The SEDIMENTARY Record

Volume 2, No. 2
June 2004

A publication of SEPM Society for Sedimentary Geology

INSIDE: BIPOLAR CLIMATE CONNECTIONS

PLUS: HAND LENS: "CARBON ISOTOPE STRATIGRAPHY"
PRESIDENT'S OBSERVATIONS — APPLIED PALEONTOLOGY
INFORMATION ON RESEARCH CONFERENCES

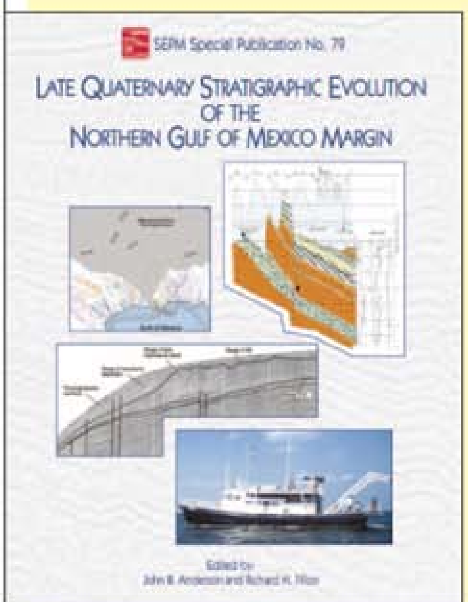
1926 SEPM
Society for Sedimentary Geology

Mail Delivery Survey

IN OUR CONTINUING EFFORT to better serve our members, we are conducting a mail-delivery survey. Please take a minute to visit our website and let us know when you received this issue of the Sedimentary Record. **www.sepm.org/mailsurvey.htm**

Change in Paleontology Councilor

DUE TO PERSONAL TIME CONFLICTS Dawn Sumner has resigned as Paleontology Councilor. The Council has appointed Stephen Leslie, University of Arkansas-Little Rock to fulfill her remaining term. Please note that Steve is also a co-editor of The Sedimentary Record and encourages your submission of articles and column ideas.



Catalog Number: 40079
314 pages
ISBN: 1-56576-088-3
List Price: $135.00
SEPM Member Price: $97.00
Student-Member Price: $67.00

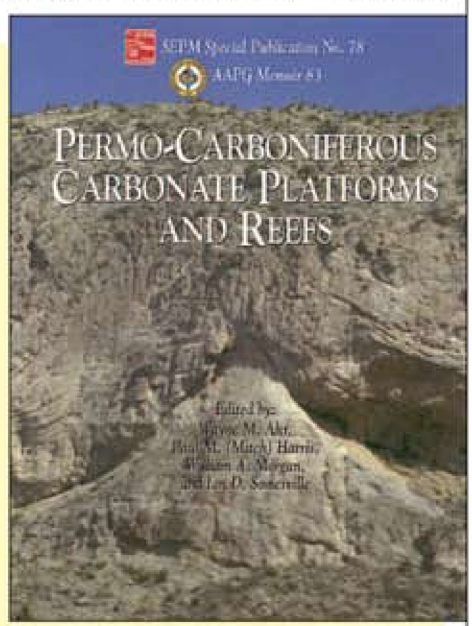
SEPM Special Publication #79:

Late Quaternary Stratigraphic Evolution of the Northern Gulf of Mexico Margin

Edited by: John B. Anderson and Richard H. Fillon

The northern Gulf of Mexico margin encompasses a variety of depositional settings characterized by different drainage basin size, physiography, fluvial morphology, climatic setting, and structural and diapiric activity. This, plus the abundance of long sediment cores and platform borings from oil industry activities, make it an unparalleled natural laboratory for sedimentological and stratigraphic studies and for testing sequence stratigraphic concepts. This volume contains twelve papers describing results from high-resolution stratigraphic studies of late Quaternary strata of the northern Gulf of Mexico, from the mouth of the Apalachicola River to the Rio Grande. These papers focus on fluvial response to climate and base-level change, variations in delta growth and evolution across the shelf, lowstand delta-fan evolution, the evolution of transgressive deposits on the shelf, the preservation of these deposits. The robust chronostratigraphic frameworks developed for the different study areas allows comparison of stratal geometries produced by contemporaneous depositional systems operating under identical eustatic conditions.

This volume will appeal to sedimentologists and stratigraphers interested in source to sink issues, such as how various forcing mechanisms influence strata formation on continental margins. It is a valuable reference for sequence stratigraphers because it provides numerous examples of sedimentary response to changing climate and eustasy and characterization of systems tracts and their bounding surfaces. Lastly, the case studies presented in this volume can be used to test and calibrate quantitative stratigraphic models and for predicting reservoir occurrence within a sequence stratigraphic framework.



SEPM Special Publication #78:

Permo-Carboniferous Carbonate Platforms and Reefs

Edited By: Wayne M. Ahr, Paul M. (Mitch) Harris, William A. Morgan, and Ian D. Somervill

Catalog Number: 40078
430 pages
ISBN: 1-56576-087-5
List Price: $159.00
SEPM Member Price: $115.00
Student-Member Price: $79.00

1926 SEPM
Society for Sedimentary Geology

www.sepm.org

Cover art: *Iceberg off the SE Greenland coast (photo by St. John, 1995).*

CONTENTS

The Sedimentary Record (ISSN 1543-8740) is published quarterly by the Society for Sedimentary Geology with offices at 6128 East 38th Street, Suite 308, Tulsa, OK 74135-5814, USA.

The Sedimentary Record is provided as part of membership dues to the Society for Sedimentary Geology.

Request for Society Award* Nominations for:

- Twenhofel Medal
- Pettijohn Medal
- Shepard Medal
- Wilson Award
- Moore Medal
- Honorary Membership

It is important that the Society continue to recognize those that have contributed to the science of sedimentary geology. Recently, the number of nominations has declined and it is critical that our members take the responsibility to reward their peers.

Anyone can either send the basic nomination information listed below to: *Judy Tarpley, SEPM; 6128 East 38th Street, Suite 308; Tulsa, OK 74135; Fax: 918-621-1685; jtarpley@sepm.org*
or fill out the form online at:
www.sepm.org/events/awards/awardsnominationform.htm

Nomination Information Required

Award: *name of award or medal (see website for criteria)*
Nominee: *name of person being nominated*
Affiliation: *institution, company or address of nominee*
Education: *basic degree information*
Date of Birth: *(for Wilson Award only)*
Summary of Major Scientific Contributions: *a one page summary of why this person should be given this award*
Additional Supporting People: *name and contact information of three or more individuals who will provide supporting letters*
Professional Activities: *a one page summary of the important activities from the nominees background contributing to sedimentary geology activities, within and outside of SEPM*
Other Honors and Awards: *other significant recognition*
Bibliographies: *list of the most significant publications (a complete bibliography is not required but may be sent as a separate attachment)*
Nominated by: *your name and contact information*

*Criteria available at:
www.sepm.org/events/awards/awardcriteria.htm

Editors

SEPM Staff

Evidence That's an Ocean Apart:

Co-Varying Records of Ice-Rafted Debris Flux and Plio-Pleistocene Bipolar Ice Sheet Disintegration

Kristen E. K. St. John*
Department of Geology
Appalachian State University
Boone, NC 28608
stjohnke@appstate.edu

address after December 2004: Department of Geology and Environmental Science, MSC 7703, James Madison University, Harrisonburg, VA 22807

ABSTRACT

The ice-rated debris (IRD) records from Ocean Drilling Program (ODP) sites 918 (St. John and Krissek, 2002) and 1101 (Cowan, 2001) provide evidence for bipolar climate connections during the Plio-Pleistocene. These IRD records were derived from distant but similarly situated glaciomarine settings, the SE Greenland and the Antarctic Peninsula continental rises. Similar methods of sediment analysis were used in developing the temporal records of ice-rafted debris accumulation; at both sites IRD mass accumulation rates were used to represent the histories of IRD supply through time. Age-depth models were also similarly constructed, relying upon magnetostratigraphic and biostratigraphic age-depth data. Comparison of IRD records from these two sites reveals a shared pattern of long-term IRD flux, which is dominated by IRD abundance maxima in both records at 0.9, 1.9, 2.7-2.9 Ma. These three episodes of high IRD flux are at least twice as large as the average IRD peaks in the respective records.

The cause of these repeated, and perhaps cyclic (~ 1 Myr), episodes of high IRD accumulation is uncertain; however, their presence in both Southern and Northern Hemisphere high latitude sites suggests that large-scale oceanographic and climatic controls were involved. That each episode occurred during eustatic highstands and during suppressed North Atlantic Deep Water formation favors repeated massive calving events related to ice sheet disintegration as a possible cause.

INTRODUCTION

In science, it is sometimes the curious observation that leads a researcher to think outside the "box". The box being defined, perhaps, by the boundaries of a carefully constructed research program, or more globally, a paradigm of thought. Deciding not to ignore, or perpetually put aside, the curious observations may divert one from an established path of research, but may also lead to new ideas and scientific insight. It can also be an exercise in creative thinking. Described here is an argument for a Plio-Pleistocene bipolar climate connection that is rooted in a curious observation: two similar 3-Myr ice-rafted debris (IRD) records from opposite polar regions, the Irminger Basin off SE Greenland and the marine basin west of the Antarctic Peninsula. A preliminary argument for a Plio-Pleistocene bipolar relationship was made by St. John and Cowan (2000); here it is developed further and is based on a comparison of the IRD records published by St. John and Krissek (2002) and Cowan (2001).

The study of north-south linkages is not new to the field of paleoclimatology. However, most studies of this type focus on identifying high-resolution bipolar connections, including lead-lag relationships, over millennial time scales for the late Pleistocene (e.g., Blunier and Brook, 2001; Kanfoush et al., 2002; Stocker, 2002). Long-term bipolar comparisons are less common (e.g., Schnitker, 1980), and by their very nature (i.e., lower temporal resolution) less robust, but valuable just the same. Climate change records over several thousand to millions of years provide a context for the late Pleistocene millennial-scale climate studies in much the same way that an understanding of U.S. history provides a context for understanding modern U.S. political science issues. In addition, given the controversy that exists over the proper interpretation of the Pliocene glacial history of Antarctica (e.g., Miller and Mabin, 1998, and related articles), and the limited understanding of the long-term history of the Greenland Ice Sheet (St. John and Krissek, 2002), continued long-term paleoclimatic study of Antarctic and Greenland records is warranted.

IRD records reflecting provenances of SE Greenland and the Antarctic Peninsula, as described here, are particularly well suited for examining possible bipolar climate relationships over the long-term because both the SE Greenland Ice Sheet and the Antarctic Peninsula Ice Cap are established as dynamic regions of climate change compared with the remainder of their respective continental cryospheres (Krabill et al., 1999; Bart and Anderson, 2000). The primary objective of this paper is to propose a hypothesis for a bipolar, subArctic-Antarctic climate connection from the late Pliocene through the mid-Pleistocene. This is based on broadly co-varying IRD records, which are dominated by three shared episodes of high IRD flux (Cowan, 2001; St. John and Krissek, 2002), and on a synthesis of concurring oceanography and climatic changes described in the literature.

LOCATIONS AND LITHOLOGIES

Detailed setting and lithological descriptions of sites 918 and 1101 are given in the respective Ocean Drilling Program Initial Reports volumes (Shipboard Scientific Party, 1994, 1999), in St. John and Krissek (2002) and in Cowan (2001). Both sites were drilled in continental rise sediment accumulations proximal to glaciated mountainous coastlines at latitudes poleward of 63° (Fig. 1). Site 918 is located ~65 km from the SE Greenland shelf edge in 1869 m of water in the Irminger Basin. Site 1101 is located ~94 km from the Antarctic Peninsula's western shelf edge in 3280 m of water. Both sites lie within the present limit of iceberg transport. Plio-Pleistocene ice-rafted debris accumulations at these sites were used to interpret temporal and spatial variations in iceberg release and transport from the adjacent coasts (Cowan 2001; St. John and Krissek, 2002). In addition, the extensive site 918 IRD record was used to argue that glacial expansion to sea level in SE Greenland preceded the general Northern Hemisphere glaciation by several million years; IRD evidence suggests it was glaciated as early as 7.3 Ma (Larsen et al., 1994; St. John and Krissek, 2002).

Largely due to the commonalities in the site

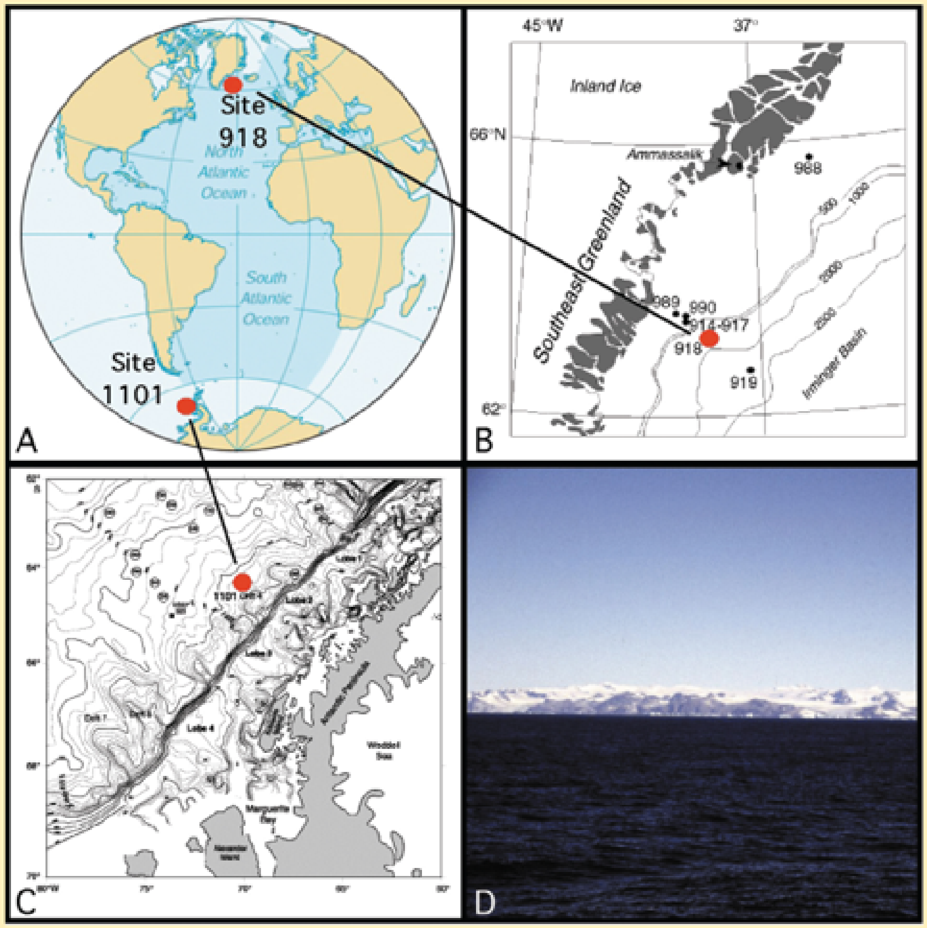


Figure 1. A. Map showing the general locations of Ocean Drilling Program Sites 918 and 1101 (modified from http://geography.about.com/library/cia/blcatlantic.htm); B. Map of Site 918 located on the upper continental rise ~65 km from SE Greenland's shelf edge in 1869 m of water in the western Irminger Basin. Shaded areas indicate outcrop regions (from Teagle and Alt, 1999); C. Map of Site 1101 located on a sediment drift on the continental rise ~94 km from Antarctic Peninsula's western shelf edge in 3280 m of water (from Cowan, 2001, and after Rebesco et al., 1998); D. Glaciated SE Greenland coast with calved icebergs (photo by St. John, 1995).

characteristics, site 918 and site 1101 sediment lithologies are also similar, although their thickness differ. The 600 m Miocene to Pleistocene sediment section upper at site 918 and the Plio-Pleistocene 218 m sediment section at site 1101 are dominated by biogenic-bearing marine muds and silts, with dropstones. These are interpreted as hemipelagic sediments and fine-grained distal turbidites with discrete occurrences of IRD. In addition, intervals of poorly sorted, ungraded sand, silt and pebbles also occur and are interpreted as glaciomarine diamictons.

COMPARABLE AGE-MODELS AND METHODS

Bulk sediment samples for IRD analysis were taken approximately every 50-75 cm from the sedimentary sections of site 918 (St. John and Krissek, 2002) and every 75 cm from the sedimentary sections of site 1101 (Cowan, 2001). In both studies, the medium to coarse sand fractions (250 mm to 2 mm) were isolated from the rest of the bulk sample and weight percentages were calculated. The proportion of terrigenous grains in this grain size fraction was then either estimated visually (site 1101) or physically isolated (Site 918). It was this terrigenous (non-volcanic) medium-coarse sand that was used as the indicator of ice-rafted debris accumulation in both studies (Fig. 2).

As described in St. John and Krissek (2002) and Cowan (2001), age models for the sedimentary sections of sites 918 and 1101 were based on shipboard (site 1101) and post-cruise (site 918) magnetostratigraphic and biostratigraphic age-depth markers. The resultant age models were used to calculate the linear sedimentation rates and sample ages. Linear sedimentation rates were high at both sites (averaging 11 cm/kyr at site 918 and 6 cm/kyr at site 1101), but were more variable at site 918. A summary of the depth ranges, calculated ages, and linear sedimentation rates for both sites is provided in Table 1 for the overlapping time span of interest (0-3 Ma).

Because IRD accumulation in a core results from a different set of processes than exist for other sediment components, it is necessary to examine the variable input of IRD in isolation (Fig. 3). This can be achieved by calculating the mass flux of IRD to the sea floor, or in other words, the IRD mass accumulation rate (MAR; Rea and Leinin, 1989). The IRD MAR is independent of the supply rates of other coarse sand-size components, such as volcanic ash and biogenic material, and therefore yield a more unequivocal record of IRD supply than would be provided by the weight percentages of the medium-coarse sand fraction alone. IRD MAR was the method used in both studies to quantify IRD flux (Cowan, 2001; St. John and Krissek, 2002). The MAR of the terrigenous medium-coarse sand (i.e., IRD) was calculated for each sample from sites 918 and 1101 as follows:

$$\text{IRD MAR } [g/cm^2/kyr] = \text{LSR } [cm/kyr] \times \text{DBD } [g/cm^3] \times \%\text{MCS} \times \%\text{IRD}$$

where the dry bulk density (DBD) value was obtained from the stratigraphically closest discrete shipboard physical property measurement, %MCS reflects the medium-coarse sand weight percent multiplied as a decimal fraction, and %IRD reflects the weight percent (site 918) or volume percent (site 1101) of terrigenous material in the medium-coarse sand fraction multiplied as a decimal fraction. This method assumes a constant linear sedimentation rate (LSR) between age-depth markers.

DATA AND DISCUSSION

IRD MARs at sites 918 and 1101 are shown in Figure 4. Generally the IRD MAR at site 918 was ten times greater than that to site 1101 since at least 3.0 Ma. Assuming the most important factors influencing IRD flux were

Figure 2. Terrigenous medium to coarse sand (250mm - 2mm) mineral grains and rock fragments interpreted as ice-rafted debris (IRD) from ODP Site 918A 6H5, 132-136 cm (~0.9 Ma).

Table 1: Summary of the depth ranges, calculated ages, and linear sedimentation rates for sites 918 (from St. John and Krissek, 2002) and 1101 (from Cowan, 2001), 0 to ~3 Ma.

	Depth (mbsf)	Calculated Age (Ma)	Linear Sedimentation Rate (cm/kyr)
Site 918	0-21.45	0-0.26	8.3
	21.45-49.00	0.26-0.99	3.8
	49.00-52.90	0.99-1.07	4.9
	52.90-71.10	1.07-1.39	5.7
	71.10 erosional unconformity	hiatus	—
	71.10-81.00	1.71-1.77	16.5
	81.00-115.10	1.77-1.95	18.9
	115.10-146.80	1.95-2.14	16.7
	146.80-413.89	2.14-3.65	17.7
Site 1101	0-55.08	0-0.78	7.06
	55.08-71.2	0.78-0.99	7.68
	71.2-76.15	0.99-1.07	6.19
	76.15-121.12	1.07-1.77	6.42
	121.42-126.98	1.77-1.86	3.25
	126.98-165.98	1.86-2.49	6.18
	165.98-209.4	2.49-2.95	9.46

source-related, this implies that there was either greater iceberg discharge from east Greenland than from the Antarctic Peninsula and/or greater debris content in the Greenland ice compared with ice calved from the Antarctic Peninsula during this time.

When comparing the timing and relative magnitude of IRD flux from these two source regions, a broadly similar pattern can be recognized; both records are dominated by IRD MAR maxima at 0.9, 1.9, 2.7-2.9 Ma. These three episodes of high IRD flux are at least twice as large as the average IRD MAR peaks in the respective records. On a finer scale differences in the two IRD MAR records are evident; there are times when IRD flux is high in one region but not the other (e.g., at 0.5 Ma). These differences are completely expected given the various local conditions that can influence the accumulation of IRD on the sea floor at any particular site, including the climatic conditions on land (e.g., debris content of the ice, iceberg calving rate and provenance) and the oceanographic conditions in the surface water environment (e.g., temperature, presence of sea ice, current strength and direction). What is not expected, is to see repeated coincident high magnitude IRD MAR peaks (i.e., at 0.9, 1.9, 2.7-2.9 Ma) in records from two regions so far apart. It is this broad pattern of high IRD flux episodes that is the focus of the discussion.

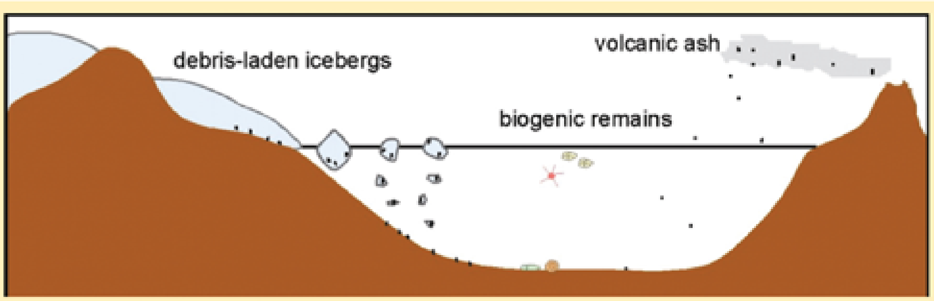


Figure 3. Sketch illustrating the primary sediment components contributing to the sediment accumulation in glaciomarine settings such as site 918. In addition to the input of terrigenous sediment from the rainout of debris laden icebergs, planktonic and benthic biogenic material is deposited. Ash from nearby volcanic eruptions may also be transported and deposited in this setting. Each sediment component can be considered a paleoenvironmental archive.

TEMPORAL PATTERNS

Both the overall co-varying pattern and the specific timing of each of the high IRD flux episodes are intriguing. That a similar pattern of high IRD flux exists for sites so distant from each other, must either be explained by global-scale oceanographic and climate connections, or be written off as pure coincidence. The question then becomes, what oceanographic and climatic conditions existed during these times of high IRD flux that could possibly increase iceberg discharge and/or the debris content of east Greenland and Antarctic Peninsula glaciers, or otherwise focus iceberg melt at these two sites?

A summary of potentially relevant conditions that existed at the times of the three high IRD flux episodes is provided in Table 2. Also included in Table 2 is reference to two other high IRD flux episodes (at ~3.5 and ~4.5 Ma; St. John and Krissek, 2002) recorded in the longer sedimentary section at site 918. The timing of these older high IRD flux episodes is poorly constrained given increased uncertainties in the site 918 age-model down core. However, it appears that similar oceanographic conditions existed at these times as existed during the influx of IRD at 0.9, 1.9 and at 2.7 Ma.

An oceanographic condition that appears to be common to all of the high IRD flux episodes was high eustatic sea level (Table 2; see references therein). One way to explain

Table 2. Comparison of the timing of high IRD flux to sites 918 and 1101 with potentially relevant oceanographic and climatic conditions.

High IRD Flux		Potentially Relevant Concurrent Oceanographic & Climatic Conditions				
Site 918, SE Greenland (St. John & Krissek, 2001)	Site 1101, Antarctic Peninsula (Cowan, 2001)					
0.9 Ma	0.9 Ma	NADW Suppressed (0.9 Ma)[1,2,3]	Low-Salinity Surface Water, Irminger Basin (0.6-0.9 Ma)[6]	Mid-Pleistocene Climate Transition (0.88-0.92 Ma)[7,8,9]	Subantarctic high IRD flux (0.65-0.9 Ma) 11, 14 & extreme deglaciation of the Antarctic Peninsula (0.88 Ma)[10]	Eustatic Highstand (1.0-0.9 Ma)[12]
1.9 Ma	1.9 Ma	NADW Suppressed (1.75-1.8 Ma)[4,5]				Eustatic Highstand (1.8-1.9 Ma)[12]
2.7 Ma	2.8 Ma	NADW Suppressed (2.5-2.7 Ma)[3,4,5]		Warm Southern Ocean (2.48-2.9 Ma)[11]	Subantarctic High IRD flux (2.8 Ma)[13]	Eustatic Highstand (2.6-2.7 Ma)[12]
3.5 Ma (?)	(below base of record)	NADW Suppressed (3.5 Ma)[3,5]				Eustatic Highstand (3.2-3.4 Ma)[12]
4.5 Ma (?)		NADW Suppressed (4.5-5.0 Ma)[3,5]				Eustatic Highstand (4.2-5.0 Ma)[12]

[1]Raymo et al., 1990; [2]Raymo et al., 1997; [3]King et al., 1997; [4]Raymo et al., 1989; [5]Haug & Tiedemann, 1998; [6]Flower, 1998; [7]Berger & Jansen, 1994; [8]Mudelsee & Schulz, 1997; [9]Clark & Pollard, 1998; [10]Anderson & Andrews, 1999; [11]Ciesiklski et al., 1982; [12]Haq et al., 1987; [13]Murphy et al., 2002;

this association is that coastal portions of the east Greenland Ice Sheet and the Antarctic Ice Cap were repeatedly susceptible to destabilization by rising sea levels and increases in the volume of iceberg discharge, and presumably increases in IRD rainout, ensued. This is essentially the scenario proposed by Bornhold (1983) for an increase in IRD flux to the SE Argentine Basin at 0.90-0.65 Ma and by Murphy et al. (2002) for an increase in IRD flux to Meteor Rise in the South Atlantic at 2.8 Ma. Alternatively or additionally, an increase in debris content of the ice would likely have occurred if the glacial ice became increasingly warm-based, as Anderson and Andrews (1999) suggested to explain an increase in Antarctic Peninsula IRD in the Weddell Sea at 0.88 Ma.

A second oceanographic condition that appears to be concurrent with each of the high IRD flux episodes at sites 918 and 1101 was suppressed North Atlantic Deep Water (NADW) formation (Table 2, and references therein). An associated increase in meltwater (i.e., iceberg melt) to the northern North Atlantic during these times of high IRD flux may account for this. A freshwater cap in the northern North Atlantic could interfere with deepwater production as surface water salinities decreased causing the water column to become more stratified (Broecker, 1991). There is oxygen-isotope evidence for such a meltwater pool in the Irminger Sea at 0.9 Ma (Flower, 1998).

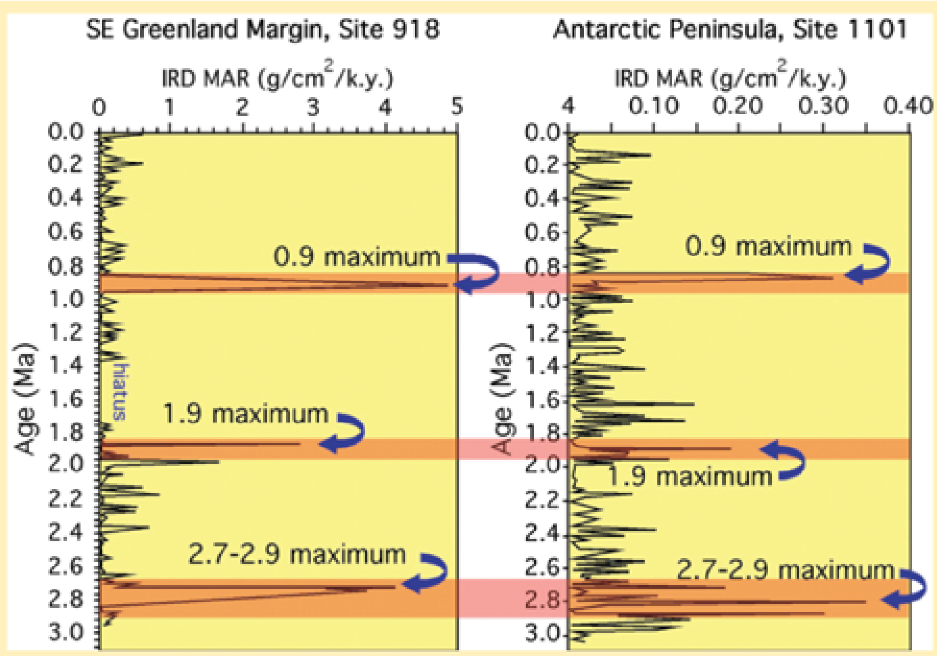


Figure 4. Ice-rafted debris mass accumulation rate (IRD MAR) records plotted against calculated ages for sites 918 (St. John and Krissek, 2002) and 1101 (Cowan, 2001). A hiatus exists in the site 918 record at 71 meters below sea floor, which is interpreted to represents duration of 320 kyr, from 1.71 to 1.39 Ma (St. John and Krissek, 2002).

The approximate 1-Myr time span between each of the high IRD flux episodes identified at both sites 918 and 1101 does not go without notice. However, because the age-models for these sites were based on a limited number of age-depth markers, chronological uncertainties in the timing of IRD flux to the two sites exist, disallowing any rigorous statistical investigation of the timing of these events or of lead-lag relationships. Speculatively, the timing of major IRD flux may reflect a 1-Myr cyclicity in global climate. Crowley and North (1991) noted that other late Cenozoic records, including those of sea level (Moore et al., 1987) and of temperature sensitive marine biofacies (Poore, 1981), display a characteristic 1-Myr fluctuation as well. A common origin for this possible cyclicity is not known (Schlanger, 1986).

TEMPORAL EVENTS

Two of the high IRD flux episodes common to sites 918 and 1101, are interesting for an additional reason: their timing with respect to global climate reorganization. Within the bounds of the age-models, the increased IRD flux to sites 918 and 1101 at 2.7-2.9 Ma may slightly precede the general onset of Northern Hemisphere glaciation at 2.65 Ma. This is consistent with the view that the SE Greenland Ice Sheet (Krabill et al., 1999; Jansen et al., 2000; St. John and Krissek, 2002) and the Antarctic Peninsula Ice Cap (Bart and Anderson, 2000; Cowan, 2001) are dynamic regions of climate change, and were specifically more sensitive to global climate forcing than was the Laurentide ice sheet in North America.

The increased IRD fluxes to sites 918 and 1101 at 0.9 Ma can also be linked to a major global climate reorganization that is well recognized but poorly understood: the mid-Pleistocene climate transition (MPT; Table 2). The MPT is marked by a period of increased ice-rafting from climatically sensitive regions around the global, such as Scandinavia (Fronval and Jansen, 1996; Jansen et al., 2000) and SE Alaska (St. John and Krissek, 1999), in addition to SE Greenland (St. John and Krissek, 2002) and the Antarctic Peninsula (Cowan, 2001). The MPT is also marked by a shift to more extreme global glacial-interglacial cycles (Berger and Jansen, 1994; Muldeless and Schultz, 1997; Clark and Pollard, 1998).

CONCLUSION

Records of IRD flux derived from similarly situated but distant glacimarine settings, the continental margins of SE Greenland (ODP site 918) and the Antarctic Peninsula (ODP site 1101), co-varied during the Plio-Pleistocene. These records are dominated by high IRD flux episodes at 0.9, 1.9, 2.7-2.9 Ma, which appear to fit in a global, and perhaps cyclic (~1-Myr), pattern of oceanographic changes in sea level and thermohaline circulation. Evidence points to repeated bipolar destabilizations of coastal ice bodies in these climatically-sensitive regions as sea levels achieved highstand positions. Subsequent increases in the calving of debris-laden icebergs would explain the episodes of high IRD flux to sites 918 an 1101. An increase in freshwater input from melting icebergs in the northern North Atlantic may also explain the concurring pattern of suppressed NADW formation.

ACKNOWLEDGMENTS

I wish to express my appreciation to E. Cowan, for her contribution of data that enabled the development of a preliminary abstract on this topic (St. John and Cowan, 2000). I also wish to thank M. Ledbetter for his constructive comments, which improved the quality of this manuscript. Results from this project were only possible to achieve due to the initial labor-intensive work of the Leg 152 and 178 shipboard parties and the financial support of post-cruise research grants from JOI-USSSP.

REFERENCES

Anderson, J.B., and Andrews, J.T., 1999, Radiocarbon constraints on ice sheet advance and retreat in the Weddell Sea, Antarctica: Geology, v. 27, p. 179-182.

Bart, P.J., and Anderson, J.B., 2000, Relative temporal stability of the Antarctic ice sheets during the late Neogene based on the minimum frequency of outer shelf grounding events: Earth and Planetary Science Letters, v. 182, p. 259-272.

Berger, W., and Jansen, E., 1994, Mid-Pleistocene climate shift – the Nansen connection. The Polar Oceans and Their Role in Shaping the Global Environment: Geophysical Monograph, v. 84, p. 295-311.

Blunier, T., and Brook, E.J., 2001, Timing of millennial-scale climate change in Antarctica and Greenland during the last glacial period: Science, v. 291, p. 109-111.

Bornhold, B. 1983, Ice-rafted debris from Leg 71, southwest Atlantic Ocean, in Ludwig, W.J., Krasheninnikov, V.A., eds., Initial Reports of the Deep Sea Drilling Program, v. 71: US Government Printing Office, Washington, DC, p. 307-316.

Broecker, W.S., 1991, The great ocean conveyor: Oceanography, v. 4, 79-89.

Ciesielski, P.F., Ledbetter, M.T., and Ellwood, B.B., 1982, The development of Antarctic glaciation and the Neogene paleoenvironments of the Maurice Ewing Bank: Marine Geology, v. 46, p. 1-51.

Clark, P.U., and Pollard, D., 1998, Origin of middle Pleistocene transition by ice sheet erosion of regolith: Paleoceanography, v. 13, p. 1-9.

Cowan, E.A., 2001, Identification of the glacial signal from the Antarctic Peninsula since 3.0 Ma at Site 1011 in a continental rise sediment drift, in Barker, P.F., Camerlenghi, A., Acton, G.D., and Ramsay, A.T.S., eds., Proceedings of the Ocean Drilling Program, Scientific Results, v. 178 [Online]: Available from World Wide Web: <http://www-odp.tamu.edu/publications/178_SR/chap_10/chap_10.htm>. [Cited 2004-03-08]

Crowley, T.J., and North, G.R., 1991, Paleoclimatology: Oxford Monograph on Geology and Geophysics, no. 18, Oxford University Press, New York.

Flower, B.F., 1998, Mid-to Late Quaternary stable isotope stratigraphy and paleoceanography at site 919 on the southeast Greenland margin, in Larsen, H.C., Saunders, A.D., and Clift, P.D., eds., Proceedings of the Ocean Drilling Program, Scientific Results, v. 152: Ocean Drilling Program, College Station, TX, p. 243-248.

Fronval, T. and Jansen, E.,1996, Late Neogene paleoclimates and paleoceanography in the Iceland-Norwegian Sea: evidence from the Iceland and Voring Plateaus, in Thiede, J., Myhre, A.M., and Firth, J.V., eds., Proceedings of the Ocean Drilling Program, Scientific Results, v. 151: Ocean Drilling Program, College Station, TX, p. 455-468.

Haq, B.U., Hardenbol, J. and Vail, P.V., 1987, The new chronostratigraphic basis of Cenozoic and Mesozoic sea level cycles, in Ross, C.A. and Hamman, D., eds., Timing and Depositional History of Eustatic Sequences: Constraints on Seismic Stratigraphy: Cushman Foundation of Forminiferal Research Special Publication, v. 24, p. 7-14.

Haug, G.H., and Tiedemann, R., 1988, Effect of the formation of the Isthmus of Panama on Atlantic Ocean thermohaline circulation: Nature, v. 393, p. 673-676.

Jansen, E., Fronval, T., Rack, F., and Channel, J., 2000, Pliocene-Pleistocene ice rafting history and cyclicity in the Nordic Seas during the last 3.5 Myr: Paleoceanography v. 15, p. 709-721.

Kanfoush, S.L., Hodell, D.A., Chrales, C.D., Guilderson, T.P., Mortyn, P.G., and Ninnemann, U.S., 2000, Millennial-scale instability of the Antarctic Ice Sheet during the last glaciation: Science, v.288, p. 1815-1818.

King, T.A., Ellis, W.G., Murray, D.W., Shackleton, N.J., and Harris, S.E., 1997, Biogenic and terrigenous sedimentation at Ceara Rise, western tropical Atlantic, supports Pliocene-Pleistocene deep-water linkage between hemispheres, in Shackleton, N.J., Curry, W.B., and Richter, C., eds., Proceedings of the Ocean Drilling Program, Scientific Results, v. 154: Ocean Drilling Program, College Station, TX, p. 331-335.

Krabill, W., Frederick, E., Manizade, S., Martin, C., Sonntag, J., Swift, R., Thomas, R., Wright, W., and Yungel, J., 1999, Rapid thinning of parts of the southern Greenland ice sheet: Science, v. 283, p. 1522-1524.

Larsen, H. C., Saunders, A. D., Clift, P. D., Beget, J., Wei, W., Spezzaferri, S. and ODP Leg 152 Scientific Party 1994, Seven million years of glaciation in Greenland: Science, v. 264, p. 952-955.

Miller, M.F., and Mabin, M.C., 1998, Antarctic Neogene landscapes – in the refrigerator or in the deep freeze?: GSA Today, v. 8, no. 4, p. 1-3.

Moore, T.C., Loutit, T.S., and Grenlee, S.M., 1987, Estimating short-term changes in eustatic sea level: Paleoceanography, v. 2, p. 625-637.

Muldeless, M. and Schulzt, M., 1997, The Mid-Pleistocene climate transition: onset of 100 ka cycle lags ice volume build-up by 280 ka: Earth and Planetary Science Letters, v. 151, p. 117-123.

Murphy, L., Warnke, D.A., Andersson, C., Channel, J., and Stoner, J., 2002, History of ice rafting at South Atlantic ODP Site 177-1092 during the Gauss and Late Gilbert Chrons: Palaeogeography, Palaeclimatology, Palaeoecology, v. 182, p. 183-196.

Poore, R.Z., 1981, Late Miocene biostratigraphy and paleoclimatoligy of the central North Atlantic: Marine Micropaleontology, v. 6, p. 599-616.

Raymo, M.E., Oppo, D.W., and Curry, W., 1997, The mid-Pleistocene climate transition: a deep sea carbon isotopic perspective: Paleoceanography, v. 12, p. 546-559.

Raymo, M.E., Ruddiman, W.F, Backman, J., Clement, B.M., and Martison, D.G., 1989, Late Pliocene variation in Northern Hemisphere ice sheets and North Atlantic Deep Water circulation: Paleoceanography, v. 4, p. 413-446.

Raymo, M.E., Ruddiman, W.F., Shackleton, N.J., and Oppo, D.W., 1990, Evolution of Atlantic-Pacific gradients over the last 2.5 m.y.: Earth and Planetary Science Letters, v. 97, p. 353-368.

Rea, D.K., and Leinen, M., 1989, Quaternary Climates: The Ocean Sedimentary Record: GSA Short Course, St. Louis, MO.

Rebesco, M., Camerlenghi, A., and Zanolla, C., 1998, Bathymetry and morphogenesis of the continental margin west of the Antarctic Peninsula: Terra Antarctica, v. 5, p. 715-725.

Schlanger, S.O., 1986, Hi frequency sea-level fluctuations in Cretaceous time: an emerging geophysical problem, in Hsu, K., ed., Mesozoic and Cenozoic Oceans: American Geophysical Union, Washington, DC, p. 61-74.

Schnitker, D., 1980, North Atlantic oceanography as possible cause of Antarctic glaciation and eutrophication: Nature, v. 284, p. 615-616.

Shipboard Scientific Party, 1994, Site 918, in Larsen, H.C., Saunders, A.D., and Clift, P.D., eds., Proceedings of the Ocean Drilling Program, Initial Reports, v. 152: Ocean Drilling Program, College Station, TX, p. 177-256.

Shipboard Scientific Party, 1999, Site 1101, in Barker, P.F., Camerlenghi, A., Acton, G.D., et al., Proceedings of the Ocean Drilling Program, Initial Reports, v. 178 [Online]: Available from World Wide Web: <http://www-odp.tamu.edu/publications/178_IR/chap_04/chap_04.htm>. [Cited 2004-03-10]

St. John, K., and Cowan, E.A., 2000, Co-varying IRD records suggest bipolar cycles of ice sheet disintegration since 3.0 Ma: EOS Transactions, American Geophysical Union, v. 81, no.48, p. F391.

St. John, K, and Krissek, L., 1999, Regional patterns of Pleistocene ice-rafted debris flux in the North Pacific: Paleoceanography, v. 14, p. 653-662.

St. John, K. and Krissek, L., 2002, The late Miocene to Pleistocene ice-rafting history of southeast Greenland: Boreas, v. 41, p. 28-35.

Stocker, T.F., 2002, North-South Connections: Science, v. 297, p. 1814-1815.

Teagle, D.A., and Alt, J.C., 1999, Data Report: Alteration and vein log of Holes 917A and 918D, Southeast Greenland margin, in Larsen, H.C., Duncan, R.A., Allan, J.F., Brooks, K., eds., Proceedings of the Ocean Drilling Program, Scientific Results, v. 163 [Online]: Available from World Wide Web: <http://www-odp.tamu.edu/publications/163_SR/chap_13/chap_13.htm>. [Cited 2004-03-08]

PRESIDENT'S OBSERVATIONS

Looking Back, Moving Forward

A Call To Action

Having just been installed as your new President, and returned from our Annual Meeting in Dallas, I would like to report on recent strides we have made that I hope will enable our Sedimentary Community to grow. Many challenges confront us, but there are encouraging signs that the "patient is building energy", and is moving in a positive direction. As I think about us, the community of Sedimentary Geology is the framework for many disciplines within the geosciences, including, but not confined to, siliciclastics, carbonates, diagenesis, sedimentary processes, paleobiology, and sequence stratigraphy. Our purpose is to advance, exchange, and disseminate knowledge in all these areas. We accomplish this through our meetings, including our partnership with AAPG and sponsored sessions at GSA, through our publications, and through our research conferences.

I think the last year has been a good one for us, with advances on a number of initiatives. First, to remain a vital part of your professional life, the Society has strengthened our partnership with AAPG. Through the efforts of Past-President Peter McCabe, Headquarters and Business Chair, John Robinson, outgoing AAPG President and member, Steve Sonnenberg, and other members of the AAPG Executive Council, we have concluded a revenue sharing agreement with the AAPG. SEPM will continue our current staff and volunteer support for the Annual Meeting, and in return, AAPG will continue their current meeting support and hotel benefits. In addition, AAPG will pay to SEPM, $10 for each SEPM member registered for the Annual meeting (as determined by checking the SEPM box on the registration form) with a cap of $5,000, and will provide, at no cost, a 10x20 exhibition booth space. This amounts to somewhere between $5,400 and $9,400 in savings in meeting costs and up to $5,000 in revenue. This is a significant step forward for us, and will allow the Society to continue making a strong contribution to the technical content of the Annual Meeting. Thanks again to those in both organizations who have made this happen.

Second, our publications continue to advance into the digital age. Council has approved our becoming a founding member of the GeoScienceWorld (GSW) aggregate of geoscience publications that also includes GSA, AAPG, AGI, Geol. Soc. London, Mineralogical Soc. Am., and SEG. Our journals, past and present, will be uploaded this year for a January, 2005 launch of this e-publishing endeavor. Many thanks and kudos go to Executive Director, Howard Harper, for his leadership on the steering committee.

Third, we would like to make our Research Conferences an even larger part of our Society's benefit to you. Through the efforts of Headquarters staff, the Research Councilors (outgoing Councilor, John Suter, and incoming Councilor, Vitor Abreu), and the Research Committee, we are becoming more proactive in seeking out cutting-edge topics for our conferences. We are aligning this initiative with ongoing efforts to identify and pursue collaborative thematic research. We co-hosted a NSF Workshop at the Annual Meeting that brought together interested scientists in our community to identify larger thematic research efforts that might garner increased NSF support for our science. We will continue this dialog with a workshop at the GSA National Meeting in Denver this fall.

All of the efforts above are directed to keeping our Society at the forefront of our science. A critical element in this effort is your participation. Council, Headquarters staff, and our volunteer members can facilitate and enable, and we are committed to being proactive in this endeavor. Success will only come with your participation in the science and in the Society. I would like to challenge each of you to be active. With so many new tools and technologies at our disposal, this is an exciting time to be in Sedimentary Geology. Research in our community is becoming very diverse, and encompasses everything from Mars to microbes.

Finally, building our community is a vital element in the growth of the Society and in advancing our science. Our publications knit us together and we must keep them at the highest level. Outgoing JSR co-editors, Mary Krause and Dave Budd, have continued the outstanding efforts of past editors, and deserve a great round of congratulations for a job well done. Incoming co-editors, Kitty Milliken and Colin North, bring new energy to a most important task, and I am confident that the Journal is in good hands. Palaios editor, Chris Maples, has made that journal a revenue generator for the first time, and Special Publications editor, Laura Crossey, and Kris Farnsworth at Headquarters have ensured us a steady stream of SP's for the near future. We must, however, continue to increase our efforts in other areas. We must continually seek to make our meetings and conferences a pipeline for publication. I have already mentioned a sharpened focus for our Research Conferences. To help grow our meetings, I am forming an ad-hoc committee, to be chaired by the President-Elect, and that will include past, present, and future Annual Meeting chairs, as well as the Research Councilor. This committee will be tasked with making sure that meeting organization remains relevant and current, that learnings are shared, and that we continue to improve meeting content and organization.

Membership growth and students continue to be a focus for us. If you aren't already aware of it, student membership is a great deal (check out our website). The SEPM Foundation continues to support student research and participation at meetings. Student research grants totaling $8,100 were awarded to eight students in 2003, and travel support ($400/student) was provided to 16 student posters at the Dallas meeting. Membership decline has slowed for the first time in a number of years. However, we do need to increase our efforts to bring new members onboard. I encourage each and every one of you to bring a friend into the Society.

All in all, we have had a good year, with a lot of positive things in progress or in the works. A much deserved thanks go to outgoing President, John Anderson for his leadership over the past year. The challenges of revenue and growth are still before us. I look forward to working with Council, Headquarters, and all of you, the Members, to keep SEPM a vibrant, important part of your professional life. In the coming months be on the look out for new initiatives on membership and in the international arena. I also encourage you all to communicate your ideas and opinions to me, to Headquarters, and to the other officers. I look forward to an exciting year.

Rick Sarg, President
rick.sarg@exxonmobil.com

FIELD NOTES

Applied Paleontology the Root of SEPM

SEPM was the Society of Economic Paleontologists and Mineralogists before it became the Society for Sedimentary Geology. It arose from the efforts of micropaleontologists, "economic paleontologists," from the oil industry, who applied their skills in the search for hydrocarbons (Russell and Tener, 1981). The world has changed a lot since SEPM's founding in 1926, and the oil business has changed with it. During the succeeding years the demise of economic paleontology has been predicted many times. Advances in wireline logging, 2D and then 3D seismic, and other high tech enabling technologies all entered the arena amid predictions that micropaleontology would no longer be needed. I'm happy to tell you that the discipline of biostratigraphy, or what I like to call "applied paleontology," has continued to deliver its unique contribution to exploration, development and production projects and in doing so provides gainful employment for a number of practitioners here in the U.S. and abroad. I count myself fortunate to have been able to work for 25 years in this niche.

Microfossils allow us to read the rocks in a way that other technologies do not. Micropaleontologists examine mostly drill cuttings, a ground up composite sample of some 30 feet (~10 m) of rock drilled by the bit and then circulated up to the surface (one of the few subsurface tools where the workers actually look at the rock rather than some remote sensing signal). The fossils are a part of the rock. They can tell us much about the environment of deposition, the geologic age, and perhaps most useful of all, precisely how one set of rock correlates to another set drilled a few miles away. The work of economic micropaleontologists was showcased in Jones and Simmons (1999), including work done at the wellsite to maximize the penetration of reservoirs (and thus production) in so-called horizontal wells (Holmes, 1999). Time and again, particularly in difficult to image areas such as near or below salt bodies, seismic fails us, and it is only biostratigraphy that provides us with "the truth" (O'Neill et al., 1999). The work of biostratigraphers during drilling impacts operational decision-making and can result in the savings of millions of dollars. Case studies like these will form a major piece of the program on March 6-11, 2005 when the North American Micropaleontology Section of SEPM hosts a conference entitled "Geologic problem solving with microfossils" (http://www.sepm.org/microfossils2005.htm).

For years many of the major companies had sizeable paleontologic staffs (e.g., in 1985 Shell had 25 paleontologists in the New Orleans office) doing operational biostratigraphy including microscopic analyses at the wellsite. In industry the last 15 years have been marked by staff reductions in all disciplines, alternating with short bursts of hiring, in some fields (but not in biostratigraphy). The business model for the majors changed from internally generated data to the use of consulting paleontologists to collect the primary data (species and abundance data) and the use of a few internal specialists to handle some of the wellsite work and to interpret and integrate consultant data with other subsurface datasets (seismic, wireline logs, etc.). This system has been very effective in the near term for sustaining the business in a cost-constrained world.

During this same period the collection of digital micropaleontologic data along with the increase in speed and power of desktop computing has allowed for much more sophisticated analyses. Abundance peaks, similarity coefficients, paleobathymetry algorithms and diversity analyses aid in the recognition of significant stratigraphic surfaces (Armentrout, 1996; Olson et al., 2003; Wakefield, 2003; Jones et al., 1996; Jones, et al. 2003). Formerly time intensive techniques such as graphic correlation (Shaw, 1964) can now be quickly employed (Mann and Lane, 1995). Applied paleontology now employs technology to tease out subtle signals to refine subsurface models.

So where do we go from here? As Yogi Berra said, "It's tough to make predictions, especially about the future." At the forward looking "Paleontology in the 21st Century" conference, Armentrout et al. (2001) predicted that continued global demand for fossil fuels will lead to the need for at least two more generations of industrial paleontologists. The graying of the industry workforce requires that to preserve this useful tool, new workers will need to enter the workforce and hone their skills. We've already seen some of this with majors (e.g., BP, Shell) and consulting firms (e.g., Paleo-Data) hiring new biostratigraphers fresh out of school and offering summer internships in biostratigraphy. This must continue in order to accomplish this succession within the field. What is of even more concern than replacing the relatively few workers in the larger companies is how the larger number of independent contractors will be replaced. At least in the U.S., most of these workers learned their trade in those big microscope shops so common in the 80s; now a thing of the past. Who will give the new workers the 10 years it takes to become an experienced industrial biostratigrapher? The majors? Large consulting firms? Independent contractors?

What skills will the new recruits need? The bread and butter of industrial paleontology are still foraminifera, calcareous nannoplankton and palynomorphs. Students looking to enter the field would do well to gain a firm taxonomic background in one or more of these groups. Computer literacy is essential, but even more so, are communication skills (oral and written) to convey your results, and literally sell your products. A thorough understanding of the sedimentary processes that created the rocks that contain your fossils (and the hydrocarbons we seek) is crucial.

Industrial paleontology has grown and changed to meet the needs of a challenging business. There is a looming crisis and an opportunity. We can meet the challenge, preserve this unique discipline and continue to meet the needs of the energy business, or we can let the skills retire with this generation and be forgotten. Yogi Berra also said, "The future is not what it used to be." So be it, but there is a future and it will be what we make of it.

Brian J. O'Neill
Shell Int'l Exploration & Production Inc.
EP Solutions
P.O. Box 51510
New Orleans, Louisiana 70151-1510
brian.oneill@shell.com

REFERENCES:

Armentrout, J. M., 1996, High resolution sequence biostratigraphy: examples from the Gulf of Mexico Plio-Pleistocene, in J.A. Howell, and J. F. Aitken (eds.) High Resolution Sequence Stratigraphy: Innovations and Applications, Geological Society, London, Special Publications 104, 65-86.

Armentrout, J.M., M.A. Lorente, B. Ozumba and S. van Heck, 2001, Industrial Paleontology, in H.R. Lane, F.F. Steininger, R.L. Kaesler, W. Ziegler and J. Lipps, Fossils and the future, Paleontology in the 21st century, Senckenberg-Buch, No. 74, p. 83-102.

Holmes, N.A., 1999, The Andrew Formation and 'biosteering' – different reservoirs, different approaches, in R.W. Jones and M.D. Simmons (eds.), Biostratigraphy in Production and Development Geology, The Geological Society (London), Special Pub. 152, p. 155-166.

Jones, G.D., A. Gary, and V. Waters, 1996, Applying the integrated paleontological system: Interpreting sequence stratigraphic architecture from microfossil signatures, Oligocene to Pleistocene section, Gulf of Mexico, in J.E. Repetski, ed., Sixth North American Paleontological Convention Abstracts of Papers, Paleontological Society Special Pub. No. 3, p. 202.

Jones, G.D., A.C. Gary, B. Kohl, R.H. Fillon, H.H. Roberts, B.J. O'Neill and R.J. Witmer, 2003, Biostratigraphic techniques for locating the position of ancient shelf margins: Examples from the Neogene of the Northern Gulf of Mexico, in H.H. Roberts, N.C. Rosen, R.H. Fillon and J.B. Anderson (eds.), Shelf Margin Deltas and Linked Down Slope Petroleum Systems: Global Significance and Future Exploration Potential, 23rd Annual GCSSEPM Foundation Bob F. Perkins Research Conference, p.767-784.

Jones R.W. and M.D. Simmons (eds.), 1999, Biostratigraphy in Production and Development Geology, The Geological Society (London), Special Pub. 152, 318 pp.

The Hand Lens—a student forum

Carbon Isotope Stratigraphy: a Gateway to the Past, Present, and Future

Analyzing sequences of marine carbonates and shales for carbon isotopes, *carbon isotope* (d^{13}C) *stratigraphy*, is a relatively young field in sedimentary geology. Carbon isotope stratigraphy is useful for interpreting changes in the global carbon cycle (i.e. stronger biological pumping of carbon, weathering of carbonates), changes in atmospheric pCO_2 , and as a stratigraphic correlation tool. Marine carbonate sequences may provide a record of primary seawater carbon isotope (d^{13}C) values. These d^{13}C values are not always constant through geologic time; fluctuations in carbon isotopes that take place on time scales longer than 10^5 years are called 'excursions' and can either be positive or negative relative to an established base line. There are more documented positive d^{13}C excursions in the geologic record (some as high as = +7‰, i.e., Lower Mississippian excursion), thus they have been studied more extensively and their potential causes are better understood.

Pioneering work on carbon isotope stratigraphy was done on several intervals of the Phanerozoic in early to mid-1980's. It was during this time that a global positive carbon isotope shift (~+2‰) was documented from the Middle Cretaceous (Arthur and others, 1987), and the oceanic anoxic events (OAE) model was proposed to explain the excursion. Other pioneering workers were documenting d^{13}C positive shifts (~+5‰) in Neoproterozoic carbonates (Knoll and others, 1986). Neoproterozoic carbon isotope stratigraphy continued in the 1990s (Kaufman and others, 1993) focusing on the documented negative d^{13}C shifts, which are important in the 'Snowball Earth' hypothesis (Hoffman and others, 1998). Brenchley and others (1994) analyzed Paleozoic carbonates and documented a global positive d^{13}C excursion in the Latest Ordovician. Kump and others (1999) suggested this excursion was associated with the Hirnantian glaciation, due to increased carbonate weathering resulting from a global regression. Other lower Paleozoic d^{13}C stratigraphy was done during the late 1990s for the Upper Cambrian, which documented a positive d^{13}C excursion (Saltzman and others, 2000). Carbon isotope stratigraphy continues today as a vigorous area of research in most marine carbonates of the geologic past. In recent years several additional lower Paleozoic positive carbon isotope excursions have been discovered. One direction carbon isotope stratigraphy will head is extensively studying these recently identified Paleozoic positive d^{13}C excursions.

As a graduate student working on carbon isotope stratigraphy, I have learned to target the thickest and stratigraphically most complete sequences. These sequences must have detailed lithostratigrapy and biostratigraphy in order to establish time frames and datums for any potential excursion and relations with lithofacies, sea level, biozones, and extinction events. Sequence and event stratigraphy are also helpful in establishing any potential relations an excursion has to sea-level cycles or event beds. Once carbon isotope data is coupled with lithostratigraphic, biostratigraphic, sequence, and/or event stratigraphic data, d^{13}C excursions can be used as stratigraphic correlation tools. With these established relations a particular d^{13}C excursion can be studied on a local to global scale, and depending upon the study's focus knowledge is gained about paleoceanography (ocean circulations, upwelling, water column stratification) and sedimentation rates in a particular basin(s), carbonate platform, or in the global oceans. Analyzing d^{13}C excursions on a global scale allows for mechanisms and models to be adopted or proposed for d^{13}C excursions. Depending upon the cause(s) of the d^{13}C excursions they can be linked to atmospheric pCO_2 draw-downs and climatic cooling. This takes place because with increased photosynthesis, there is enhanced organic carbon burial that pumps more organic carbon to the deep sea. This reduces CO_2 levels and cools the climate.

In my recent work on the Middle Ordovician Guttenberg Carbon Isotope Excursion (GICE) I have had to develop a multidisciplinary approach to studying many aspects of this excursion as well as building on previous carbon isotope stratigraphy done on this excursion (Ludvigson and others, 2000). As a carbon isotope stratigrapher there are many subdisciplines of geology that I must understand (e.g., sedimentology, biostratigraphy, sequence stratigraphy, isotope geochemistry, and paleoceanography). With an understanding of all these subdisciplines of geology I was then able to establish relations of the GICE in sections from Laurentia, to biostratigraphy, sequence and event stratigraphy, paleoceanography, aquafacies (temperature-salinity-defined water masses), and potentially global climate.

Carbon isotope stratigraphy is an exciting field of sedimentary geology to be involved in because it's a relatively new and multidisciplinary field. Carbon isotope stratigraphy has many uses and combines many subdisciplines of geology for a complete understanding of the global carbon cycle in the geologic past. A complete understanding of carbon isotope stratigraphy, especially in the Paleozoic where there are several d^{13}C perturbations on time scales longer than 10^5 years, is essential in understanding the dynamics of Earth's history. Paleozoic excursions are of particular interest to me because they are generally larger magnitude and longer duration than those perturbations found in Mesozoic and Cenozoic strata. Much is still to be gained from Paleozoic carbonate sequences, and carbon isotope stratigraphy can allow for a greater understanding of this part of Earth's geologic history. The future of carbon isotope stratigraphy will be in understanding these perturbations in the global carbon cycle through geologic time, using carbon isotopes along with other isotope stratigraphy (i.e. Sr, Nd), as well as looking at relationships of carbon isotope stratigraphy to glaciations and glacio-eustatic sea level changes. There are many directions that carbon isotope stratigraphy can head and many problems that it can potentially address. As a carbon isotope stratigrapher, I realize that being knowledgeable in multiple fields of geology allows for the potential to solve complex geologic problems and have a greater understanding of Earth's dynamic history.

Seth A. Young
Department of Geological Sciences, The Ohio State University, 275 Mendenhall Laboratory, 125 S. Oval Mall, Columbus, OH 43210, USA; young.899@osu.edu

REFERENCES

Arthur, M. A., Schlanger, S. O., and H. C. Jenkyns. 1987. The Cenomanian-Turonian oceanic anoxic event, II. Palaeoceanographic controls on organic-matter production and preservation. Geological Society of London Special Publication 26:401-420.

Brenchley, P. J., Marshall, J. D., Carden, G. F., Robertson, D. B., Long, D. F., Meidla, T., Hints, L., and Anderson, T. F. 1994. Bathymetric and isotopic evidence for a short-lived late Ordovician glaciation in a greenhouse period. Geology 22:295-298.

Hoffman, P.F., Kaufman, A.J., Halverson, G.P., and Schrag, D.P. 1998. A Neoproterozoic snowball Earth. Science 281:1342-1346.

Kaufman, A.J., Jacobsen, S.B., and Knoll, AH. 1993. The Vendian record of Sr and C isotopic variations in seawater: Implications for tectonics and paleoclimate. Earth and Planetary Science Letters 120: 409-430.

Knoll, A.H., Hayes, J.M., Kaufman, A.J. , Swett, K., and Lambert, I.B. 1986. Secular variation in carbon isotope ratios from Upper Proterozoic successions of Svalbard and East Greenland. Nature 321: 832-838.

Kump, L. R., Arthur, M. A., Patzkowsky, M. E., Gibbs, M. T., Pinkus, D. S., and Sheehan, P. M. 1999. A Weathering hypothesis for glaciation at high atmospheric pCO_2 during the Late Ordovician. Palaeogeography, Paleoclimatology, Paleoecology 152:173-187.

Ludvigson, G. A., Witzke, B. J., Schneider, C. L., Smith, E. A., Emerson, N. R., Carpenter, S. J., and Gonzalez, L. A. 2000. A profile of the Mid-Caradoc (Ordovician) carbon isotope excursion at the McGregor Quarry, Clayton County, Iowa. Geological Society of Iowa Guidebook 76:25-31.

Saltzman, M. R. Brasier, M. D., Rippperdan, R. L., Ergaliev, G. K., Lohmann, K. C., Robinson, R. A., Chang, W. T., Peng, S., and B. Runnegar. 2000. A global carbon isotope excursion (SPICE) during the Late Cambrian: relation to trilobite extinctions. Palaeogeography, Paleoclimatology, Paleoecology 162: 211-223.

Volume 2, No. 2 - June 2004 (2.6MB) -- correction

CORRECTION: In the Field Notes article of the June, 2004 issue, the following references were omitted:

Mann, K.O. and H.R. Lane, 1995, Graphic Correlation, SEPM (Society for Sedimentary Geology), Sp. Pub. 53, 263 pp.

Olson, H.C., A.C. Gary and G.D. Jones, 2003, Similarity curves as indicators of stratigraphic discontinuities, in H.C. Olson and R.M. Leckie (eds.), Micropaleontologic proxies for sea-level change and stratigraphic continuities, SEPM (Society for Sedimentary Geology), Sp. Pub. 75, p. 89-96.

O'Neill, B.J., A.E. DuVernay and R.A. George, 1999, Applied palaeontology: a critical stratigraphic tool in Gulf of Mexico exploration and exploitation, in R.W. Jones and M.D. Simmons (eds.), Biostratigraphy in Production and Development Geology, The Geological Society (London), Sp. Pub. 152, p. 303-308.