borehole wall with a resolution of about 1 cm, and the chert layers stand out as resistive bands in the image. At this site, the chert layers occur on average every 83 cm, with an average thickness of about 9 cm. The cherts are typically layered rather than nodular, suggesting that they formed at horizons that were originally rich in silica, and that diagenesis enhanced this depositional signal. The FMS image logs cover the Cenomanian to Campanian, and the chert layers are most abundant in the Turonian. When the time intervals between chert layers are plotted as a histogram, the intervals cluster around the Milankovitch astronomical periods. Spectral analysis of the FMS data gives peaks in the general range of the astronomical frequencies. We will discuss the various paleoceanographic conditions that could have led to the observed short and long term patterns of chert formation.

PP41C-0847 0830h POSTER

Non-steady state redox conditions in bottom and pore waters of the Mid-Cretaceous NW-African shelf at Tarfaya (SW-Morocco): Climate control and implications for synchrony of basin-wide oxidation of shallow waters during the CT-OAE2

Thomas Wagner[1] (49-421-218-8950; twagner@uni-bremen.de)

Sabine Kasten[1] (49-421-218-3945; skasten@uni-bremen.de)

Sadat Kolonic[1] (49-421-218-8938; skolonic@uni-bremen.de)

[1]University of Bremen, Geosciences, PO Box 330440,, Bremen 28334, Germany

Widespread deposition of organic-carbon-rich marine sediments during the Oceanic Anoxic Events (OAEs) is a distinct feature of the Cretaceous ocean that was intrinsically linked to periods of extreme oxygen-depletion in the water column. High-resolution geochemical and biofacial records from the southern proto-North Atlantic including the NW-African shelf have recently become available indicating that the redox state of the water column was far from stable during the OAE2. Instead it varied between anoxic/euxinic and probably suboxic/oxic conditions on Milankovitch- and maybe even shorter time scales. Despite these stimulating implications little is known about the degree of oxygenation of the water column, the dynamics of contrasting redox conditions, and whether oxidation of the water column occurred synchronous on a basin-wide scale, i.e. across the North American and NW-African shelves. We report millennial-scale geochemical records from a bathymetric transect through the Tarfaya Basin in SW-Morocco to address the nature, pacing, and synchrony of shallow marine redox cycles associated with the OAE2. The data propose that reoxidation of the water column repetitively occurred on orbital frequencies, the transition from anoxic to oxic conditions was abrupt and strong enough to result in distinct metal-rich layers (e.g. Mn) in the sedimentary column. The presence of these distinct layers propose non-steady state diagenesis with progressively downward migrating oxidation fronts. As known from more recent geological analogs, short oxic periods during the OAE2 drastically reduced the preservation potential of marine organic matter in the sediment and supported the re-colonization of the sea floor by benthic organisms. Correlation of one distinct and longer-lasting oxygenation event positioned right in the maximum of the CT global carbon isotopic excursion between the Tarfaya Basin and recently published data from the type section of the Western Interior Basin at Pueblo for the first time allow the discussion of basin-wide synchrony of this oxidation event and probable mechanism.

PP41C-0848 0830h POSTER

Model Simulations of Orbitally Forced Terrestrial and Surface Ocean Variability in the Paleogene Greenhouse Climate

Karen L Bice[1] (508-289-3320; kbice@whoi.edu)

Richard D Norris[2] (858-822-1868; RNorris@ucsd.edu)

[1]Woods Hole Oceanographic Institution, Mail Stop #23, Woods Hole, MA 02543, United States

[2]Scripps Institution of Oceanography, 308 Vaughan Hall, La Jolla, CA 92093, United States

We have performed an extensive suite of slab ocean GCM experiments in order to begin to understand cyclical changes in carbonate content observed in Paleocene and Eocene sediments recovered from Demerara Rise (ODP Leg 207). In the first part of this study, the sensitivity of surface temperature and moisture flux fields will be compared against globally distributed Eocene terrestrial records in order to determine the degree to which the model's prediction of atmospheric changes compares with cycles in terrestrial paleoclimate records. In addition, model-predicted upper ocean forcing temperature and moisture flux changes will be compared against variations in planktonic foraminiferal oxygen isotope signals in high resolution Paleogene records from the subtropical North Atlantic. Atmospheric model experiments were performed with the GENESIS v. 2.0 model using an early Eocene paleogeographic reconstruction, 1500 ppm CO2 and solar luminosity reduced by 0.3 percent from the modern. We have seen that the use of general circulation models to reliably define the paleoclimate variations expected on orbital timescales requires model runs with at least 30 years of quasi-steady state output. A high degree of variance in the precipitation field in tropical latitudes and autocorrelation in surface temperature over ocean model cells requires datasets of at least 30 years of output in order to define statistically significant differences between experiments with different specified orbital configurations.

PP41C-0849 0830h POSTER

Seasonal Isotopic Ca, B, O, C and Sr Fractionation in Late Oligocene Oysters (C. Gigantissima)

Annette Deyhle[1] (858 822 4345; adeyhle@ucsd.edu)

Douglas MacDougall[1] (858 534 3294; jdmacdougall@ucsd.edu)

Michael X Kirby[1] (858 822 5622; mkirby@ucsd.edu)

[1]Scripps Institution of Oceanography, 9500 Gilman Drive, La Jolla, CA 92093-0212, United States

Stable isotope compositions preserved in shell calcite may record various aspects of the environment at the time of calcification. Data from natural samples of C. gigantissima from the Belgrade Formation, North Carolina 27+-1 Ma), suggest that Ca and B isotope fractionation is temperature dependent and is also a function of water composition. Also, Ca and B isotope fractionation seems to be highly species dependent and for paleotemperature reconstruction it is important to study each species in order to elucidate their response to both temperature and paleo environment. These relationships make seasonal variations in shells extremely useful for interpreting the paleoecology of fossil organisms, as isotope fractionation is different in seawater and brackish water (as seen with oxygen isotopes). In this study, Ca, B, C and O isotopic values were measured along a profile perpendicular to skeletal growth increments, known as stable isotope sclerochronology. This method enables to resolve intra-annual differences in stable isotopes. High resolution O and C isotopic profiles show that C. Gigantissima formed skeletal growth increments annually at seasonally varying growth rates, with convex and concave bands forming during summer and winter, respectively (Kirby, 2000). Assuming shell growth ceased at 10C, the estimated paleotemperature derived from oxygen isotopes gives a seasonal range of temperature of ca. 15C, with summer temperatures reaching ca. 25C. Samples from winter and summer bands show a small range of total variation in $^{44}Ca/^{40}Ca$ of 0.5 permil. The Ca isotope fractionation is positively correlated to temperature with more positive $\delta^{44}Ca$ of ca. -1.43+- 0.1 permil in the summer and more negative Ca isotopic compositions of ca. 1.93+- 0.1 permil in the winter. The data imply a temperature dependence that is ca. 0.03 permil per C. This is significantly less than the 0.24 permil per C reported by Naegler et al (2000) for cultured Globigerina sacculifer. However, aragonite precipitated in the laboratory at temperatures of 10 and 40C appears to show an even smaller temperature dependence of approximately 0.01 permil per C (Deyhle et al., 2002) to 0.015 permil per C (Gussone et al., 2003). Additional data gained on O, C and B isotopes further confirm that skeletal growth increments in C. Gigantissima show an annual variation, with average seasonal changes of 3.2+- 0.4 permil, 1.1+- 0.4 permil and 4.3+- 0.5 permil, respectively. Interestingly, B isotopes which were previously used as paleo-pH proxy, clearly show an intra-annual temperature dependent fractionation of almost 0.3 permil per C, suggesting that B may be a useful paleo-temperature proxy. Likewise $\delta^{13}C$, B isotopes may also be influenced by the amount of respired CO_2 reaching the site of calcification. $^{87}Sr/^{86}Sr$ isotopic ratios of 0.70809 +- 0.000018 are the same within our analytical uncertainty and thus suggest fully marine conditions with no change in any freshwater input summer to winter. In summary, stable isotope analysis show significant intra-annual changes which are influenced by temperature and possibly other factors. Further studies need to be conducted on Ca and B isotopes to better understand whether temperature is the main fractionation mechanism on a seasonal time scale or if parameters like shell growth rate and other vital effects play also a critical role in isotopic variations.

PP41C-0850 0830h POSTER

A 9 Million Year Long High-Resolution Benthic $\delta^{13}C$ and $\delta^{18}O$ Record: Implications for Late Oligocene to Middle Miocene Paleoceanography

Julia M Frazier[1] (831-459-5800; jfrazier@es.ucsc.edu)

James C Zachos[1] (jzachos@es.ucsc.edu)

Appy Sluijs[2] (a.sluijs@students.uu.nl)

Nick J Shackleton[3] (njs5@cam.ac.uk)

[1]Univ. of California, Santa Cruz, Earth Sciences Dept., Santa Cruz, CA 95064, United States

[2]Utrecht Univ., Geobiology Dept., Utrecht 3584 CD, Netherlands

[3]Cambridge Univ., Godwin Laboratory for Quaternary Research, Cambridge CB2 3RS, United Kingdom

We present a high-resolution (3 ky) stable isotope time series based on benthic foraminifera data collected from ODP site 926 on Ceara Rise in the western equatorial Atlantic. With data from a second Site 929, the combined record continuously spans a period of almost 9 million years (17.8-26.7 Ma). The age model is based on tuning to a new orbital solution (Laskar 2002). This work extends previously published records deeper into the Oligocene and further into the Miocene in an attempt to create a continuous time-series with the resolution to resolve paleoclimatic change on orbital to tectonic time-scales. As observed previously, the long-term $\delta^{13}C$ and $\delta^{18}O$ records collected from benthic foraminifera *C. mundulus* display pervasive cyclic responses at all Milankovitch frequencies with power largely concentrated in the obliquity and 400 kyr eccentricity bands. Cross-spectral analysis of these records and orbital curves indicates a high degree of correlation at all primary Milankovitch periods. The extended, spliced record reveals several new features. Over the long-term, the $\delta^{18}O$ record now captures the structure of the late Oligocene warming which initiates at roughly 26.5 Ma, and through a series of steps, peaks by 24.5 Ma, before the initiation of cooling at 23.5 Ma. Over the short-term, high frequency $\delta^{13}C$ cycles with amplitudes in excess of $0.5^{o}/_{oo}$ are evident throughout the record. However, the amplitudes are noticeably higher during two periods, 25.9 to 26.7 Ma in the late Oligocene, and 17.9 to 19.5 Ma in the early Miocene, with minimum falling as low as $-1.0^{o}/_{oo}$ during the former. The extreme amplitudes of these $\delta^{13}C$ cycles suggest vertical migration of a mixing line between two water masses, Northern and Southern Component water, implying changes in deep water circulation. Carbonate dissolution proxies support this inference.

PP41D MCC: 3004 Thursday 1020h

Rapid Climate Change During the Holocene and Last Glacial II *(joint with A, OS, C, GC)*

Presiding: **C Morrill,** National Center for Atmospheric Research**; D M Anderson,** NOAA Paleoclimatology Program

PP41D-01 1020h

Radiocarbon Record of Rapid Deep Water Production Changes During the Last Deglaciation

Li Cao[1] (845-365-8625; lcao@ldeo.columbia.edu)

Richard G Fairbanks[1] (845-365-8499; fairbanks@ldeo.columbia.edu)

Richard Mortlock[1] (mortlock@ldeo.columbia.edu)

Thomas P Guilderson[2] (tguilderson@llnl.gov)

[1]Li Cao, Lamont Doherty Earth Observatory, Columbia University, Rt.9W, Palisades, NY 10964, United States

[2]Thomas P. Guilderson, Center for Accelerator Mass Spectrometry, Lawrence Livermore National Laboratory, Livermore, CA 94551, United States

Several dramatic excursions in the oxygen isotope values of Greenland ice cores and corresponding increases in polar sea ice extent occur during the last deglacial interval. The fate of North Atlantic Deep Water (NADW) during these brief excursions is of great interest but is poorly documented due to a lack

of high-resolution proxies of NADW. We have generated two high-resolution marine Δ^{14}C records spanning 10,500 to 15,000 years BP based on paired thorium/uranium and radiocarbon age determinations on corals collected offshore Barbados (13^{o}13'N, 59^{o}32'W) in the western tropical Atlantic and Kiritimati Atoll (1^{o}99'N, 157^{o}78'W) in the central equatorial Pacific. Our marine records both show a series of Δ^{14}C fluctuations averaging 35$\pm$10 per mil in amplitude. Intervals of increasing Δ^{14}C values correspond to the extreme low oxygen isotope intervals, indicating reduced deep-water production during cold events in the North Atlantic region. The concordance between our tropical Atlantic and Pacific Δ^{14}C records (reservoir corrected) and their overlap with the floating tree ring Δ^{14}C chronology of Freidrich et al., (1999) between 13,200 and 14,200 years before present, strongly indicates that the ocean is the source of these Δ^{14}C fluctuations. Our coral Δ^{14}C records compare well with the Δ^{14}C record from the varved sediments of the Cariaco Basin (Hughen et al., 2000) from 10,500 to 12,900 years BP,but are markedly different from the Cariaco record from 12,900 to 14,700 years BP. A simple box diffusion carbon cycle model (Oeschger et al., 1975) reproduces the oceanic and atmospheric Δ^{14}C fluctuations using a fifty percent reduction in the deep water production diffusion term. Our thorium/uranium age determinations provide precise and accurate dates on the initial increases and decreases of deep-water production and the exact duration of the fluctuations.

PP41D-02 1035h

Spatial Pattern of Rapid Climatic Oscillations and Vegetation Response During the Last Deglaciation in Northeastern North America

Zicheng Yu (1-610-758-6751; ziy2@lehigh.edu)

Lehigh University, Department of Earth and Environmental Sciences, 31 Williams Drive, Bethlehem, PA 18015, United States

Large and abrupt climatic oscillations occurred during the last deglaciation evident from ice, lacustrine and marine records in different regions. Stable isotopes retrieved from these records could provide a common proxy in correlating the records and detecting temporal and spatial patterns. The emerging pattern is critical in understanding the nature and forcing mechanisms of climate changes. Here I provide new isotopic and pollen results from the Mid-Atlantic region of USA to expand the existing late-glacial records from the Great Lakes region to the Atlantic Seaboard. White Lake, a marl lake in NW New Jersey, provides high-resolution sedimentary records since ca. 15,000 cal yr BP (15 ka). The chronology of late-glacial and early Holocene period was controlled by 6 AMS^{14}C dates on terrestrial macrofossils. Oxygen isotopes of marl samples (contain >90% carbonates) from this period vary between -8 and -4 permil (VPDB) and show multiple oscillations at millennial and centennial scales, including the Younger Dryas (YD) with ca. 3 permil shifts in δ^{18}O at 12.6-11.3 ka and three cold events of 1-2 permil shifts during the Bølling-Allerød (B-A) period at 14.3-12.6 ka. Pollen diagram from this site shows strong similarity with previously published pollen records from this region, with the YD event having high boreal taxa (*Alnus, Abies, Betula*) after establishment of a mixed deciduous-coniferous forest containing *Quercus, Fraxinus* and *Ostrya/Carpinus*. A plateau-like B-A period is similar to some (Ammersee, Germany; Cariaco Basin, Caribbean) but not other records (ice cores form Greenland Summit; Crawford Lake, Ontario) around the Atlantic Ocean, suggesting that a strong climate gradient might have existed then. Vegetation shows different sensitivity in responding to the YD at sites along a transect from New Jersey, through western New York, to southern Ontario, which was probably caused by a combination of species migration/availability, location of then ecotones, and amplitudes of climate change. The new results and synthesis indicate that climate gradients have changed dramatically over short time period during the last deglaciation, which must have played a major role in determining the state of climate and climate sensitivity for a given region.

PP41D-03 1050h INVITED

Abrupt Change 8200 Years Ago: The Smoking Gun?

Richard B. Alley (1-814-863-1700; ralley@essc.psu.edu)

Department of Geosciences and EMS Environment Institute, Pennsylvania State University, Deike Building, University Park, PA 16802, United States

The large, rapid, widespread climate change about 8200 years ago followed a large freshening of the North Atlantic Ocean, and produced climate anomalies in the Northern Hemisphere that are consistent with the expected response to North Atlantic cooling and that mimic the larger and longer-lasting effects of the Younger Dryas and older events. The short-lived nature of this Holocene event explains the lack of a signal at high southern latitudes, and the other features support the hypotheses that abrupt climate changes have been forced by North Atlantic freshening, and that Holocene warmth is not a guarantee of stability. Comparison of modeled and observed impacts of North Atlantic freshening suggests that some models are somewhat undersensitive compared to the real world.

PP41D-04 1105h

Speed and Magnitude of Abrupt Climate Change at 8,200 yrs B.P. from the Greenland Ice Core (GISP2)

Takuro Kobashi[1] (858-822-2746; tkobashi@ucsd.edu)

Jeffrey P. Severinghaus[1] ((858) 822-2483; jseveringhaus@ucsd.edu)

Edward J. Brook[2] (brook@vancouver.wsu.edu)

Alexi Grachev[1] (agrachev@ucsd.edu)

[1]Scripps Institution of Oceanography, University of California, San Diego, La Jolla, CA 92093-0208, United States

[2]Department of Geology, Washington State University, 14204 NE Salmon Creek Avenue, Vancouver, WA 98686, United States

At ~8,200 years before present, an abrupt climate change occurred, which is believed to be the largest in the past 10,000 years. The scale of the event was probably global, as seen in reduced atmospheric methane concentration and paleoclimatic evidence around the globe indicating drying and cooling trends. The timing of the climate change also coincides with widespread abandonment of villages in southwestern Asia, which marks the end of the Pre-Pottery Neolithic B (PPNB) interval. Owing to the similarity between the warm early-Holocene and the projected warmer future climate, the 8.2 k event provides us an invaluable test case for a future potential abrupt climate change. We reconstructed the speed and magnitude of temperature change at the event, using argon and nitrogen isotopes in trapped air from the Greenland ice core coupled with the oxygen isotope record of ice. This method makes use of two isotopic fractionations, gravitational and thermal, which occur within the firn layer (snow layer above the air bubble close-off depth). The analyses of argon and nitrogen isotopes can separate the two effects, and allows us to directly retrieve temperature information (Severinghaus et al., Nature, v. 391, 141, 1998). The magnitude of temperature change in central Greenland at 8.2kyr B.P. is preliminarily estimated to be 5 $\pm$ 2 $^{\circ}$C for the decadal average with the experimentally determined thermal diffusion constants (Grachev and Severinghaus, Geochim. et Cosmochim. Acta, v.67, 345, 2003; J. Phys. Chem., v.107, 4636, 2003), implying an oxygen isotope-temperature coefficient, α, of ~0.4 permil/$^{\circ}$C. Using oxygen isotope record of ice and α, we estimate that the abrupt cooling took place within ~5 years with an 'instantaneous' magnitude of ~8°C, and climate was locked in the cold phase for ~60 years. In addition, we plan to measure methane concentration in trapped air, which will constrain the mechanisms of the abrupt climate change.

PP41D-05 1120h

Cold Water Coral Mounds and Early Holocene Climate Change

Peter W Readman[1] (353-1-662-1333; pr@cp.dias.ie)

Brian M O'Reilly[1] (353-1-662-1333; bor@cp.dias.ie)

Patrick M Shannon[2] (353-716-2331; p.shannon@ucd.ie)

[1]Dublin Institute for Advanced Studies, 5 Merrion Square, Dublin 2, Ireland

[2]Department of Geology, University College Dublin, Dublin 4, Ireland

Cold-water coral mounds occur in discrete clustered populations over a broad region from the glaciated Norwegian continental margins to the non-glaciated margins of Iberia and northwest Africa. They are potentially sensitive indicators of change in oceanic circulation, coupled to past climate change. Here we report on an interesting correlation between the Holocene growth of a mound population west of Ireland and early Holocene palaeoclimatic variations in the North Atlantic region, notably the well documented 8.2 kyr cold event. An accurate age structure for the mound population is calculated using recent growth rate estimates for the main coral framework constructor *L. pertusa* and a previously formulated population growth model. The calculated curve for the Holocene period fits the observed population data well, except for a pronounced and significant deflection in the data trend beginning at about 8500 calendar years (cal. yr) ago in the early Holocene. This date corresponds to the time (8470 cal. yr) that the glacial lakes Agassiz and Ojibway, which were once dammed by a remnant of the Laurentide ice sheet, drained catastrophically into the Labrador sea releasing $>10^{14}$ m^3 of fresh water. The 8.2 kyr event had as much a global effect on the large-scale structure of deep-water aphotic ecosystems as it did on continental shelf and terrestrial ecosystems.

PP41D-06 1135h

Holocene North Atlantic Deepwater Carbon Isotope Variability

Delia W. Oppo[1] (doppo@whoi.edu)

Jerry F. McManus[1] (jmcmanus@whoi.edu)

James L. Cullen[2] (james.cullen@salemstate.edu)

[1]Woods Hole Oceanographic Inst., 360 Woods Hole Rd MS 23, Woods Hole, MA 02543, United States

[2]Salem State College, Dept. of Geological Sci., Salem, MA 01970, United States

Using data generated on Ocean Drilling Project site 980 (2200 m water depth) from the northeastern subpolar North Atlantic, we recently demonstrated that deepwater carbon isotope values in this region varied on millennial time scales in the Holocene (Oppo et al., 2003). We attributed low d13C values at 9300, 8000, 5000, and 2800 years ago to episodic reductions in North Atlantic Deep Water production. A preliminary benthic d13C record from a relatively shallow core (1300 m) on the eastern flank of the Reykjanes Ridge displays similar variability. Because this core is located in the path of Iceland Scotland Overflow Water, these new data raise the possibility that changes in source water d13C, rather than North Atlantic Deep Water production, drove the d13C variations. We will use published and unpublished data to assess these alternative mechanisms of deepwater d13C variability.

PP41D-07 1150h

Holocene Climate Variability

Kirk A. Maasch[1] (207-581-2197; kirk.maasch@maine.edu); Paul A. Mayewski[1] (207-581-3019; paul.mayewski@maine.edu); Wibj Karlén[2]; Eelco J. Rohling[3]; J. Curt Stager[4]; Eric J. Steig[5]

[1]Climate Change Institute and Department of Earth Sciences, 5790 BGSC University of Maine, Orono, ME 04469-5790, United States

[2]Department of Physical Geography and Quaternary Geology, Stockholm University, Stockholm 106 91, Sweden

[3]School of Ocean and Earth Science, Oceanography Centre Southampton University, Southampton SO14 3ZH, United Kingdom

[4]Natural Resources Division,, Paul Smith's College, Paul Smiths, NY 12970, United States

[5]Quaternary Research Center and Department of Earth and Space Sciences, University of Washington, Seattle, WA 98195, United States

During the Holocene (the last 11,500 calendar years) Earth's climate has been highly variable, not stable. Although the dramatic climate disruptions of the last glacial period have received considerable attention, relatively little has been directed toward the climate variability of the Holocene. Examination of nearly fifty, globally distributed paleoclimate records reveals that as many as six periods of rapid climate change (RCC) ca. 9-8, 6-5, 4.2-3.8, 3.5-2.5, 1.2-1.0, and beginning at 0.6 ka BP have occurred. All but the ca. 9-8 ka RCC and the most recent RCC are characterized in general by bipolar cooling, intensification of atmospheric circulation in the high latitudes, and increased aridity at low latitudes. The RCC since 0.6 ka features bipolar cooling and both humidity and aridity in the low latitudes. This interval appears to be more complex than the classic cool poles, dry tropics pattern that typified the Pleistocene and most of the Holocene RCCs. Several RCCs coincide with major disruptions of civilizations, underscoring the significance of Holocene climate variability. Of all potential climate forcing mechanisms considered, solar variability superimposed on long term changes in insolation seems to be most important for all of the RCCs except perhaps the ones ca. 9-8 ka and 4.2-3.8 ka.

PP41D-08 1205h

The Greening of the McGill Paleoclimate Model. Part II: Simulation of Holocene Millennial-Scale Natural Climate Variability

Lawrence A Mysak[1] (1-514-398-3768; lawrence.mysak@mcgill.ca)

Yi Wang[1] (1-514-398-37687448; yiwang@zephyr.meteo.mcgill.ca)

Zhaomin Wang[1] (1-514-398-7448; wangz@zephyr.meteo.mcgill.ca)

Victor Brovkin[2] (49-331-288-2592; victor@pik-potsdam.de)

[1]Dept. of Atmos. & Oceanic Sci., McGill University and Centre for Climate and Global Change Research, 805 Sherbrooke St. West, Montreal, QC H3A 2K6, Canada

[2]Potsdam Institute for Climate Impact Research (PIK) Climate System Research Department, P. O. Box 601203, Potsdam 14412, Germany

Multiple proxy data reveal that the middle Holocene (6 kyr BP) was warmer than the early Holocene (8 kyr BP) as well as the preindustrial period (1700 AD) in most regions of the Northern Hemisphere. This warmth is somewhat counterintuitive because the summer insolation was decreasing during this time. Cooling in the late Holocene (after 6 kyr BP) is hypothesized to be due mainly to the astronomical forcing. This cooling was also accompanied by significant changes in vegetation cover (i.e., treeline retreat from northern high latitudes; the desertification of the Sahara/Sahel region) and a small but gradual increase of atmospheric CO2 concentration (from 260 ppm to 280 ppm). The early-to-middle Holocene warming, on the other hand, is hypothesized to be due in part to ice-albedo feedback in Northern America, associated with decreases in the Laurentide ice sheet, which completely disappeared by 6 kyr BP. The snow-vegetation-albedo feedback is also hypothesized to have played a role in this early warming event. To test the above hypotheses, the earlier geophysical McGill Paleoclimate Model has been coupled to the vegetation model known as VECODE (VEgetation COntinuous DEscription, one of the simpler dynamic global vegetation models), and a number of sensitivity experiments have been performed. The model results illustrate the role that Northern Hemisphere land cover changes played in explaining the natural millennial-scale climate variability from the early Holocene (8 kyr BP) to the preindustrial period (1700 AD).

PP42A MCC: Level 2 Thursday 1330h

Rapid Climate Change During the Holocene and Last Glacial III Posters

(joint with A, OS, C, GC)

Presiding: **C Morrill,** National Center for Atmospheric Research**; J Chiang,** University of California, Berkeley

PP42A-0851 1330h POSTER

Seafloor Surveys Provide Circum-Basin Evidence for Thick Pleistocene Ice in the Arctic Ocean

Margo H Edwards[1] (808-956-5232; margo@soest.hawaii.edu)

Leonid Polyak[2] (614-292-2602; polyak.1@osu.edu)

Jennifer L Engels[3] (808-956-8711; engels@hawaii.edu)

Bernard J Coakley[4] (907-474-5385; Bernard.Coakley@gi.alaska.edu)

[1]Hawaii Institute of Geophysics and Planetology, School of Ocean and Earth Science and Technology, University of Hawaii, 1680 East-West Road, POST 815, Honolulu, HI 96822, United States

[2]Byrd Polar Research Center, Ohio State University, Columbus, OH 43210, United States

[3]Department of Geology and Geophysics, School of Ocean and Earth Science and Technology, University of Hawaii, 1680 East-West Road, POST 815, Honolulu, HI 96822, United States

[4]Department of Geology and Geophysics, University of Alaska Fairbanks, Fairbanks, AK 99775-5780, United States

In 1998 and 1999 a U.S. Navy nuclear-powered submarine was used to collect swath bathymetry and sidescan data for the Arctic Basin as part of the SCICEX program. Data collected over Chukchi Borderland and Lomonosov Ridge revealed glacially-formed erosion and sculpting of the seafloor at water depths of several hundred meters. These results provided key evidence that very thick floating ice sheets (ice shelves) or densely packed armadas of table icebergs had covered portions or perhaps the entirety of the Arctic Ocean at some time intervals during the Pleistocene [Polyak et al., 2001]. At the time of this revelation, opportunistically collected SCICEX swath data for other shallow regions (< 1000 m) in the Arctic Basin had not yet been processed. Here we present a compendium of glacigenic features imaged in the Arctic using the SCICEX swath-mapping system. In addition to the published findings for Lomonosov Ridge and Chukchi Plateau, the data show new evidence for grounded ice on Yermak Plateau, Northwind Ridge and the Alaska Margin in the depth range of 300 to 1000 m. We characterize the orientation, depth, and extent of observed glacigenic features and document their three-dimensional morphology. Where possible, the swath topography is supplemented by high-resolution subbottom profiler data to create a volumetric representation of erosion. These two- and three-dimensional maps of ice contact features have been used to constrain the provenance and relative timing of arctic ice sheets. Multiple fields of glacigenic lineations (flutes) observed on Northwind Ridge and Chukchi Plateau are similar in strike, trending NNW. Polyak et al. [2001] inferred that these features had been formed by ice originating from the Canadian Arctic Archipelago. The discovery of flutes on the Alaska margin oriented parallel to the shelf break supports this prediction. This pattern of the spatial distribution of glacigenic bedforms suggests that ice shelves from the Canadian Arctic Archipelago extended more than 1000 km, covering much, if not all, of the Amerasia Basin. Ice shelves in the Eurasia Basin achieved comparable size based on the erosion documented on Lomonosov Ridge, which indicates ice moving from the Barents/Kara continental margin. Pending investigation of temporal relationships between glacigenic bedforms from various parts of the Arctic and future mapping of other shallow features will provide a comprehensive history of thick-ice events in the Arctic Ocean.

PP42A-0852 1330h POSTER

Assessing the Rapid Temperature Changes of D/O Events 9 to 12 From Air Isotope Measurements on North GRIP Ice Using a New On-line Technique

Huber Christof[1] (huber@climate.unibe.ch)

Leuenberger Markus[1] (leuenberger@climate.unibe.ch)

[1]Climate and Environmental Physics, Physics Institute, University of Bern, Sidlerstrasse 5, Bern 3012, Switzerland

Rapid temperature variations fractionate gas isotopes in the firn column of polar ice sheets due to thermal diffusion and gravitation. Hence, gas isotope measurements allow the determination of past surface temperature variations during rapid climate changes like Dansgaard-Oeschger (D/O) events. We have developed a new on-line extraction and measuring technique for bubble air trapped in ice cores. An ice sample is continuously melted and the air is subsequently separated from the meltwater and analyzed in an isotope ratio mass spectrometer. It allows fast and high resolution measurements of the isotopic ratios of nitrogen (δ^{15}N), oxygen (δ^{18}O, δ^{17}O) and argon (δ^{36}Ar), as well as the corresponding elemental ratios. We will present high resolution measurements of four consecutive D/O events 9 to 12 on North GRIP ice (around 40'000 to 48'000 years BP). With the use of a combined firn densification, temperature, and gas diffusion model, based on oxygen isotope measurements of the ice, $\delta^{18}O_{ice}$-temperature coefficients in the range between 0.3 and 0.4 $^{o}/_{oo}$/K are found. This corresponds to temperature shifts of about 8 to 16°C, which is in line with already determined temperature shifts for rapid climate change events. A first comparison of these isotope measurements with methane and nitrous oxide will be shown, to investigate leads and lags.

PP42A-0853 1330h POSTER

Quantification of Surface Temperature Changes During Rapid Climatic Events 18-20 From air Isotopic Measurements in NorthGRIP ice Core and Precise Phasing With CH4 Variations

amaelle landais[1] (landais@lsce.saclay.cea.fr); jean-marc barnola[2] (barnola@lgge.obs.ujf-grenoble.fr); Celine Goujon[2] (goujon@glaciog.ujf-grenoble.fr); Nicolas Caillon[1] (caillon@lsce.saclay.cea.fr); jean jouzel[1] (jouzel@lsce.saclay.cea.fr); Valerie Masson-Delmotte[1] (masson@lsce.saclay.cea.fr); jerome chappellaz[2] (jerome@lgge.obs.ujf-grenoble.fr); sigfus johnsen[3] (sigfus@mail.gfy.ku.dk); Dorthe Dahl-jensen[3] (ddj@gfy.ku.dk)

[1]IPSL/LSCE, Orme des merisiers, Gif s Yvette 91191, France

[2]LGGE, 54 rue moliere, st martin d'heres 38402, France

[3]Dpt of geophysics, Julianes Maries Vej 30, copenhagen 2100, Denmark

Although water stable isotope profiles from Greenland ice cores have evidenced the succession of glacial climate variability, their quantitative interpretation in terms of temperature changes remains uncertain due to possible changes in the seasonality of the precipitation. Here we use an alternative paleothermometry method based on the gravitational and thermal diffusion of permanent gases in the firn in response to abrupt temperature changes. The variety of measurements conducted on the air trapped in the ice enables to study the relative timing of fluctuations in local temperature (isotopic measurements of 15N/14N, d15N and 40Ar/36Ar, d40Ar), ice volume (18O/16O of atmospheric oxygen, d18Oatm) and wetland CH4 production. We have obtained high resolution profiles of these tracers measured along the Dansgaard-Oeschger events 18, 19 and 20 from the recently drilled NorthGRIP ice core. d15N combined to CH4 data on the whole profile confirm the in phase increase of both temperature and CH4 during DO events. d15N, d40Ar and firn densification associated to heat diffusion modeling enable us to estimate the associated temperature changes (to be compared to the estimate by Lang et al, GRIP event 19). Indeed, nitrogen combined to argon isotopic anomalies enable to extract the sole thermal effect from the total signal. Finally, the air d18Oatm shows a slow increasing trend due to the ice sheet growth. Gathering information on temperature changes and ice sheet evolution from the air isotopic measurements led to a better understanding of the relationship between water isotopes and surface temperature.

PP42A-0854 1330h POSTER

Rapid Eolian Events Within The Last Glacial Loess Series of Europe (EOLE project)

Denis-Didier Rousseau[1,2] (33 467144652; denis@dstu.univ-montp2.fr); Pierre Antoine[3] (Pierre.Antoine@cnrs-bellevue.fr); Christine Hatté[4] (Christine.Hatte@lsce.cnrs-gif.fr); Olivier Moine[1] (omoine@isem.univ-montp2.fr); Andreas Lang[5] (lang@liv.ac.uk); Michel Fontugne[4] (Michel.Fontugne@lsce.cnrs-gif.fr); Ludwig Zoeller[6] (Ludwig.Zoeller@uni-bayreuth.de)

[1]Universite Montpellier II-CNRS, Institut des Sciences de l'Evolution, pl. Bataillon, case 61, Montpellier 34095, France

[2]Lamont-Doherty Earth Observatory, Columbia University, Palisades, NY 10964, United States

[3]CNRS, Laboratoire de Geographie Physique, 1, Place Aristide Briand, Meudon 92195, France

[4]CNRS-CEA, Laboratoire des Sciences du Climat et de l'Environnement UMR 1572 CEA/CNRS Bât 12, Domaine du CNRS, Avenue de la Terrasse, Gif-sur-Yvette -91198, France

[5]University of Liverpool, Department of Geography, Liverpool L69 7ZT, United Kingdom

[6]Universitaet Bayreuth, Lehrstuhl Geomorphologie, Bayreuth 95440, Germany

The EOLE project focuses on the impact of millennial climatic variations (Dansgaard /Oeschger) and abrupt events (Heinrich), on the loess environments of Western and Central Europe between 30 and 15ka BP (50°N transect between 2° and 17°E). The evidence of rapid climatic events in the loess sequences is based on their physical (grain-size, CaCO3, Iron, magnetic susceptibility) and biogeochimical (mollusks, organic carbon, $\delta 13C$) characterizations, within the best-developed sequences (high-resolution 1 sample/5 cm; 10 to 15 m in thickness). The main results have been obtained in the Nussloch reference sequence (Rhine valley, Germany) where cyclic variations appear within the Upper Pleniglacial from high-resolution grain-size and MS analyses. These variations are mainly underlined by the %20-50μm$\wedge$%<20μm ratio (grain-size index GSI) which is interpreted as an indirect proxy of the a dynamics: high values within pure typical loess ("L?ss Events" L1 to L8)/ low values in the various tundra gley layers G1 to G8. Our investigations show that, during the Upper Pleniglacial, the loess deposition is basically characterized by a succession of rapid sedimentation phases (especially during Heinrich events 2 and 3), separated by stops (or strong reduction) in the a flux. According to OSL and 14C dating, a correlation between GSI index and the dust record from GRIP or GISP II ice cores is proposed. In addition, the cyclicity of the loess record seems to represent the expression, in continental environments, of the 1500 years cycles described in North Atlantic sediments. In parallel, the analysis of the13C of loess organic matter and of the malacological assemblages at Nussloch shows a close correspondence with the d18O from GRIP. Finally these results show that the high frequency climatic variability that characterizes the North Atlantic and Greenland records during the LGM had a strong impact on sedimentation and on terrestrial environments of Western and Central Europe.