removed a wedge of rock 4-7 km thick at the coast, declining inland to ~ 1 km. Most denudation occurred in the Eocene under temperate climatic conditions from fluvial planation of the mountains and incision of river valleys near the coast, with sedimentation occurring offshore. A subsequent pulse of denudation, most rapid at 34-31 Ma, and declining until ~17 Ma, coincided with further crustal extension and a change from cool temperate to polar climate. During this interval, local warm-based glaciers first built up on mountain massifs and experienced cyclic periods of expansion and retreat. Glacier temperatures, meltwater, vegetation and chemical weathering progressively decreased and there was a cold polar climate before inundation by a full Antarctic ice sheet. This latter event occurred between 14.8 and 13.6 Ma and the ice sheet was sufficiently thick to override the Transantarctic Mountains and extend to the edge of the continental shelf. Following retreat offshore and thinning of the maximum ice sheet, the last ~ 13.6 Ma have seen little landscape or climatic change under a hyperarid polar climate. Glacier fluctuations in the last ~ 13 Ma owe their variability to internal glacier dynamics or changes in relative sea level.

PP32D-05 1700h

Pliocene Warming, Contribution of Atmosphere, Oceans and Cryosphere

Alan Michael Haywood[1] (+44 1223221420; ahay@bas.ac.uk)

Paul Jonathan Valdes[2] (p.j.valdes@bristol.ac.uk)

[1]British Antarctic Survey, Geological Sciences Division, High Cross, Madingley Road, Cambridge CB30ET, United Kingdom

[2]The University of Bristol, School of Geographical Sciences, University Road, Bristol BS8 1SS, United Kingdom

The relative role of the atmosphere, oceans and cryosphere in contributing towards middle Pliocene warmth (ca. 3 Ma BP) is investigated using the HadCM3 coupled ocean-atmosphere general circulation model (GCM). The model was initialised with boundary conditions from the USGS PRISM2 data set and a Pliocene atmospheric CO_2 level of 400 ppmv and run for 300 simulated years. The simulation resulted in a global surface temperature warming of 3°C compared to present-day. In contrast to earlier modelling experiments for the Pliocene, surface temperatures warmed in most areas including the tropics (1 to 5°C). Compared with present-day, the model predicts a general pattern of ocean warming (1 to 5°C) in both hemispheres to a depth of 2000 m, after which no significant differences are noted. Sea ice coverage is massively reduced (up to 90%). The flow of the Gulf Stream/North Atlantic Drift is up to 100 mms^{-1} greater in the Pliocene case. Analysis of the model-predicted meridional stream function suggests a global pattern of reduced outflow of Antarctic bottom water (AABW; up to 5 Sv), a shallower depth for North Atlantic Deep Water formation and weaker thermohaline circulation (3 Sv). The decrease in AABW occurs mainly in the Pacific rather than Atlantic Ocean. Model diagnostics for heat transports indicate that neither the oceans nor the atmosphere are transporting significantly more heat in the Pliocene scenario. Rather, these results indicate that the major contributing mechanism to global Pliocene warmth was the reduced extent of high latitude terrestrial ice sheets (50% reduction on Greenland, 33% reduction on Antarctica) and sea ice cover resulting in a strong ice-albedo feedback. These results highlight the need for further studies designed to improve our knowledge regarding Pliocene terrestrial ice configurations before further coupled ocean-atmosphere modelling experiments are conducted.

PP32D-06 1715h INVITED

Internal ice sheet layer distortions in interior West Antarctica

Martin J Siegert[1] (+44 117 928 8902; m.j.siegert@bristol.ac.uk)

Antony J Payne[1] (a.j.payne@bristol.ac.uk)

Andreas Vieli[1] (a.vieli@bristol.ac.uk)

Gwendolyn J.-M. C. Leysinger Vieli[1] (g.leysinger-vieli@bristol.ac.uk)

Ed King[2] (ecki@bas.ac.uk)

[1]Bristol Glaciology Centre, School of Geographical Sciences, University of Bristol, Bristol BS8 1SS, United Kingdom

[2]British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom

Upstream of Ice Stream D in West Antarctica, ice penetrating radio-echo sounding (RES) data reveal a major and distinctive englacial structure, where internal layers are located at an ice depth up to 1 km deeper than their surrounding elevations. The linear englacial fold' that is formed by the layer pattern can be traced well across 10 km, and less well for much longer. The long-axis of the structure is located at a 30 degree angle to the current ice flow direction. We examine a number of ways in which this layer pattern may have formed and show that it is more easily explained if the ice flow direction were along the line of the fold's axis than under the current glaciological setting. Using ice flow modelling, we interpret the englacial feature to have been caused by ice-sheet downdraw and/or basal melting at a time when the ice flow direction was different to today. Current ice dynamics may account for subsequent deformation of the internal layer patterns in the last few thousand years.

PP32D-07 1730h INVITED

Calving Bay Reentrants During the Late Pleistocene to Holocene Retreat of the Antarctic Ice Sheet: Sedimentologic and Geomorphologic Evidence

Eugene Domack[1] (315 859-4711; edomack@hamilton.edu); Amy Leventer[2] (aleventer@mail.colgate.edu); Robert Dunbar[3] (dunbar@stanford.edu); Stefanie Brachfeld[4] (brachfelds@montclair.edu); Patricia Manley[5] (manley@middlebury.edu); Charles McClennen[2] (McClennen@colgate.edu)

[1]Hamilton College, 198 College Hill Road, Clinton, NY 13323, United States

[2]Colgate University, 13 Oak Drive, Hamilton, NY 13346, United States

[3]Stanford University, Department of Earth and Environmental Sciences, Stanford, CA 94305, United States

[4]Montclair State University, Department of Geology, Upper Montclair, NJ 07043, United States

[5]Middlebury College, Department of Geology, Middlebury, VT 07654, United States

Swath bathymetric surveys of major paleoice stream troughs from both the West and East Antarctic continental shelf are coupled with Jumbo Piston and ODP (Sites 1098 & 1099) sediment cores to develop a temporal and spatial model for deglaciation. Deglaciation is demonstrated to have post dated MWP-1a by at least 1000 years for several ice stream systems including those off the Antarctic Peninsula. The nature of sediment lithofacies at the transition from grounded ice to glacial marine conditions demonstrates a process of sediment focusing where by marine varves are deposited in front of calving ice fronts for several hundred years following deglaciation. The marine varves are characterized by alternating couplets of diatom ooze and siliciclastic silty, sandy clays. Sediment core sites that demonstrate this ubiquitous lithofacies are located within inner shelf basins (troughs) that mark the landward juncture of major ice drainage off the continent and initiation of ice streaming out across the continental shelves. Seven such systems are detailed within this study including the Palmer Deep, Mertz Trough, Mertz-Ninnis Trough, Svenner Channel, Nielsen Basin, and Iceberg Alley. Swath bathymetry indicates that ice receded via backstepping of grounding lines within the main axis of the ice stream troughs (i.e. Mertz Trough). This configuration of grounding lines must have led to calving bay reentrants that extended several tens to hundreds of kilometers into the interior of surrounding ice sheets. The focusing of sedimentation within the inner portions of these reentrants is explained by the concentration of iceberg rafting and the restriction of estuarine circulation and associated productivity within the calving bays. The existence of such embayed drainage for several hundred years implies that significant drawdown of ice sheet elevations could have been accommodated by the streaming and calving of glacial ice at the heads of these embayments. The timing of the recessional events is constrained by over 200 radiocarbon dates that fix recession to around 11 ka BP, a thousand years after MWP-1a but roughly coincident with the well known Younger Dryas event.

PP32D-08 1745h

Recent History of the NW Corner of the Ross Ice Shelf, Antarctica, from Sediment Cores

Peter Barrett[1] (peter.barrett@vuw.ac.nz); Gavin Dunbar[1] (gavin.dunbar@anu.edu.au); Lionel Carter[2] (l.carter@niwa.cri.nz); Giovanna Giorgetti[3] (giorgetti@unisi.it); Frank Niessen[4] (fniessen@awi-bremerhaven.de); Uwe Nixdorf[4] (unixdorf@awi-bremerhaven.de); Alex Pyne[1] (alex.pyne@vuw.ac.nz); Christina Riesselman[5] (criessel@pangea.stanford.edu); Natalie Robinson[1] (natalie.robinson@vuw.ac.nz)

[1]Antarctic Research Centre, Victoria University of Wellington, P O Box 600, Wellington 6002, New Zealand

[2]National Institute of Atmosphere and Water, Private Bag 14-981, Kilbirnie, Wellington 6010, New Zealand

[3]Dipartimento di Scienze della Terra, Via Laterina 8, Siena 53100, Italy

[4]Alfred-Wegener-Institut für Polar- und Meeresforschung , Columbusstrasse, Bremerhaven D 27568, Germany

[5]Department of Geological and Environmental Sciences, Stanford University, Stanford 94305-2115, United States

Cores of sea floor sediments beneath the Ross Ice Shelf behind Ross Island contain a record of sub-ice shelf sedimentation over the last 20,000 years. The sediments have been accumulating in a 900-m-deep depression resulting from the loading of Erebus volcano, and are being deposited from relatively slow (5-10 cm/sec) currents whose average flow direction is eastward (from McMurdo Sound toward the central Ross Sea). Cores from the two sites were both 60 cm long, but significantly different in character. The core from site 1 was taken about 5 km east of the shelf edge where the ice is 70 m thick. It is an unconsolidated pebbly sandy mud from 62 to 34 cm below the sea floor, where it changes over a cm to a soft fine sandy mud that dominates the rest of the core. Samples yielded uncorrected AMS bulk organic carbon ages of 24,550 years at 34 cm, 18,080 years at 21 cm and 4343 years at 1 cm, indicating an average sedimentation rate of 0.03 mm/year. The changes in sedimentary facies are taken to record a shift of the grounding line landward followed by establishment of the present open circulation that continued to the present day. The low shear strength throughout the core shows that the ice shelf was not grounded, even at the height of the Last Glacial Maximum. The core from site 2, which lies 12 km east of the shelf edge beneath 140 m of ice, is entirely a soft terrigenous sandy mud with a higher diatom content than the upper part of site 1, but similar in other respects. It yielded ages from 12,797 years at 59 cm, 6562 years at 29 cm and 2701 years at 2 cm, indicating a higher sedimentation rate (0.06 mm/year), and records relatively constant conditions throughout that time. The facies and chronology suggest that the Ross Ice Shelf front has not retreated significantly from its present position during the Holocene. The cores also indicate the potential value for recovering a history for the Ross Ice Shelf back to Pliocene times through the proposed coring of Windless Bight by the ANDRILL consortium to 1000 m below the sea floor.

URL: http://andrill-server.unl.edu/

PP41A MCC: 3004 Thursday 0800h

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

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

PP41A-01 0800h

A high-resolution 25 ka sea-surface temperature record from the NW Atlantic Ocean: foraminiferal Mg/Ca compared to δ^{18}O and sediment parameters.

Harunur Rashid[1] (617-258-5572; hrashid@mit.edu)

Ed A Boyle[1] (617-253-3388; eaboyle@mit.edu)

Lloyd D Keigwin[2] (508-289-2681; lkeigwin@whoi.edu)

[1]Earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology, 77 Massachusetts Ave., Cambridge, MA 02139, United States

[2]Woods Hole Oceanographic Institution, 93 Water Street, Woods Hole, MA 02543, United States

We have measured the Mg/Ca ratio in planktonic foraminifera *Neogloboquadrina pachyderma*(sinistral), *Globigerina bulloides* and *Globigerina ruber* (white variety) in two North Atlantic cores. A modified version of the Boyle and Keigwin (1985/6) cleaning technique was employed (removing cemented clays, metal oxides and organic matter). Mg/Ca ratios within the Heinrich layers in the Labrador Sea (Hu90013-29; 58.2361°N, 56.4576°W; 2918m) vary from 0.30 to 1.25 mmol/mol measured mainly in the *N. pachyderma* (s.). In core CHN82-20PC (43.3°N, 29.5°W; 3020 m) in the open North Atlantic Mg/Ca ranges from 0.67 to 1.20

mmol/mol (in *G. bulloides* and white *G. ruber*). *G. bulloides* and *G. ruber* Mg/Ca were offset even when allowing for potential species calibration differences, in a sense that is consistent with the δ^{18}O offset between these species. For calibration of Mg/Ca to temperature, we applied the Nürnberg (1995) calibration for *N. pachyderma* (s.), the Mashihotta *et al.* (2000) calibration method for *G. bulloides*, and the Lea *et al.* (2000) method for *G. ruber*. These results suggest fluctuations in sea-surface temperature (SST) between -2 and 10°C during the deposition of Heinrich layers in the Labrador Sea. A 6°C cooling in SST was observed between the initiation and cessation of Heinrich layer 1 at CHN82-20 core site. However, SST rose as much as 8°C during the Bolling-Allerod and fell 4°C during the Younger Dryas.

PP41A-02 0815h

Were the Laurentide Surges (Heinrich events) Necessarily Preceeded by Precursor Events?

Elsa Jullien[1] (33540008731; f.grousset@epoc.u-bordeaux1.fr)

Francis E Grousset[1] (33540008731; f.grousset@epoc.u-bordeaux1.fr)

Isabelle Billy[1] (33540008362; i.billy@epoc.u-bordeaux1.fr)

[1]EPOC, CNRS (UMR 5805), Universite Bordeaux I, Avenue des Facultes, Talence 33405, France

It has been shown that precursor events occur right before most of the Heinrich events recognized in the Atlantic Ocean within the so-called Ruddiman IRD belt: they are enriched in both haematite-coated grains and tephras (Bond and Lotti, 1995), revealing Icelandic and Arctic origins. Isotopic (Sr-Nd) and mineralogical fingerprints of these precursors display typical European signatures, in cores from both the European margin (Grousset et al., 2000 ; Scourse et al., 2000) and the Mid-Atlantic Ridge (Grousset et al., 2001). Were the North Atlantic Heinrich events triggered by the behavior of the European ice sheets is still an open question that has to be documented. Such signatures, however, record Fennoscandian and Icelandic iceberg discharges occurring prior the major Laurentide surges. Recent observations, however, have challenged this interpretation. Farmer et al. (2003) have shown that sediment samples from the Saint Lawrence Gulf display the same Sr-Nd isotopic signature as the typical European ones. Thus, early arrivals of icebergs derived from the southern rim of the Laurentide could characterize some precursors. I order to clarify this problem, we have studied precursor events (in H2 and H4) in a series of seamount cores located in the IRD belt, from 40° to 10°W. A multi-proxy approach (Sr-Nd isotopes ; Fe-Mn-Ti-Ca CORTEX data ; IRD counts, etc) reveal that : 1) precursor events occur only prior H1 and H2. We did not observe any precursor prior H4 and H5 : this peculiarity had been already reported by Vance and Archer (2002) ; 2) typical European precursors occurred on the Eastern side of the North Atlantic, whereas in the western basin, precursors were made of Laurentide-derived IRD. Thus, precursors could be derived simultaneously from all the pan-Atlantic ice-sheets, revealing a global period of iceberg release affecting all ice-sheets. Their study could allow to assess if they respond to D-O cycles (Broecker, 2003), but better model ages have to be produced first. Bond and Lotti (1995), Science 267, 1005-1010. Broecker W.S. (2003), Science 294, 2308-2309. Farmer et al. (2003), Earth & Planet. Sci. Lett. 209, 227-243. Grousset et al. (2000), Geology 28, 123-126 Grousset et al. (2001), Paleoceanography 16, 240-259. Scourse et al. (2000), Earth & Planet. Sci. Lett. 182, 187-195. Vance and Archer (2002), Goldschmidt Conf. Abst., A798.

PP41A-03 0830h

Expression of Heinrich Events in the Southern Ocean

Julian P Sachs[1] (617-253-0474; jsachs@mit.edu)

Robert F Anderson[2] (boba@ldeo.columbia.edu)

Katharina Pahnke[3] (pahnkek@cf.ac.uk)

Rainer Zahn[4] (rainer@geo.ub.es)

[1]Department of earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology 77 Massachusetts Avenue, Room E34-254, Cambridge, MA 02139, United States

[2]Lamont-Doherty earth Observatory of Columbia University, Geochemistry Building P.O. Box 1000, Palisades, NY 10964, United States

[3]School of Earth, Ocean and Planetary Sciences, Cardiff University Park Place, Cardiff CF10 3YE, United Kingdom

[4]Department d'Estratigafia, Paleontologia i Geosciencies Marines, Universitat de Barcelona Campus de Pedralbes, Barcelona 08028, Spain

Eight massive iceberg discharges to the North Atlantic, Heinrich Events (HEs), occurred between 65,000-10,000 years ago during the last glacial period. Each resulted in extreme freshening and cooling of the North Atlantic and substantial reorganization of the North Atlantic's meridional overturning circulation. Synchronous changes in the chemistry or biology of sediment cores from the Southwest equatorial Atlantic, the Southeast subtropical Atlantic and the Arabian Sea, and in a speleothem from southeastern China argue for a widespread impact of Heinrich Events on climate. Yet most evidence for climate change associated with HEs is from the Northern Hemisphere, clustered in the North Atlantic region. Here we show for the first time that HEs had a profound impact on the Subantarctic Southern Ocean, causing sea surface temperatures (SSTs) to rise and algal productivity to soar in the waters east of New Zealand. Algal productivity increased concurrently in Subantarctic waters southwest of Africa, southeast Atlantic Ocean. Sea surface temperatures in Chatham Rise core MD97-2120 (45°32' S, 174°56' E, 1210 m) were reconstructed from both alkenone unsaturation ratios and from Mg/Ca ratios in shells of the planktonic foraminifer *G. bulloides*. Algal productivity was inferred from the concentration of alkenones in the same core and in core TN057-21-PC2 from the Cape Basin. Elevated thorium-230 normalized fluxes of alkenones and authigenic uranium concentrations in the Cape Basin core are consistent with increased algal productivity during HEs. Our results support the notion of a bipolar seesaw' in temperature during major alterations of the North Atlantic's meridional overturning circulation. At the same time, the large increases in Subantarctic algal productivity that accompanied those events imply that the meridional overturning circulation of the Southern Ocean changed significantly. We propose several mechanisms by which flooding of the North Atlantic with meltwater during HEs could result in increased SSTs and productivity in the Subantarctic Ocean.

PP41A-04 0845h INVITED

CHARACTERIZATION OF CLIMATE VARIABILITY AND INTERHEMISPHERIC CLIMATE LINKAGES ON MILLENNIAL TIME SCALES

Gerard H Roe[1] (206-543-4980; gerard@ess.washington.edu)

Eric J Steig[1] (206-543-6327; steig@ess.washington.edu)

[1]Earth and Space Sciences University of Washington, box 351360 univ of washington, seattle, wa 98195, United States

The well-dated isotope time series from ice cores in central Greenland (GISP2 and GRIP) and West Antarctica (Byrd) provide a basis for evaluating the behavior of the climate system on millennial timescales. They have been invoked as evidence that millennial-scale climate variability at high latitudes is driven by global-scale climate mechanisms such as an interhemispheric "seesaw", a resonant response to an underlying millennial-scale forcing, and teleconnections with the tropics. We characterize the fundamental behaviour of these two time series and evaluate the degree to which these records support the various theories. We find that a first-order autoregressive (AR(1)) stochastic climate model with a physical timescale of t=600 +/- 300 years is a self-consistent explanation for the Antarctic record during the glacial period. While the character of the rapid warming events in Greenland precludes any autoregressive process from being a complete explanation of the data, AR(1) with t=400 +/- 200 years is a better characterization than stochastic resonance as it has been formulated in the literature. Adding a simple threshold rule to AR(1) can account for the asymmetries (though not the 1500-year spectral peak, which remains enigmatic). Our analyses support recent results showing that 10 to 25% of the variance in the Byrd record at sub-Milankovitch timescales may be explainable by the time-integral of the GISP2 record. However, most of this shared variance occurs during longer episodes often associated with Heinrich events, rather than the shorter Dangaard-Oeschger events. Even for the larger North Atlantic events, regional (non-global) variability dominates in both records. One would therefore not expect that individual warming or cooling events can be directly correlated between these records. One would also not necessarily expect strong correlation with tropical climate records, even if the tropics were the driver of climate variability on these timescales. Finally, we find that the characteristic timescales for these records are significantly shorter during the Holocene, suggesting that the processes determining the pacing of millennial-scale variability is fundamentally different during glacial vs. interglacial regimes.

PP41A-05 0900h

Glacial-Interglacial Contrast in Climate Variability at Centennial-to-Millennial Timescales: Observations and Conceptual Model

Michael Schulz[1] (mschulz@palmod.uni-bremen.de)

André Paul[1] (apau@palmod.uni-bremen.de)

[1]Dept. of Geosciences and DFG Research Center Ocean Margins, University of Bremen, PO Box 330440, Bremen 28334, Germany

A set of published paleoclimatic proxy records from the northern hemisphere is used to assess glacial-interglacial differences in climate variability at centennial-to-millennial time scales during the past fifty thousand years. The employed proxy data represent a range of climate subsystems (taken as the smallest units capable of coherent climate variations). Glacial climate variability is dominated by the Dansgaard-Oeschger cycles and appears highly coherent between the involved climate subsystems, implying frequency locking to a *fundamental* 1470-year pacing signal. In contrast, there is no compelling evidence for a dominant and persistent centennial-to-millennial climate cycle during the Holocene. Interglacial climate variations seem to be less coherent than those of the last glacial period, suggesting that the climate subsystems were able to vary at their natural periods. A conceptual model is introduced to interpret this contrast in coherency at glacial-interglacial timescales. In the model, climate subsystems are represented by relaxation oscillators with different frequencies in the centennial-to-millennial band. Allowing for interaction between the free running oscillators can lead to a synchronization of the oscillators and the development of a frequency of the synchronized oscillators that differs from any frequency of the free oscillations. We suggest that the coupled/synchronized system resembles the glacial mode of climate variability whereas the decoupled state is reminiscent of an interglacial with its non-coherent climate variations over a wide frequency range.

PP41A-06 0915h INVITED

Understanding Abrupt Climate Change During the Last Glacial Period: Recent Developments and Outstanding Issues

David S. Battisti (206 543 2019; david@atmos.washington.edu)

Dept. of Atmospheric Sciences University of Washington, Box 351640, Seattle, WA 98195-1640, United States

I will summarize the two leading classes of hypotheses for the cause of the abrupt, near global scale climate changes observed during the last glacial period, known as the Dansgaard-Oeschger events. The first class of hypotheses invokes instabilities in the ocean thermohaline circulation (OTC) as a causal mechanism for these abrupt climate changes, and for the millennial time scale between jumps. The second class of hypotheses invokes multiple states in the coupled atmosphere/ocean system in the tropics, and features global teleconnections that affect changes (albeit passive) in the OTC. Climate models have been used to illustrate, and then probe, these two families of hypotheses. The output from these models, when confronted with the observations, suggests that the present hypotheses are far from being a complete explanation of the observed phenomenon. In this talk I will summarize the recent modeling developments that have shed light on some of these problems (e.g., how to communicate changes in the North Atlantic to the whole Northern Hemisphere), and the issues that are still outstanding (e.g., what are the major factors that determine the equatorward extent of sea ice in the N. Atlantic?)

PP

PP41A-07 0930h

Enhanced Global Marine Denitrification Records the Initiation of the Last Deglaciation

Mark A Altabet[1] ((508)9998622; maltabet@umassd.edu)

Matthew J Higginson[1] ((508)9106394; mhigginson@umassd.edu)

[1]School for Marine Science and Technology, University of Massachusetts Dartmouth, 706 South Rodney French Boulevard, New Bedford, MA 02744, United States

Denitrification is the predominant global loss term for combined nitrogen and can exert a major control on its oceanic inventory, as well as global productivity and atmospheric CO_2. It typically occurs in organic-rich continental margin sediments and in intermediate waters within intense oxygen-minimum zones when bacteria utilize NO_3^- as an electron acceptor and

in doing so convert it primarily to N_2 gas. Denitrification strongly fractionates nitrogen isotopes, leaving the remaining NO_3^- enriched in $\delta^{15}N$. A paleoceanographic record for denitrification intensity is created when $\delta^{15}N$-enriched NO_3^- is transported to surface waters, consumed by phytoplankton, transported downward with organic matter and preserved in the sediments. When there is good to excellent preservation of organic matter at the sea floor due to either suboxic bottom water and/or high sediment accumulation rates, sediment $\delta^{15}N$ faithfully records the $\delta^{15}N$ of sinking organic matter. Marine water-column denitrification is principally concentrated in three areas: the Arabian Sea, the Eastern Tropical North Pacific and Eastern Tropical South Pacific. The advent of well-dated, high-resolution records of sedimentary $\delta^{15}N$ generated by us from each of these regions now facilitates comparison of the relative timing of their large changes in denitrification since the last glacial maximum (~25 Ka). By assigning a hypothetical equal contribution to global marine denitrification from well-constrained records from each region, we have calculated a marine denitrification composite (MDC) record which strongly resembles the Taylor Dome ice core Antarctic CO_2 record. Such early and coincidental changes in $\delta^{15}N$ and CO_2 prompt us to hypothesize that changes in the inventory of marine nitrate caused by increased denitrification subsequently altered global marine carbon sequestration, especially in the vast oligotrophic regions of the oceans, at a time of concurrent reductions in atmospheric dust inventory. Since the process of denitrification is accelerated by low oxygen conditions, it is sensitive to both remote ventilation rates at the source of intermediate water and in situ respiration rates during the sinking of organic matter. We note that the timing of increased denitrification during deglaciation is earliest in the ETSP, followed by a peak in the ETNP, with maximum $\delta^{15}N$ recorded in the Arabian Sea approximately 2.9 Kyr later. The ventilation of intermediate water originates in the Southern Ocean and is advected simultaneously to the denitrification regions. Therefore, regional processes such as export production must primarily determine denitrification rates, modulated by preconditioning of intermediate water masses. We conclude that although the initial trigger for deglaciation may lie with SST and ice-cover changes in the Southern Ocean, its progress to interglacial conditions was determined by regional effects such as rates of upwelling driven by low-latitude Walker/Hadley Circulation and the monsoon at each location.

URL: http://www.smast.umassd.edu/cmastweb/biohigginson.html

PP41A-08 0945h

Abrupt Climate Change During the Last Glacial Cycle Based on Gulf of Mexico Sediments

Benjamin P Flower[1] (7275533986; bflower@marine.usf.edu)

David W Hastings[2] (7278647884; hastings@eckerd.edu)

Heather Hill[1] (7275531016; hhill@marine.usf.edu)

Terrence M Quinn[1] (7275531658; tquinn@marine.usf.edu)

[1]University of South Florida, 140 7th Avenue South, St. Petersburg, FL 33701, United States

[2]Eckerd College, 4200 54th Avenue South, St. Petersburg, FL 33711, United States

Evidence is emerging that the tropical climate system played a major role in past global climate change during the last glacial cycle. However, existing studies indicate asynchronous temperature variability in the western equatorial Atlantic, complicating the identification of causal mechanisms. Because the Gulf of Mexico (GOM) is linked to the equatorial Atlantic, sea-surface temperature (SST) records from the GOM help assess the phasing between low- and high-latitude Atlantic climate. High sedimentation rates of >40 cm/k.y. and laminated sediments in Orca Basin allow sub-centennial-scale resolution. Paired $\delta^{18}O$ and Mg/Ca data on the planktic foraminifer *Globigerinoides ruber* from core EN32-PC6 are used to separate deglacial changes in SST and $\delta^{18}O$seawater due to low-salinity meltwater from the Laurentide Ice Sheet (LIS). Mg-SST increases by $>3.0^oC$ between 17.2 and 15.2 ka (calendar years) encompassing Heinrich Event 1 in the North Atlantic. Comparison to polar ice core records indicates GOM SST was not in phase with Greenland air temperature, consistent with thermohaline circulation modulation of Atlantic climate. This warming represents the bulk of the 4.2+/-0.9°C increase from the last glacial maximum (24.0+/-0.8°C) to early Holocene (29.0+/-0.4°C). Subtracting temperature and ice-volume effects from *Gs. ruber* $\delta^{18}O$ reveals two episodes of LIS meltwater input, one of $>1.5^o/_{oo}$ from ca. 16.2-15.7 ka and a second major spike of $>2^o/_{oo}$ from ca. 15.2-13.0 ka that encompassed meltwater pulse 1A (mwp-1A) and peaked at ca. 13.4 ka. These results suggest that (1) subtropical Atlantic SST warming preceded peak LIS decay and mwp-1A by >2 k.y., (2) thermohaline circulation may have modulated Atlantic climate on the millennial scale during the last deglaciation, and (3) major LIS meltwater input to the GOM ended before North Atlantic Deep Water suppression during the Younger Dryas. A new 31.79 m Calypso piston core collected in July 2002 on the R/V Marion Dufresne (MD02-2551) documents GOM climate variability associated with Dansgaard-Oeschger (D-O) cycles known from Greenland ice records. *Gs. ruber* $\delta^{18}O$ data from the 40-30 ka interval (30 year resolution) reveal cycles of $>1^o/_{oo}$ amplitude that closely match D-O cycles 8-5, although the relative phasing is complex. Paired $\delta^{18}O$ and Mg/Ca data indicate that these oscillations reflect significant changes in $\delta^{18}O$seawater that result from changes in evaporation/precipitation balance and LIS meltwater input. Overall, significant sub-centennial- to millennial climate variability persists throughout the last glacial cycle in the GOM.

PP41B MCC: Level 2 Thursday 0830h

Mesozoic Black Shales: Fresh Looks at an Old Problem I Posters *(joint with OS)*

Presiding: **K G MacLeod,** University of Missouri**; P A Meyers,** University of Michigan

PP41B-0835 0830h POSTER

The Mid-Barremian Event (MBE): the Prelude to the OAE1a

Rodolfo Coccioni[1] (0039-0722-304237; cron@info-net.it)

Simone Galeotti[1] (0039-0722-304273; s.galeotti@uniurb.it)

Mario Sprovieri[2] (0039-081-5423818; sprovier@gms01.geomare.na.cnr.it)

[1]University of Urbino, Istituto di Geologia e Centro di Geobiologia Campus Scientifico, LocalitàCrocicchia, Urbino, PU 61029, Italy

[2]IAMC, Sezione Geomare Sud-CNR, Calata Porto di Massa, NAPOLI, NA 80100, Italy

Detailed litho-, bio- and chemostratigraphic investigations of the Hauterivian-lowermost Aptian Maiolica pelagic limestones in the Umbria-Marche sequence, allowed to identify that the Selli Level, which is the regional sedimentary expression of the OAE 1a, represents the climax of a ca. 5 myr-long cycle of black shale deposition starting at the lower/upper Barremian boundary within polarity Chronozone M3 and H. similis-H. kutznetsovae planktonic foraminiferal Zone, that is in the lowermost part of the calcareous nannofossil Zone NC 5D. This long-term cycle starts with a prominent short-term event, here named mid-Barremian Event (MBE), which is associated with several changes in the biotic and abiotic records. In particular, a comparison of the available chemo- litho- , and biostratigraphic data from the Umbria-Marche Basin, allows to recognise that the MBE is defined by: 1) a 0.5 per mil positive shift in the carbon isotope values (Hadji, 1993; unpublished data); 2) a major step in the initial evolutive radiation of planktonic foraminifera (unpublished data); 3) a major turnover in the radiolarian assemblages (Jud, 1994; O'Dogherty, 1994). The above mentioned change in carbon isotope values can be confidently correlated over the Mediterranean Tethys which is the sole area where a detailed isotopic record is available for the entire Barremian (Erba et al., 1999; Wissler et al., 2002). These lines of evidence concur to define the MBE as an outstanding event associated with large scale changes in the ocean-climate system likely related to the rapid oceanic Ontong-Java Plateau formation, which eventually led to OAE1a. Remarkably, the MBE largely predates the well known series of biotic and geochemical events occurring prior to the OAE1a and may be considered as the real turning point in the Barremian-Aptian long-term cycle of black-shale deposition and evolutionary turnovers in several fossil groups. References Erba, E., Channell, J.E.T., Claps, M., Jones, C., Larson, R., Opdyke, B., Premoli Silva, I., Riva, A., Salvini, G., and Torricelli, S., 1999, Integrated stratigraphy of the Cismon Apticore (Southern Alps, Italy): a "reference section" for the Barremian-Aptian interval at low latitudes. Journal of Foraminiferal Research, v. 29, pp. 371-391. Hadji, S., 1993, Stratigraphie isotopique des carbonates pélagiques (Jurassique supérieur-Crétacé inférieur) du bassin d'Ombrie-Marches (Italie). PhD Thesis, Univ. Pierre et Marie Curie, Paris, 118 pp. O'Dogherty, L., 1994, Biochronology and Paleontology of Mid-Cretaceous Radiolarians from Northern Apennines (Italy) and Betic Cordillera (Spain): Mémoires de Géologie (Lausanne), v. 21, 413 pp. Rud, J., 1994, Biochronology and Systematics of Early Cretaceous Radiolaria of the Western Tethys: Mémoires de Géologie (Lausanne), v. 21, 147 pp. Wissler, L., Weissert, H., Masse, J.P., and Bulot, L., 2002, Chemostratigraphic correlation of Barremian and lower Aptian ammonite zones and magnetic reversal: Int. J. Earth Sci. (Geol. Rundsch.), v. 91, pp. 272-279.

PP41B-0836 0830h POSTER

Timing and Paleoceanography of Early Cretaceous Oceanic Anoxic Events in the Pacific Ocean as Determined From Wireline Logs

Stuart A Robinson[1] (1-845-365-8695; stuartr@ldeo.columbia.edu)

Trevor Williams[1] (1-845-365-8626; trevor@ldeo.columbia.edu)

Paul R Bown[2] (44-207-679-2431; p.bown@ucl.ac.uk)

[1]Lamont-Doherty Earth Observatory of Columbia University, 61 Route 9W, Palisades, NY 10964, United States

[2]Dept of Earth Sciences, University College London, Gower Street, London WC1E 6BT, United Kingdom

DSDP and ODP core recovery of Early Cretaceous pelagic sediments in the Pacific Ocean has been limited by the widespread occurrence of chert. Remarkably, Leg 198 of the Ocean Drilling Program (Shatsky Rise, north west Pacific) was very successful in recovering shales rich in organic-carbon, dated as being equivalent to the Early Aptian "Selli Level", thus confirming the truly global nature of Oceanic Anoxic Event 1a. However, recovery of contiguous deposits of late Aptian and Albian age was generally poor. Two of three sites at which OAE1a was recovered (1207 and 1213) were logged using standard downhole geophysical tools, which provide us with an alternative method for investigating the sedimentary and paleoceanographic history of these sites. Using the downhole logs we present an interpretation of the Aptian-Albian sedimentary history of Shatsky Rise and discuss the paleoceanographic implications of changing abundances of clay, carbonate and biosiliceous sediments. Plotting the geophysical logging data against time yields interesting information about the onset, duration and termination of organic-carbon burial. Comparison with logging and biostratigraphic data from other sites in the Pacific and Tethys allows us to assess whether OAE1a was truly synchronous and to evaluate differences in paleoceanography in different ocean basins during OAE1a.

PP41B-0837 0830h POSTER

Correlation, Fauna And Sedimentary Environments Of The Mid-Cretaceous Oceanic Anoxic Event Horizons In North-west Pacific Margin.

Reishi Takashima[1] (+81-92-726-4764; takashima_rei4@hotmail.com); Hiroshi Nishi[1] (+81-726-4643; hnishi@rc.kyushu-u.ac.jp); Fumihisa Kawabe[2] (+81-90-4667-1004; fkawabe@aoni.waseda.jp); Kazuyoshi Moriya[1] (+81-92-726-4818; moriya@scs.kyushu-u.ac.jp); Ryoji Wani[3] (-81-90-2567-7028; wani@kahaku.go.jp); Hisatake Okada[4] (+81-11-706-3537; oka@ep.sci.hokudai.ac.jp)

[1]Kyushu University, 4-2-1 Ropponmatsu, Chuo-ku, Fukuoka 810-8560, Japan

[2]Institute of Natural History, 3-14-24 Takada, Toshima-ku, Tokyo 171-0033, Japan

[3]National Science Museum, 3-23-1, Hyakunincho, Shinjuku-ku, Tokyo 169-0073, Japan

[4]Hokkaido University, N10W8, Kita-ku, Sapporo 060-0810, Japan

The Cretaceous Yezo Group exposed in northern Japan consists mainly of mudstone and turbiditic sandstone deposited in the continental slope to shelf off the eastern margin of Asian continent. The 10000-m-thick sequence provides a synthesis concerning paleontological, sedimentological and paleoenvironmental histories during early Aptian to Maastrihitian in the mid-latitude North-west Pacific margin. Based on an integration of bio- and chemo-stratigraphic results of the Yezo Group using macrofoaails (ammonoids and inoceramids), microfossils (planktic foraminifers and calcareous nannofossils) and carbon isotope of wood fragments, we can recognize five chemo-stratigraphic events corresponding to the Oceanic Anoxic Events (OAE 1a, 1c, 1d, MCE, 2) that are accompanied with prominent negative or positive $\delta^{13}C_{wood}$ excursion. No black shales or marine-organic rich sediments were consequently detected at these horizons in the Yezo Group because voluminous siliciclastic influx from the Asian Continent diluted organic matter content in the sediments. The characteristics of faunal turnover and