is contemporaneous with other midden sites in the northern Chihuahuan Desert and may have occurred abruptly during the "Clovis-aged Drought" when the water table at nearby Murray Springs dropped to unusually low levels just before 10,900 14C yr B.P. Few middens in our series dated from the middle Holocene (8000 - 4000 14C yr B.P.), a period during which middens are scarce across the Southwest. The gap was previously attributed to hydrologic drought during the middle Holocene and declines in woody perennials and packrat populations. However, beach ridge and lacustrine deposits from Laguna El Fresnal and Laguna Santa Maria indicate wetter than present conditions in the Borderlands during the middle Holocene. The late Holocene is marked by the arrival of Chihuahuan Desert scrub elements and few departures. Desertscrub elements begin to appear by about 4000 14C yr B.P., marking the transition to present-day vegetation. Larrea tridentata and Fouquieria splendens, two of the dominant desert species present at the sites today; both appear later than in surrounding areas.

PP32B-0300 1330h POSTER

Historic Carbon Isotopic Shifts in Pinyon Pines and Woodland Junipers are Unprecedented During the Quaternary History of These Taxa

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Packrat (*Neotoma*) midden macrofossil records from arid and semiarid western North America provide evidence that pinyon pines and woodland junipers have grown together for at least the past 50,000 radiocarbon years. The midden records show that this association was sustained despite large-scale changes in climate and atmospheric CO_2 concentrations over the past 50 millenia. Reconstruction of physiological parameters, using ^{13}C analysis of a select sample of pinyon pine and juniper macrofossils from radiocarbon-dated ancient packrat middens, shows distinct physical responses to these changes despite a offset between the carbon isotopic values of the two genera, with pinyon pines having consistently lower ^{13}C values than junipers. Remarkably, analysis of historic (from herbarium sheets) and present-day (from field collections) materials from northern Arizona and the Four-Corners region indicates that the long-term offset between the carbon isotopic values of pinyon pines and woodland junipers has inverted; with the junipers now providing isotopically lighter values than the pinyon pines. This reversal began in the late 1800's to early 1900's and has widened over the past century. The inverted isotopic offsets in the historic period may be due to the unprecedented levels of carbon dioxide and other trace gases in the atmosphere.

PP32C MCC: 3004 Wednesday 1340h

Southern Ocean Climatic Evolution: The Marine Geologic Record II *(joint with OS, C, GC)*

Presiding: **N Exon,** Geoscience Australia**; D A Warnke,** California State University, Hayward

PP32C-01 1340h

A History of Water Mass Circulation in the Paleogene Southern Ocean from Nd Isotopes

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Using fossil fish teeth from ODP site 689 (2080m, Maud Rise) we have generated a 28 Myr record of Nd isotope ratios and concentrations for the early middle Eocene to early Miocene at an average resolution of 250-300 kyr. ϵ_{Nd}(T) values documented in this time series range from -9.5 to -7.35, and demonstrate a pattern of secular variations that is remarkably similar to benthic foraminiferal $\delta^{13}C$ records from this site. This correlation suggests that secular variations of ϵ_{Nd}(T) values observed at site 689 are related to changes in ocean circulation and may provide insight into the history of water mass circulation in the Southern Ocean. Early middle Eocene ϵ_{Nd}(T) values average -9.25 and display little variation compared to younger portions of the record, which illustrate long term oscillations beginning in the late middle Eocene. Starting at 40.8 Ma ϵ_{Nd}(T) values increase over a 6 Myr interval from -9.4 to -7.35 in a stepwise fashion. Although ϵ_{Nd}(T) values begin to rise during the late middle Eocene the period of most rapid change occurs in the late Eocene (after 37 Ma). ϵ_{Nd}(T) values begin to fall in the earliest Oligocene reaching -8.75 at 30 Ma, then rise to -7.75 during the late Oligocene, but fall again to -8.75 by the end of the Oligocene. A hiatus occurs from the latest Oligocene to early Miocene. Following that interval, late early Miocene values average -8.5. Throughout the record the most radiogenic Nd isotopic compositions ($\sim$ -7.5), are associated with high $\delta^{13}C$ values (1.2-1.4 $^{o}/_{oo}$), while nonradiogenic Nd isotopic compositions are associated with lower $\delta^{13}C$ values (.2-.4 $^{o}/_{oo}$). The subsidence curve constructed for site 689 indicates a middle Eocene paleodepth of 1200-1500 m. A mean ϵ_{Nd}(T) value of -9.25 during the middle Eocene possibly reflects upward mixing of Warm Saline Deep Water (WSDW) from the Tethys Sea, which has been documented at a deeper site on the Maud Rise (690) on the basis of an oxygen isotopic inversion between the two sites (Kennett and Stott, 1990). If this interpretation is correct, these data are the first to characterize the Nd isotopic signature of Paleogene WSDW in the Southern Ocean. The rapid shift toward radiogenic ϵ_{Nd}(T) values at 37 Ma in this time series is coeval with a change in climate-productivity-ventilation patterns at this site (Diester-Haass and Zahn, 1996) based on stable isotopes and benthic foraminiferal accumulation rates. We suggest that the early opening of the Drake Passage at 37 Ma created or strengthened the proto Antarctic Polar Front (pAAPF) south of site 689. Rapidly increasing ϵ_{Nd}(T) values at this time could represent the Cenozoic precursor to Antarctic Intermediate Water (AAIW) combined with the inflow of radiogenic Pacific Water through the Drake passage. This interpretation in consistent with increasing $\delta^{13}C$ values and the apparent position of the pAAPF based on microfossil assemblages in the Southern Ocean (Cooke et al., 2002). Oligocene oscillations of ϵ_{Nd}(T) values may be related to the appearance of cold, dense Antarctic Bottom Water (AABW) following first major Antarctic ice growth. The presence of AABW may have caused the depth of the mixing zone between WSDW and AAIW to shoal, resulting in lower ϵ_{Nd}(T) values at site 689. By the late Oligocene there is evidence that the Drake Passage was open to deep water flow (Scher and Martin, 2003) and it is likely that Circumpolar Deep Water (CPDW) became the bottom water mass at this site.

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The Paleocene-Eocene Thermal Maximum in the Southern Ocean: Middle Bathyal Constraints from ODP Sites 689 and 738

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The Paleocene-Eocene Thermal Maximum (PETM; 55 Ma) is marked by a 2-3 $^{o}/_{oo}$ negative carbon-isotope excursion (CIE), increased temperatures, reduced ocean-atmosphere circulation, and intensified oceanic carbonate dissolution. The most parsimonious mechanism to drive these global patterns was a massive methane hydrate destabilization that released methane to the ocean-atmosphere and elevated pCO^2. PETM reconstructions of the Southern Ocean are based largely on the lower-bathyal ODP Site 690 (South Atlantic Sector; 1,900 m paleodepth). To improve our understanding of this climatically sensitive region, we determined cm-scale variations in bulk-carbonate stable-isotopes and wt% carbonate through the PETM at the lesser known middle-bathyal ODP Sites 689 (Atlantic Sector; 1.1 km paleodepth) and 738 (Indian Sector; 1.3 km paleodepth). Sites 689 and 738 both contain three stratigraphic intervals of relatively stable $\delta^{13}C$ values through the CIE onset; we view these intervals as coeval to similar intervals at Site 690, which Bains et al. (1999) interpret as pauses between distinct methane releases. This congruence suggests that Sites 689 and 738 are as stratigraphically complete as Site 690 through the CIE onset, although much of the subsequent CIE recovery interval is lost in a coring gap at Site 689. Through the CIE recovery interval, Site 738 $\delta^{13}C$ increases by 0.8 $^{o}/_{oo}$ over an $\sim$5-cm interval compared to an equivalent increase over a greater than 150-cm interval at Site 690. Rather than a hiatus, we hypothesize that this Site 738 pattern records ocean-atmosphere $\delta^{13}C$ changes at a relatively constant MAR, which is consistent with Farley and Eltgroth's (2003) Site 690 ^3He data indicating increased MARs through the CIE recovery interval. These findings imply that (1) the MAR increase was not circum-polar, and (2) carbon cycling/removal from the ocean-atmosphere reservoir was more rapid than previously estimated. Carbonate saturation is a critical parameter in carbon-cycle dynamics; wt% carbonate may provide a first-order estimate of carbonate saturation changes by assuming constant carbonate export production. Sites 689 and 738 wt% carbonate values drop markedly at the CIE onset as predicted by the methane hydrate hypothesis and documented at deeper pelagic PETM sections. Unlike deeper records, Site 689 and 738 wt% carbonate values then transiently increase, stabilize, and drop again at the third and final $\delta^{13}C$ step-decrease during the CIE. Following this second drop, wt% carbonate values at both middle-bathyal sites rapidly increase to pre-CIE values within the CIE minimum, while values at the lower-bathyal Site 690 gradually increase through the CIE recovery interval. We hypothesize that these patterns reflect carbonate saturation profile changes in response to pulsed pCO^2 increases from distinct methane releases. Specifically, given that wt% carbonate values remain suppressed at Site 690, we interpret the "double-dip" pattern at Sites 689 and 738