U12B MCC: 3001-3003 Monday 1600h

The Contributions of 20 Years of Scientific Ocean Drilling III

Presiding: **N Pisias,** Oregon State University**; M L Delaney,** Institute of Marine Sciences, University of California, Santa Cruz

U12B-01 1600h

Tracking the Equator Into the Paleogene

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Stratigraphy has been compiled for 63 tropical Pacific drill sites that sample lower Neogene and Paleogene sediments. These Sites derive from drilling on DSDP Leg 5 through ODP Leg 199. All Sites have been put on the biostratigraphic and paleomagnetic timescale refined by Leg 199 scientists. Sediment accumulation rates have been calculated for ten intervals ranging in age from 10 Ma to 56 Ma. A simple fixed hotspot model was used for Pacific lithospheric plate rotation in reconstructing the position of the selected sites for each of these ten intervals. The reconstruction of all intervals show the development of a tongue of relatively high accumulation rates associated with the oceanographic divergence at the geographic equator. The estimated position of the geographic equator based on these reconstructions lies consistently south of the position of the equator based on the rotation model used. However, the southward displacement is generally 2 degrees of latitude or less. We believe that this relatively small disagreement between the two estimates of equatorial position back to 56 Ma indicates: 1) Whatever hotspot movement that may have occurred in the interval between 40 and 56 Ma did not affect the motion of the Pacific plate; its motion after 40 Ma appears to have been approximately the same as before 40 Ma. 2) The estimated rate of true polar wander during the interval of 40 - 56 Ma must be very small (0.125°/m.y.) and is probably not significant (i.e., well within the error of these reconstructions).

U12B-02 1620h

The Faithful Record of Synchrony and Amplitude of Neogene Sea Level Variability in Carbonate Depositional Environments From ODP Legs 133, 166, And 194

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Recognizing the importance of sea level change in shaping near shore and open ocean environments, the Ocean Drilling Program (ODP) devoted numerous legs to the study of eustatic sea level and to how these changes are recorded in sediments from various depositional settings. Three ODP legs (133, 166, 194) utilized a series of holes to examine the sedimentary records from carbonate platform-to-basin transects to gain a better understanding of Neogene sea level variations. Because carbonate platforms are constructed by organisms that are sensitive to changes in environmental conditions such as water depth (sea level), the dominant energy regime (wind or currents), nutrient content, and water temperature, the study of sediments shed from carbonate platforms provides fundamental information regarding past environmental change. Unconformities and varying depositional regimes between sea level high- and lowstands allow sea level changes to be imaged on seismic data by series of unconformity-bounded seismic sequences. A synthesis of sequence stratigraphic results from Legs 133, 166, and 194 clearly demonstrates chronostratigraphic significance of prominent unconformity surfaces that produce seismic sequence boundaries on the margins in both the Atlantic and Pacific Oceans. The timing of many of these unconformities is remarkably similar in both oceans, indicating a strong eustatic control on their development. The timing of these sequences also correlates well with major shifts in stable oxygen isotopes, which are primarily controlled by changes in ice volume and thus are an excellent proxy for eustatic sea level variability. Between the three locations studied, 15 (Leg 133), 17 (Leg 166), and 13 (Leg 194) Neogene sequences are identified. Their sequence boundaries dated by correlating them seismically to the conformable successions in drilling locations distal to the carbonate platform complexes, where more quiescent conditions and reduced diagenesis help maintain a continuous depositional history through time. 10 of the sequence boundaries display, within the seismic and biostratigraphic resolution, the same ages in all transects, documenting the synchrony of unconformities that are caused by relative sea level changes. In addition, stratigraphic relationships and biostratigraphic information from Leg 194 provide evidence that the magnitude of the late middle Miocene eustatic fall was 86 ± 30 m. This data provides an important calibration point for the global sea level curve and is similar to those derived from other proxies, such as oxygen isotopes, yet is greater than the magnitudes estimated from sediment sequences of siliciclastic margins (e.g. ODP Leg 150).

U12B-03 1640h

Ocean Drilling Program Records of the Last Five Million Years: A View of the Ocean and Climate System During a Warm Period and a Major Climate Transition

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The warm Pliocene (4.7 to 3.0 Ma), the most recent period in Earth's history when global equilibrium climate was warmer than today, provides the opportunity to understand what role the components of the climate system that have a long timescale of response (cryosphere and ocean) play in determining globally warm conditions, and in forcing the major global climate cooling after 3.0 Ma. Because sediments of this age are well preserved in many locations in the world's oceans, we can potentially study this warm period in detail. One major accomplishment of the Ocean Drilling Program is the recovery of long continuous sediment sequences from all ocean basins that span the last 5.0 Ma. Dozens of paleoceanographers have generated climate records from these sediments. I will present a synthesis of these data to provide a global picture of the Pliocene warm period, the transition to the cold Pleistocene period, and changes in climate sensitivity related to this transition. In the Pliocene warm period, tropical sea surface temperature (SST) and global climate patterns suggest average conditions that resemble modern El Niños, and deep ocean reconstructions indicate enhanced thermohaline overturning and reduced density and nutrient stratification. The data indicate that the warm conditions were not related to tectonic changes in ocean basin shape compared to today, rather they reflect the long term adjustment of the climate system to stronger than modern radiative forcing. The warm Pliocene to cold Pleistocene transition provides an opportunity to study the feedbacks of various components of the climate system. The marked onset of significant Northern hemisphere glaciation (NHG) at 2.75 Ma occurred in concert with a reduction in deep ocean ventilation, but cooling in subtropical and tropical regions was more gradual until Walker circulation was established in a major step at 2.0 Ma. Thus, regional high latitude ice albedo feedbacks, rather than low latitude processes, must have been primarily responsible for NHG at 2.75 Ma. And, regional air-sea feedbacks in the tropics, rather than ice sheet expansion, must have been primarily responsible for the marked increase in Walker circulation at 2.0 Ma. Finally, the detailed timing of events from different regions suggests that a tectonic threshold' cannot explain the warm to cold climate transition. Studies of the last 5.0 Ma can also be used to understand how climate responds to changes in the Earth's radiative budget because seasonal and latitudinal variations in solar forcing are extremely well known, and many of the records that have been generated have the resolution and age control appropriate for the study of the climate response to these variations (Milankovitch cycles). In particular, how feedbacks operate when the mean climate state is warm versus cold can be studied. There is clear evidence that the amplitude of the climate response to solar forcing depends on the background mean state. In other words, the sensitivity of the climate to small perturbations in solar forcing has changed with time, and the balance of evidence indicates that tropical conditions, not high latitude conditions (such as ice sheet size) control this sensitivity. In sum, the Ocean Drilling Program has provided scientists with a window into the Pliocene warm period, and an opportunity to understand the workings of the ocean-climate system

U12B-04 1700h

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A Tropical Climate Puzzle: Plio-Pleistocene Obliquity-Dominated Temperature and Productivity Records From the Eastern Equatorial Pacific

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A recent hypothesis suggests that the cooling of Earth's climate during the Cenozoic lead to a change in the ocean's thermal structure and a gradual shoaling of the thermocline. At about the same time as continental ice sheets began forming in the Northern Hemisphere ($\sim$3 Ma) these oceanographic changes shifted the ocean's heat budget out of equilibrium with the local insolation field changing both regional and global climate. In this state of local disequilibrium, low- and high- latitude climate are linked because heat gained in low-latitude upwelling zones must be balanced by heat lost at high-latitudes. Thus, variations in the distribution of insolation at high latitudes associated with changes in obliquity, are felt in the tropics as well as at high latitudes. To test this theory, we characterize changes in sea surface conditions in one of the Earth's major upwelling zones from 4 Ma to the present. We document sea surface temperature (SST) and coccolithophorid productivity variations at Ocean Drilling Program Site 846 (3° S, 91° W) in the Eastern Equatorial Pacific (EEP) using the alkenone organic proxy. We find that SSTs in the EEP ranged from $\sim$20 to 27°C and that productivity varied significantly, with greater values occurring during glacial periods. Our results indicate that a long-term cooling trend of $\sim 1^\circ$C/Myr occurred from the early Pliocene to the present. Our temperature record shows the characteristic late Pleistocene high-amplitude 100-kyr dominated "sawtooth" pattern observed in most climatic records. However, the typically lower amplitude interval of the Pliocene and early Pleistocene is interrupted by high-amplitude excursions (2-4°C coolings) occurring with $\sim$400 kyr periodicity. These excursions are accompanied by large increases in productivity and in some cases correspond to orbital eccentricity minima. Spectral analysis indicates the persistent presence of strong spectral power in the obliquity (41-kyr) band and negligible spectra power in the precessional (23-kyr) band. We find a late-Pleistocene transfer of power from 120 and 80 -kyr frequency bands (sub-harmonics of the 41-kyr signal) to the 100-kyr band. The continuous strength of obliquity, typically a 'polar' signal, and the absence of precession, typically a 'tropical' signal, in climate records from the EEP supports the implication of a mechanism linking tropical and high latitude climates during the Plio-Pleistocene. The presence of obliquity variations in these climate records prior to 3 Ma implies that this phenomenon may have preceded the onset of glaciation in the Northern Hemisphere. Finally, the response of tropical SST and productivity to eccentricity forcing suggests the presence of significant non-linear feedbacks in the Plio-Pleistocene climate system.

U12B-05 1720h

Phosphorus: Sedimentary Geochemistry, Mass Balance, and Ocean History From ODP Sediments

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Phosphorus is a key nutrient fueling oceanic primary productivity, exerting critical control on geological time scales on productivity and potential organic carbon burial. Primary productivity plays a critical role in the delivery of phosphorus to sediments via organic matter export from the surface ocean and delivery to sediments. The fluxes of phosphorus to and from the ocean through time are driven by factors such as

changes in continental weathering and in oceanic biogeochemical processes and their effects on sedimentation. Material recovered by the Ocean Drilling Program has been essential to deciphering the sedimentary geochemistry of phosphorus and its ocean history through time. We demonstrate that the burial of phosphorus in marine sediments on depths scales of tens to hundreds of meters is controlled by geochemical transformations in the sediment resulting from microbially mediated organic matter oxidation. These transformations are often reflected in interstitial water geochemistry as well, and they have significant influence on carbon/phosphorus burial ratios. These result in a widely disseminated authigenic phase, presumably carbonate fluorapatite. This phase is present at low concentrations in all of the marine sediments we have examined, and is therefore a major sink for oceanic phosphorus burial. Determining the geochemistry and concentration of phosphorus burial provided us the basis for records of phosphorus accumulation in sediments, which we coupled with multi-proxy investigations of tracers related to export productivity (barium excess), biogenic sediment accumulation (opal and calcium carbonate), and sedimentary redox state (sediment trace metals, interstitial water geochemistry). I use several examples to illustrate P burial responses on different timescales in intervals of carbon cycle and/or climate change. These will also be used to demonstrate the fruitful lessons we have learned about geochemical methods, age models and physical properties, and the challenges and value of multi-proxy approaches to ocean history.

U12B-06 1740h

Analogue or Anomaly? Ocean Drilling Evidence From Marine Isotope Stage 11

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Ocean Drilling makes it possible to recover high quality sedimentary archives from important earlier geologic intervals, such as Marine Isotope Stage 11 (MIS 11), approximately 400 ky BP. Similar orbital configurations and comparable atmospheric greenhouse gas concentrations have led to the suggestion that MIS 11 is a suitable, possibly the best, geological analogue for the natural development of Holocene and future climate. Yet the anomalously strong climate response during MIS 11 in the absence of strong seasonal insolation changes has long been described as the "the stage 11 problem". Here we review evidence from a number of widely distributed ODP locations indicating that MIS 11 was not likely to have been a "super interglacial" interval characterized by both significantly higher sea-level and global temperatures. We discuss the stability and strength of the meridional overturning circulation as a potential compensator for the limited insolation. We present detailed faunal, ice-rafting, and isotopic records from North Atlantic ODP Sites 980 (55°N, 15°W, 2.2km), 983 (60°N, 24°W, 2.0km), and 984 (61°N, 25°W, 1.6 km) confirm the relative stability of MIS 11 on millennial timescales, and document that the transition to the more characteristic instability of the Pleistocene occurred dramatically and abruptly following the warm interval. In addition, we consider a variety of tuning techniques and apply a new independent dating approach to deep-sea sediment sequences to show that the regional stable warmth of MIS 11 in the North Atlantic long outlasted the elapsed portion of the Holocene. Next, we address the question of possibly higher sea levels during MIS 11 with isotopic evidence from ODP Site 925 (4°N, 43°W, 3.0km) in the Tropical Atlantic, ODP Site 1242 (8°N, 84°W, 1.4km) in the eastern tropical Pacific, and ODP Site 806 (0°N, 159°W, 2.5km) in the western tropical Pacific. Finally, we discuss possible ways to reconcile the apparently conflicting evidence in existing records of sea-level, temperature, and variability during MIS 11.

U13A MCC: 3001-3003 Monday 1815h

Frontiers of Geophysics

Presiding: **R E Dickinson,** Georgia Institute of Technology

U13A-01 1820h INVITED

Voyager 1 in the Vicinity of the Solar Wind Termination Shock

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The termination shock marks the abrupt slowing of the solar wind from supersonic to subsonic speeds as it approaches the edge of the heliosphere. The shock likely accelerates anomalous cosmic rays and reaccelerates galactic cosmic rays and other solar and interplanetary ions. In mid 2002 when Voyager 1 was at 85 AU, it observed an unusual enhancement of MeV ions and electrons that was not present at Voyager 2 at 68 AU. Although some aspects of the energetic particle data suggest that Voyager 1 entered the subsonic flow of the heliosheath at that time, the anomalous cosmic ray intensity remained lower than expected at the shock and the interplanetary magnetic field did not show the compression expected as the wind slows. These and other aspects such as strong field aligned beaming suggest an unexpected complexity in the vicinity of a termination shock that is more dynamic than anticipated. Our understanding of this new region of the heliosphere should continue to increase as Voyager 1 surfs along the shock over the next several years.

U21A MCC: 2002-2004 Tuesday 0800h

Virtual Observatories in Space and Earth Sciences I

Presiding: **L Paxton,** Applied Physics Laboratory, Johns Hopkins University; **M B Weiss,** Applied Physics Laboratory, Johns Hopkins University

U21A-01 0800h INVITED

Moving Beyond IGY: An Electronic Geophysical Year (eGY) Concept

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During the International Geophysical Year (1957-1958), member countries established many new geophysical observatories pursuing the major IGY objectives - to collect geophysical data as widely as possible and to provide free access to these data for all scientists around the globe. Today, geophysics has attained a rather good understanding within traditional regions, i.e., the atmosphere, ionosphere, magnetosphere, and other such geospheres. At the same time, it has become clear that much of the new and important science is coming from the studies of interfaces and coupling between geospheres. Thus, if geophysical data are made 'transparently" available to a much wider range of scientists and students than to those who do the observations, then new and exciting discoveries can be expected. An International Association of Geomagnetic and Aeronomy (IAGA) task force, recognizing that a key achievement of the IGY was the establishment of a worldwide system of data centers and physical observatories, proposes that for the 50th anniversary of IGY, the worldwide scientific community should endorse and promote an *electronic Geophysical Year (eGY)* initiative. The proposed *eGY* concept would both commemorate the IGY in 2007-2008 and provide a forward impetus to geophysics in 21st century, similar to that provided by the IGY fifty years ago. The IAGA task force strongly advocates: (1) Securing permission and release of existing data; (2) Creating access to information; and (3) Conversion of relevant analog data to digital form. The *eGY* concept embraces all available and upcoming geophysical data (e.g., atmospheric, ionospheric, geomagnetic, gravity, etc.) through the establishment of a series of *virtual geophysical observatories* now being 'deployed" in cyberspace. The *eGY* concept is modern, global, and timely; it is attractive, pragmatic, and affordable. The *eGY* is based on the existing and continually developing computing/networking technologies (e.g., XML, Semantic Web, etc.) and international cyber infrastructure. Moreover, the International Union of Geodesy and Geophysics (IUGG) has supported the *eGY* concept, which can smoothly be incorporated into various existing 'International Year" initiatives - such as the International Polar Year, International Heliophysical Year, or International Year of the Planet Earth.

U21A-02 0820h

Virtual Observatories, Virtual Archives: Only as Good as Their Metadata?

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Over the last 27 years, the National Snow and Ice Data Center has participated in a number of programs that have striven to provide ready access to high-quality observations and long-term geophysical records. In the last 10 years these programs have increasingly involved data archived at multiple, geographically distributed sites. The key lessons we have learned from these experiences are that providing access to data is not sufficient for users to find and successfully use it, and that ensuring long-term preservation of data is especially difficult in a distributed environment. Developing and maintaining appropriate metadata (i.e., information about the data) is key to facilitating data discovery and use and is also important to data preservation, as is maintaining linkage between the data and its metadata. Yet there are many programmatic, scientific and technical challenges to developing and maintaining these metadata and linkages. Examples from a variety of NSIDC programs illustrate these challenges and some of the tools and techniques employed to overcome them.

U21A-03 0835h

CoSEC: Orchestrated Web Services for Living with a Star

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The Collaborative Sun-Earth Connector (CoSEC) is a testbed for developing and deploying data and modeling services for the space science community. We will demonstrate the concept using the current prototype, www.lmsal.com/cosec, and offer templates and tools for expanding the prototype with existing space science data and models using the SolarSoft framework. In addition we will discuss how CoSEC to relates to other projects, including other space science Virtual Observatories and the European Grid of Solar Observations. This research has been supported through NASA grant NAG5-10784.

URL: http://www.lmsal.com/cosec