PP22B-09 1550h INVITED

Atmospheric Forcing of Increased Thermohaline Overturning in the North Atlantic During the Late Holocene

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New evidence from a series of fresh, high quality cores in the subpolar North Atlantic suggests that the production of North Atlantic Deep Water (NADW) has not been stable during the last few thousand years of the Holocene. Both benthic carbon isotopic and cadmium calcium ratios document a steady increase in NADW production at the same time that sea surface temperatures fell and ice rafting increased. The change in the deep water nutrient proxies is accompanied by higher benthic oxygen isotope ratios, indicating a shift to denser (colder?) deep water at the same time. We interpret this seemingly paradoxical increase in rate of NADW production with deteriorating climate as a consequence of high northern latitude atmospheric cooling during the Neoglacial episode of the mid to late Holocene. We suggest that the cooling led to an increase in convection in the Greenland - Norwegian Seas and subsequent increase in the cold and dense overflows that feed NADW. We regard our findings as strong evidence that change in NADW production during the late Holocene was forced by the atmosphere rather than by mechanisms operating within the ocean. The change in North Atlantic deep circulation has no consistent relation to the millennial-scale cyclicity that has been recognized previously within the Holocene; if the North Atlantic's deep circulation was altered during those events, it is masked in our records by the more prominent longer term change tied to the atmospheric forcing.

PP22C MC: 303 Tuesday 1615h

Cesare Emiliani Lecture *(joint with OS, GC)*

Presiding: **P B deMenocal,** Lamont-Doherty Earth Observatory of Columbia University**; L C Peterson,** University of Miami**; L D Keigwin,** Woods Hole Oceanographic Institution

PP22C-01 1615h INVITED

Reconstructions of the CO_3 Ion Distribution in the Glacial Deep Ocean

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Emilianis 1955 Journal of Geology paper on the ^{18}O record preserved in foraminifera launched the field of paleoceanography. Subsequent studies of ^{13}C, cadmium, barium, zinc, and magnesium in these calcitic shells have greatly amplified the value of this archive. In 1995 Lohmann proposed yet another innovation by showing that the weight loss by these shells reflected the carbonate ion concentration in bottom water.

Application of Lohmanns foraminifera weight method to cores from a range in water depth suggests that unlike todays ocean, where the carbonate ion concentration is in most places quite uniform with depth, the glacial ocean appears to have been strongly stratified. If so, then our attempts to reconstruct deep ventilation and circulation on the glacial ocean, we must think in terms of several deep water sources differing significantly in density.

Our measurements also reveal strong dissolution events in the equatorial Atlantic associated with the onset of cold periods and that the deep waters of the equatorial Pacific are currently undergoing a major decline in carbonate ion concentration.

PP31A MC: Hall D Wednesday 0830h

Synthesizing Millennial Variability I *(joint with IP, A, H, OS, GC)*

Presiding: **J McManus,** Woods Hole Oceanographic Institution**; M Sarnthein,** University of Kiel

PP31A-0486 0830h POSTER

Decoding Marine Water Properties and Vertical Water Mass Structure at Millennial Time Scale. A Geochemical Approach of Multi-Foraminifer Species from the Western Mediterranean Sea

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Paleoceanographic-paleoclimatic records of the Western Mediterranean Sea (IMAGES-MD 95-2043) have previously documented the strong sensitivity of the area to the millennial scale variability of the last glacial period. These studies have also provided a good stratigraphic tool (based on a high resolution alkenone-SST profile) to link records to the Dansgaard-Oescheger variability from Greenland ice cores.

Two geochemical methods (Mg/Ca ratios and $\delta^{18}O$) have been employed for this approach. Measurements were carried out on one benthic species (*Cibicidoides pachydermus*) and several planktonic. species (almost continuos records of *Globigerina bulloides, Globorotalia inflata* and *Neogloboquadrina pachyderma* (d) and more fragmentary records of *Orbulina universa, Globigerinoides ruber alba* and *Globorotalia truncatulinoides*. In order to minimize sampling noise, large planktonic foraminiferal samples (~50 specimens) were picked (250-300om), crushed and cleaned together for the two geochemical measurements. Mg/Ca ratios of planktonic species were converted to temperature values and used to correct the temperature effect on $\delta^{18}O$, after ice-volume correction, and thus estimate sea water $\delta^{18}O$ values. Calibration uncertainties for the benthic Mg/Ca ratios prevented us from coverting them to temperatures and thus were used to provide qualitative information of deep water conditions.

Planktonic Mg/Ca ratios allow the identification of three different foraminifera groups; the warm group (*O. universa, G. ruber* and *G. bulloides*) the intermediate group (*G. truncatulinoides* and *G. inflata*) and the cold group (*N. pachyderma* d). The warm group (best represented by *G. bulloides*) shows the largest oscillations (4-6°C) which occurred in parallel to those monitored by the alkenone record. The intermediate group shows a surprising flat pattern without temperature changes related to the last deglaciation or D-O variability. The cold group shows a short variability (2-3°C) with warmer values during the coldest intervals (HE1 and HE4): in the opposite direction to that expected. These different features are interpreted in terms of changes in the water column structure and underly the importance of the regional oceanography in controlling the foraminifer habitat. Both warm (surface) and cold (sub-surface) foraminifers document a two phase salinity anomaly associated to HE: an earlier intense salinity increase was followed by a rapid freshening. Benthic records suggest the presence of a cold and relatively salty water mass for the full HE. During the deglaciation salinity changes were not so well coupled between the different water layers.

PP31A-0487 0830h POSTER

14C Marine Reservoir Age 14.2 to 12.8 kyr cal BP

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We constructed several floating pine tree-ring chronologies from sites in Eastern and Southern Germany, Switzerland and Northern Italy, dated by 14C to the Late Glacial [Friedrich et al., 2001]. While still floating they cannot be used to determine the magnitude of the marine 14C reservoir age, but as the tree-ring time scale is annual, decadal 14C analyses of these chronologies allow to check if the 14C reservoir age of the tropical warm pool was constant in time, by comparing high-precision (+- 25 yr) tree-ring based 14C series to the high-resolution marine 14C data set obtained from the Cariaco basin [Hughen et al., 2000]. For the time interval between 14.2 and 13.2 k cal BP the marine reservoir age appears to have been essentially constant, with variations of 100 yr or less.

Furthermore, a hemisphere-wide cooling event (G1d in the GRIP ice core, grey-scale minimum in the Cariaco varves) is seen, within the 14C time window defined by the Cariaco data set and our tree-ring 14C analyses, to occur as a drastic growth reduction in the European tree-ring sections. Using this event as an anchor, we can determine the magnitude of the marine reservoir age over the common time interval. Between 14.2 and 13.9 k our tree-ring based 14C data confirm the value of ca. 420 yr marine reservoir age.

However, during the final two centuries prior to the YD the marine reservoir age of the tropical warm pool increases to ca. 600 yr. Based on carbon cycle models we discuss the implications of our findings in terms of solar and oceanic forcing of the radiocarbon budgets.

Friedrich, M., B. Kromer, K.F. Kaiser, M. Spurk, K.A. Hughen, and S.J. Johnsen, High resolution climate signals in the Boelling/Alleroed Interstadial as reflected in European tree-ring chronologies compared to marine varves and ice-core records., Quaternary Science Reviews, Vol. 20 (11), 1223-1232, 2001.

Hughen, K.A., J.R. Southon, S.J. Lehman, and J.T. Overpeck, Synchronous Radiocarbon and Climate Shifts During the Last Deglaciation, Science, 290, 1951-1954, 2000.

PP31A-0488 0830h POSTER

Abrupt millennial climatic terrestrial changes from western European eolian records during the last glaciation?

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High expectation has been focussed on the massive iceberg discharges in the North Atlantic, Heinrich events, during the last glaciation, and their worldwide terrestrial counterparts. However these events are particular episodes among more regular cyclic events named Dansgaard-Oeschger events in ice-cores or Bond cycles in marine cores. Here we examine grain-size, d13C, and susceptibility data from Nussloch, one of the most complete West European eolian sequence. These indices indicate that, at least during the 19-31 kyr interval which is highly documented in this terrestrial series, millennial variations of the environment (moisture and vegetation) associated to oscillations in the wind dynamics match the low-high dust content in the atmosphere over Greenland. Height soil-loess successions repeat during this interval as well. Our study thus shows that the abrupt climatic changes expressed by the cyclic Dansgaard-Oeschger events are at least either recorded in the west European loess sequences. This implies a global atmospheric dynamics linking, not only temperature, but also the dust deposition over Greenland and Europe.