# The SEDIMENTARY Record

doi: 10.2110/sedred.2010.4
Volume 8, No. 4, December 2010

A publication of SEPM Society for Sedimentary Geology
with the Sedimentary Geology Division of GSA

**INSIDE:** THE PLEISTOCENE COOLING BUILT CHALLENGER MOUND, A DEEP-WATER CORAL MOUND IN THE NE ATLANTIC: SYNTHESIS FROM IODP EXPEDITION 307

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## Cenozoic Carbonate Systems of Australasia

*Edited by: William A. Morgan, Annette D. George, Paul M. (Mitch) Harris, Julie A. Kupecz, and J.F. (Rick) Sarg*

The Cenozoic carbonate systems of Australasia are the product of a diverse assortment of depositional and post-depositional processes, reflecting the interplay of eustasy, tectonics (both plate and local scale), climate, and evolutionary trends that influenced their initiation and development. These systems, which comprise both land-attached and isolated platforms, were initiated in a wide variety of tectonic settings (including rift, passive margin, and arc-related) and under warm and cool-water conditions where, locally, siliciclastic input affected their development. The lithofacies, biofacies, growth morphology, diagenesis, and hydrocarbon reservoir potential of these systems are products of these varying influences.

The studies reported in this volume range from syntheses of tectonic and depositional factors influencing carbonate deposition and controls on reservoir formation and petroleum system development, to local studies from the South China Sea, Indonesia, Kalimantan, Malaysia, the Marion Plateau, the Philippines, Western Australia, and New Caledonia that incorporate outcrop and subsurface data, including 3-D seismic imaging of carbonate platforms and facies, to understand the interplay of factors affecting the development of these systems under widely differing circumstances.

This volume will be of importance to geoscientists interested in the variability of Cenozoic carbonate systems and the factors that controlled their formation, and to those wanting to understand the range of potential hydrocarbon reservoirs discovered in these carbonates and the events that led to favorable reservoir and trap development.

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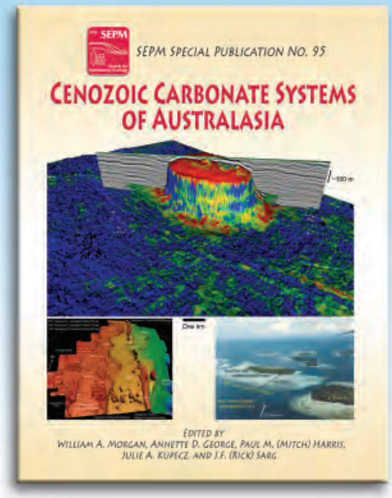



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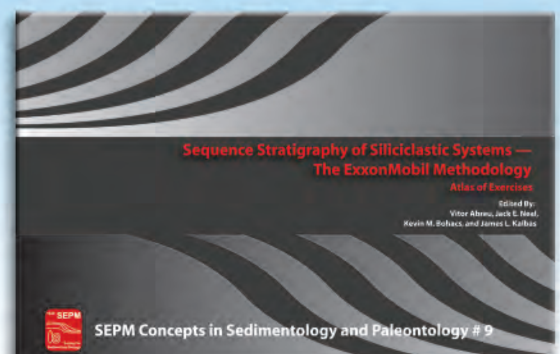
## Sequence Stratigraphy of Siliciclastic Systems – The ExxonMobil Methodology

*Edited by: Vitor Abreu, Jack E. Neal, Kevin M. Bohacs and James L. Kalbas*

The stratigraphic concept of a depositional sequence was introduced to the scientific literature by Exxon Production Research Company (EPRco) in the late 70s, building on the shoulders of giants like Chamberlain, Sloss and Wheeler. Since then, several papers compared and contrasted the original Exxon (and later, ExxonMobil) sequence-stratigraphic school with other approaches to subdivide the geologic record, as well as, debating the ExxonMobil model validity and impact on the community. At its core, the ExxonMobil "model" is really a stratigraphic interpretation method, which was never explicitly documented in the literature. The objective of this book is to present the ExxonMobil sequence stratigraphic method in its current form in an attempt to clarify its usage and application in diverse geologic data and depositional environments. This publication is the result of more than 3 decades of sequence stratigraphy research and application at EPRco and at the ExxonMobil Upstream Research Company (URC). The objective is to emphasize the most important aspects of Sequence Stratigraphy – a method to guide geologic interpretation of stratigraphic data (seismic profiles, well-logs, cores and outcrops) across scales (from local to regional and global) and depositional environments (from continental to deep marine).

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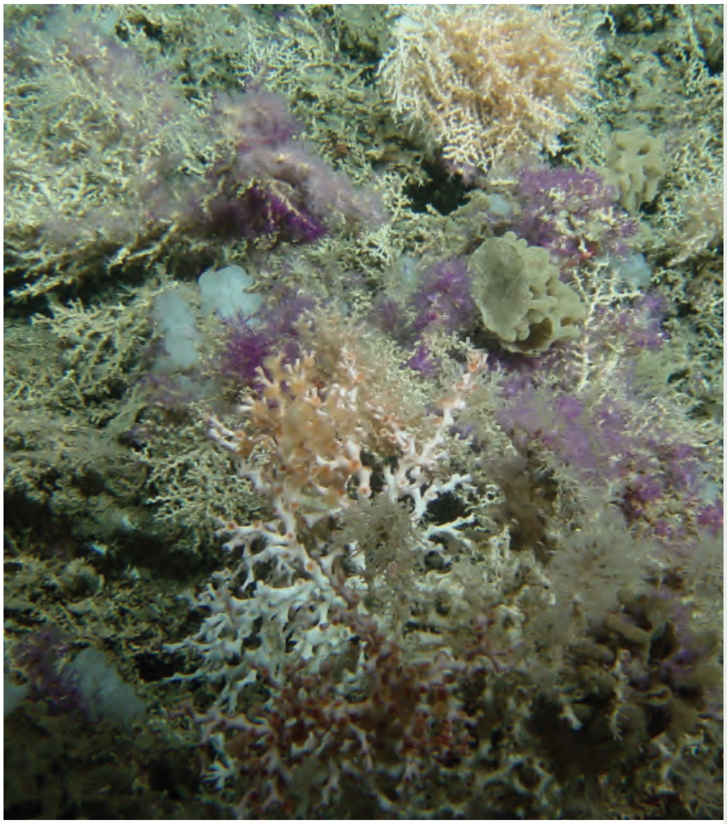

*Cover photo: Living deep-water mound community on Galway Mound (51°27'N and 11°45'W) located 9 km NNW from Challenger Mound drilled during IODP Expedition 307. The mound surface was densely colonized mainly by a branching coral species, Lophelia pertusa. This ROV imagery was collected with the ROV Victor 6000 onboard of the R/V Polarstern on the Alfred-Wegener Institute coordinated cruise ARK XIX/3a in June 2003. The imagery is courtesy and copyright of IFREMER.*

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The Sedimentary Record (ISSN 1543-8740) is published quarterly by the Society for Sedimentary Geology with offices at 4111 S. Darlington, Suite 100, Tulsa , OK 74135-6373, USA.






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# The Pleistocene Cooling Built Challenger Mound, a Deep-water Coral Mound in the NE Atlantic: Synthesis from IODP Expedition 307

**Akihiro Kano[1]*, Timothy G. Ferdelman[2], Trevor Williams[3]**
[1]Graduate School of Social and Cultural Studies, Kyushu University, Motooka 744, Fukuoka 819-0395, Japan
[2]Max-Planck-Institute for Marine Microbiology, Celsiusstrasse 1, D-28359 Bremen, Germany
[3]Lamont-Doherty Earth Observatory, 61 Route 9W, Palisades, New York 10964, USA
*Corresponding Author, e-mail: kano@scs.kyushu-u.ac.jp, Phone: +81(92)702-5655
doi: 10.2110/sedred.2010.4.4

## ABSTRACT

IODP Expedition 307 revealed the interior of a deep-water coral mound in NE Atlantic for the first time and improved our understanding of these intriguing structures. From the summit of our drilling target, Challenger Mound at ~800 m deep in the Porcupine Seabight, south west of Ireland, we recovered the entire mound section of 155 m long, which almost entirely consists of coral-bearing sediments and rests on the Miocene siliciclastics.

The mound initiation is temporally correlated to the global cooling at the beginning of Pleistocene, when modern circulation was established in Atlantic. A key oceanographic feature of the mound provinces is the density gradient that developed above the saline Mediterranean Outflow Water where organic particles persist for a longer time and fuel the coral communities.

Growth of the deep-water mounds reflected the glacial/interglacial change. Our age model recognized two growth stages separated by a substantial hiatus; the depositionally continuous lower mound (2.6-1.7 Ma) accumulated under the low-amplitude relative sea-level change, and the discontinuous upper mound (1.0 Ma to mid-Holocene) developed under the high-amplitude relative sea-level change. Low cellular abundances in the geochemical features of the mound sediments did not support the hypothesis that hydrocarbon seepage and associated microbial activity significantly enhanced mound initiation and development.

Key Words: deep-water coral mound, Pleistocene, IODP

## ENIGMATIC MOUNDS ON THE SEAFLOOR

That non-photosynthetic coral communities can thrive at great depths of >1000 m has been known since the mid-eighteen century, but only in the 1960s did deep-sea exploration lead to the discovery of mound-like structures covered with corals (Stetson and Squires, 1962). These coral build-ups form up to several kilometer wide and up to 350 m high mounded topography on shelf slopes and seamounts in water-depths down to 1500 m Superficial biota and sediments associated with these unique ecosystems and geological structures have been revealed in subsequent oceanographic surveys over the last decade.

Despite recent and intense exploration, detailed information on the stratigraphy, lithology and geochemistry of deep-water coral mounds is very limited. To establish a depositional and biogeochemical/diagenetic model, Challenger Mound (Fig. 1; Site U1317, 52°23' N, 11°43' W, water depth = ca. 800m) in the Porcupine Seabight was drilled during the IODP Expedition 307 in May 2005. To place Challenger Mounds in the regional stratigraphic framework of the Northeastern Atlantic, we also drilled and examined two other sites: Site U1316 at the basin-ward foot of Challenger Mound and Site U1318 on the shallower shelf slope (Fig. 1).

## PORCUPINE MOUND PROVINCE

The Porcupine Seabight, located to the west of Ireland, is a well-studied mound area in north Atlantic. In this 50 km long and 65 km wide embayment (Fig. 1), more than 2000 mounds cluster in four provinces (Magellan, Hovland, Viking, and Belgica; Fig. 1) at water depths ranging from 550 to 1030 m (Foubert and Henriet, 2009).

Mounds appear to align along bathymetric contours (Beyer et al., 2003) suggesting a preferential depth range. The hydrography of the Porcupine mound provinces is characterized by two stratified water masses: the warm Eastern North Atlantic Water (ENAW) flowing northwards within the upper 700 m and the saline Mediterranean Outflow Water (MOW) observed down to 1,200 m (De Mol et al., 2002). Living cold-water coral communities occur around the interface of ENAW and MOW, where the bottom current is strong due to internal waves and increases nutrient availability (White, 2007). Cold-water corals are heterotrophic filter feeders that rely on zooplankton and particulate organic matter (Kiriakoulakis et al., 2007).

Challenger Mound in the Belgica mound province (Fig. 1) has an elongated shape of ~1 km wide and ~150 m high. In the seismic profile, the mound occurs as a transparent seismic unit and roots on the sharp slope break of seismic unit (P1; Fig. 1).

## SEDIMENTOLOGY AND STRATIGRAPHY

### Challenger Mound (U1317)

Five holes (A-E) were drilled on the Challenger Mound in water depth ranging from 790 to 840 m. The four drilled holes (A-C, and E) a cross-section of the mound, in which the mound unit thins from the summit (Hole E) to the mound shoulder (Hole A; Fig. 2).

At Site U1317, we identified two major sedimentary units; the Pleistocene carbonate mound succession, and the Miocene calcareous silt and sandy silt (Ferdelman et al., 2006; Williams et al., 2006). A firmground consistently marks the contact between the two units (Fig. 3A), without any evidence of lithification. Lithification in the mound unit was recognized only in several intervals as irregular-shaped consolidated crusts (Fig. 3B).

The mound sediments consist of coral floatstone (Fig. 3C, D) to rudstone (Fig. 3E) with a wacke- to packstone matrix. The corals occur

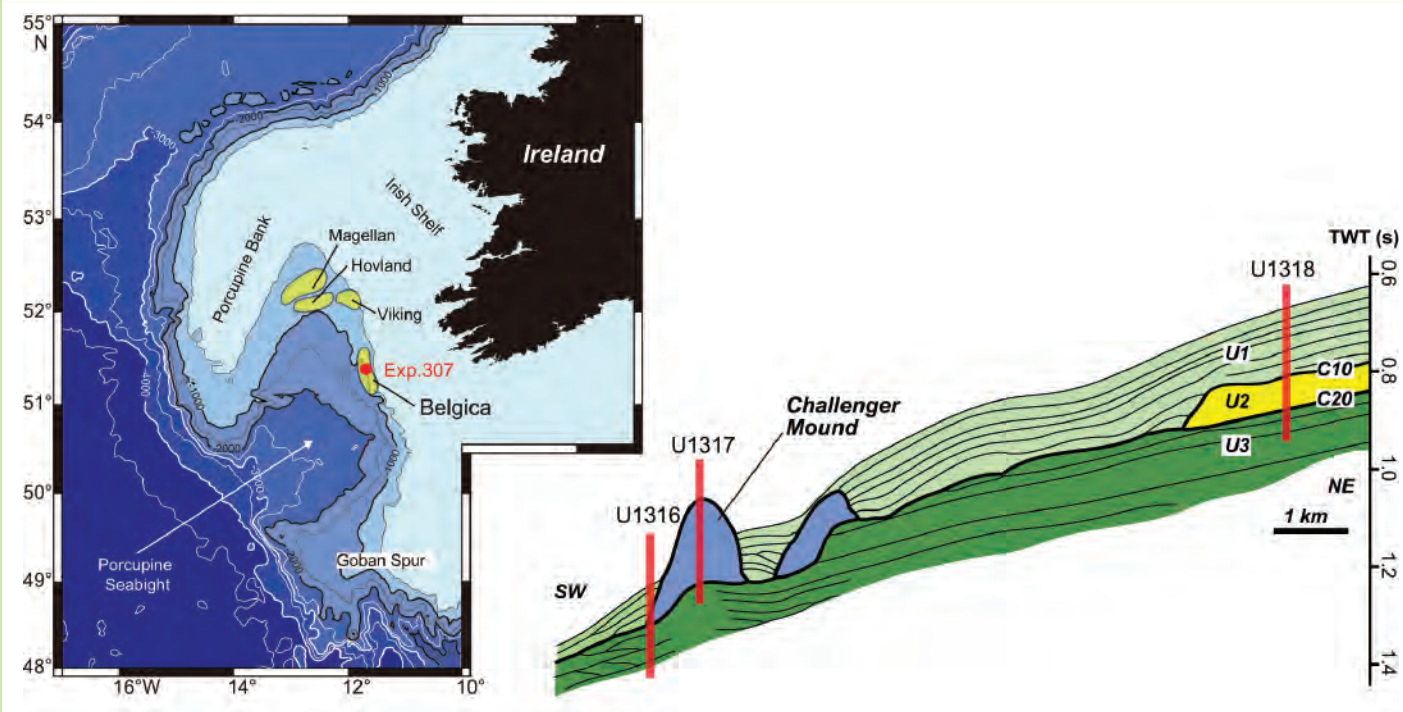


*Figure 1. Location map showing the Belgica Mound Province in Porcupine Seabight, and interpreted seismic section (De Mol et al., 2002) showing three drilling sites (U1316-1318).*

as branches of *Lophelia pertusa* (rarely *Madrepora oculata*) that forms up to 15% of the total sediment volume. The matrix is mixture of carbonates and siliciclastics.

Shipboard bio- and magneto-stratigraphy help placing the studied interval into a broad age framework. Especially significant are a continuous normal polarity signal in the uppermost 17 m that corresponds to the Brunhes chron (<0.78Ma), and the first appearance datum (FAD) of planktonic foraminifera *Globorotalia inflata* (2.09Ma) at ~65 mbsf (meter below sea floor) of Hole U1317E (Fig. 4). The age model was improved by integrating the Sr isotope stratigraphy of coral skeletons (Kano et al., 2007) resulting in ages generally becoming younger from ~2.60 Ma near the base to 0.57 Ma near the top (Fig. 4). This age model also revealed a significant hiatus of 0.7 Myr (1.7-1.0 Ma) within the mound succession at 23.6 mbsf. The hiatus defines the boundary between the lower mound and the upper mound (Fig. 4) and is accompanied by a sharp decline in the magnetic susceptibility and NGR that were also observed in the other holes (Fig. 2; Foubert and Henriet, 2009).

Cyclic fluctuations of 10-20 m wavelength appear in lithological properties in the lower mound. The lighter colored deposits (Fig. 3C) are high in carbonate content (up to 84%), while the darker colored deposits (Fig. 3D) record high values of magnetic susceptibility, natural gamma radiation and siliciclastic fraction (Titschack et al., 2009). This cyclicity correlates well with Pleistocene glacial-interglacial fluctuations, as confirmed by $\delta^{18}O$ of planktic foraminifer (*Globigerina bulloides*) (Fig. 4; Sakai et al., 2009). The lighter interglacial layers generally have a coarse grained (typically ~50 μm) matrix winnowed by strong contour current, while the darker glacial layers contains much finer fraction (~20 μm) likely originated from ice-rafted clay (Thierens et al., 2010).

Sakai et al. (2009) recognized eleven glacial and ten interglacial intervals from the lower mound succession, which were correlated to the interval from MIS 92 (2.24 Ma) to 72 (1.82 Ma) by slightly adjusting the FAD of G. *inflata* (2.09 Ma) to 63 mbsf. However, development of the lower mound was not continuous, especially at the mound initiation stage, in which Titschack et al. (2009) observed four possible erosional surfaces.

Erosional surfaces are more common in the upper mound where a subtle cyclic change in the $\delta^{18}O$ records (Fig. 4) is observed. Since the upper mound includes the boundary between the Brunhes/Matuyama chrons, this interval was correlated to MIS 19 and 18 (0.8-0.7 Ma) by Sakai et al. (2009). However, this correlation disagrees with the longer age range (~1.0-0.5 Ma) estimated by Sr isotopic ages (Kano et al., 2007). The inconsistency can be interpreted as a result of the discontinuous deposition that has lasted at least until middle Holocene. The upper mound obviously includes several hiatal horizons, for which the age gaps have not accurately evaluated by the available methods.

**Off-Mound Sites (U1316 AND U1318)**

The most extensive sedimentary sequence below the mound-base unconformity was recovered upslope at Hole U1318B (Fig. 1). The 155-m-thick Miocene sequence (Late Burdigalian to Late Serravallian; Louwye et al., 2008) includes two seismic units U3 and U2 that are separated by an interpreted unconformity C20 (Fig. 1; Stocker et al., 2001). However both dinoflagellate biostratigraphy and magnetostratigraphy did not show any hiatus corresponding to the C20 unconformity (Louwye et al., 2008) compared to the mound-base angular unconformity (C10 in Fig. 1) which corresponds a substantial age gap of more than 7 Ma.

In well U1316, a 2-4 m thick coral-bearing unit overlies the Miocene sequence at the base of the mound. This unit is made of coral floatstone alternated with sandstone facies. At the shelf margin site (U1318), the post-Miocene sequence consists of a 4-6 m thick glauconitic sandstone which includes black apatite nodules, bivalves (Fig. 3F), and dropstones. The Sr isotopic ratio of a bivalve indicates an age ranging from 1.3 to 1.1 Ma (Kano et al., 2007), which corresponds to the major hiatus interval of Challenger Mound. The age is consistent with nannofossil assemblage indicating the early Pleistocene

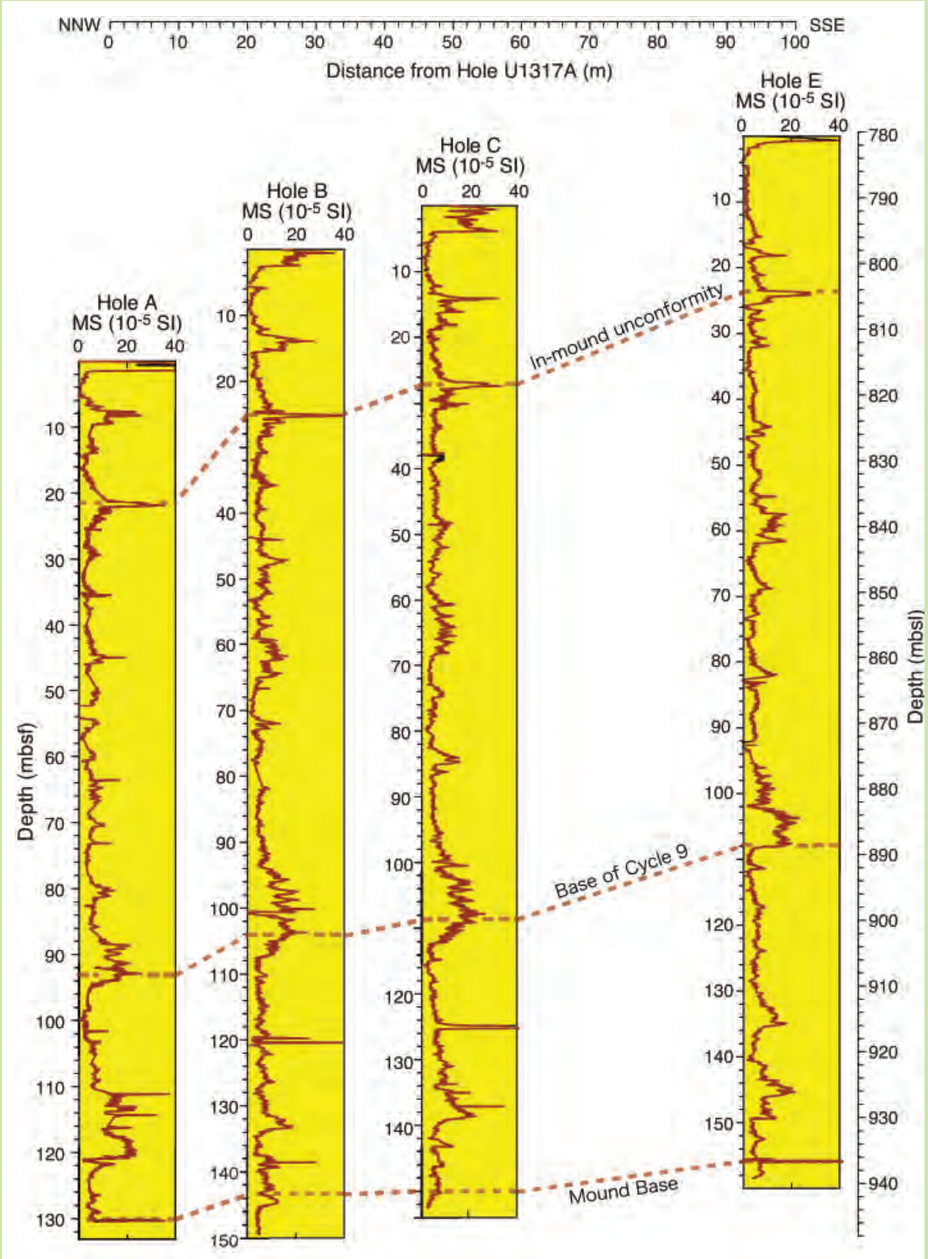


*Figure 2. Correlation of the four drilled holes at Site U1317 based on stratigraphic profile of magnetic susceptibility (SI).*

small *Gephyrocapsa* Zone (0.96-1.22 Ma).

The uppermost unit at Sites U1318 and U1316 consists of greyish brown silty clay interbedded with sandy layers, correlated with the seismic unit U1 (Fig. 1). This unconsolidated silty clay has characteristic cm-scale lamination (Fig. 3G) or is otherwise bioturbated. Dropstones are common in the upper part of the unit. Except for the lowermost part, the silty clay yields *E. huxleyi* indicating an age younger than 0.24 Ma.

## MOUND GROWTH AND INTERNAL LIFE

Analysis of the IODP Expedition 307 data indicates a link between paleoclimates and the growth of the deep-sea coral mound. Challenger Mound started growing around 2.6 Ma, approximately corresponding to newly-ratified base of the Quaternary (2.58 Ma; Gibbard et al., 2010) when there was a step to cooler global temperatures and modern Atlantic circulation began. At this time when the density gradient developed between the Mediterranean Outflow Water (MOW) and the overlying Eastern North Atlantic Water (ENAW) (De Mol et al., 2002), organic particles became concentrated at this boundary, providing food to the coral mound community. Moreover, living cold-water corals appear to be confined to a narrow range of water density (Dullo et al., 2008); suggesting that this condition first arose in the Porcupine Seabight at ~2.6 Ma. The Pleistocene global cooling amplified the glacial/interglacial cycles that were recorded in the mound sediment (Fig. 4). The amplified climate change may also have inhibited the mound growth itself. We observe that the lower mound appeared to have grown quickly when the amplitude of the change in sea-level was small. A large change in sea-level and concurrent change in the positioning of the density gradient between MOW and ENAW would have diminished food supply and coral growth.

Beside these environmental controls, processes associated with hydrocarbon seepage have been proposed to initiate and enhance mound development, as high seawater methane concentrations have been reported in near some of the mound provinces (Hovland et al., 1998). Furthermore, Paull et al. (1992) proposed that anaerobic oxidation of methane (AOM) induces increased alkalinity that results in enhanced hardground development that in turn provides suitable substrate for the corals.

Expedition 307 tested this hydrocarbon hypothesis. The first geochemical and lithological analyses quickly discounted a role for methane seepage and subsequent AOM (Ferdelman et al., 2006). The present-day zone of AMO is not within the mound sediments, but occurs in the sub-mound Miocene sediments, and there appears to be no indication of a present or past AOM signal in the dissolved methane (Mangelsdorf et al., 2010).

Mound coral ecosystems have been proposed to be “hotspots” of organic carbon mineralization and deep sub-seafloor microbial systems. However, compared with other deeply-buried, continental-margin microbial ecosystems, the Challenger Mound sediments exhibit very low rates of organic carbon turnover (Table 1). Moreover, abundances of bacteria and archaea were consistently low throughout the mound sediments itself (Webster et al., 2009). Biomarker data analysis also shows evidence of low abundance of past populations, whereas present-day bacterial populations were below the detection limit for intact phospholipid determination (Mangelsdorf et al., 2010). Interestingly, both biomarker lipid distributions and cell abundances (Webster et al., 2009) suggest that the underlying Miocene sediments, as well as the sediments from the off-mound Site U1318 contain higher abundances of living microbes. Thus, rates of microbial processes within the mound sediments are extremely low and largely decoupled from the highly diverse, active surface ecosystem (Wehrmann et al., 2009). Such microbial processes play a role in pore water and mineral diagenesis (Frank et al., 2010), but are very unlikely to contribute to the initiation and growth of the coral mound.

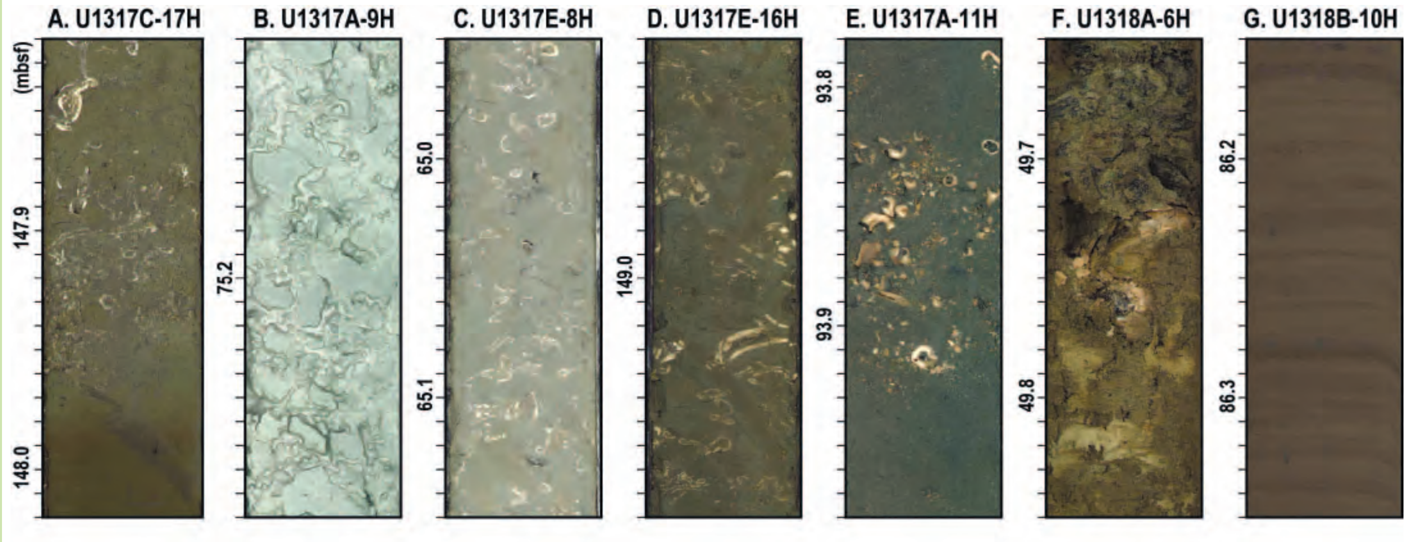


*Figure 3. Selected core images (20 cm long) from IODP Expedition 307. A. Mound base in Hole U1317C. B. Lithified mound sediment in U1317A. C. Lighter colored coral bafflestone in U1317E. D. Darker colored coral bafflestone in U1317E. E. Coral rudstone in U1317A. F. Bivalve-bearing sandy sediment in U1318A. G. Laminated silty clay in U1318B.*

## CONCLUSIONS

Our results imply that global and local oceanographic conditions were essential for the mound initiation and growth. The coral community started growing as the same time as the onset of the Pleistocene cooling. Subsequent mound growth was divided into two stages in response to different amplitudes in the climatic change; the relatively continuous lower mound accumulated under the low-amplitude relative sea-level change, and the discontinuous upper mound developed under the high-amplitude change (Fig. 4). Accumulation of drift sediment around the mound did not start until after mound growth ceased (Huvenne et al., 2009).

This control on the initiation and development of Challenger Mound may not be generalized to other deep see mounds but it does suggest future research perspectives such as whether the onset of mound development is a global geological episode that corresponds to the onset of Quaternary. Mounds in the Belgica province all root on the post-Miocene unconformity (van Rooij et al., 2003), but some, like Challenger Mound, are currently dormant and not growing, while others host active growing coral communities. We predict that each mound has its own growth history, depending on its latitude, depth, and position in the oceanographic circulation. Drilling other deep sea mounds will test this prediction.

| | $10^{-4}$mol m$^{-2}$ a$^{-1}$ | |
|---|---|---|
| | SO42- | CH4 |
| **Mound**<br>**0 - 130 mbsf** | -6.5 | -0.4 |
| **Sub-Mound Miocene Sediments**<br>**130 - 270 mbsf** | -1.6 | -1.2 |
| **Total** | -8.1 | -1.6 |
| **Peru Margin (ODP 201)** | -90 to -250 | |

*Table 1. Fluxes of methane and sulfate as indicators of anaerobic oxidation of methane and sulfate reduction. Interstitial water distributions of $SO_4^{2-}$ and methane were modelled using a one-dimensional, steady-state diagenetic model. Formation factors were estimated from porosities (ϕ) obtained onboard during Exp 307 (Ferdelman et al., 2006), and the relationship Ds= ϕ2D to correct the diffusion coefficients for tortuosity. For comparison, integrated sulfate reduction rates from the continental margin of Peru are included (D'Hondt et al., 2004).*

## ACKNOWLEDGMENTS

The successful achievements of IODP Expedition 307 would never have occurred without the dedication and enthusiasm of Prof. Jean-Pierre Henriet, who was the lead proponent of the expedition. We would like to thank the IODP and Transocean crews of the JOIDES Resolution, the staff at the College Station and Bremen core repositories, the Geological Survey of Ireland, and the members of the IODP Expedition 307 Scientific Party. We would also thank Xavier Janson, Ruarri Day-Stirrat, and Wayne Wright for their useful comments. AK acknowledges support from J-DESC; TGF from the German DFG-IODP program and the Max Planck Society, and TW from IODP-USIO.

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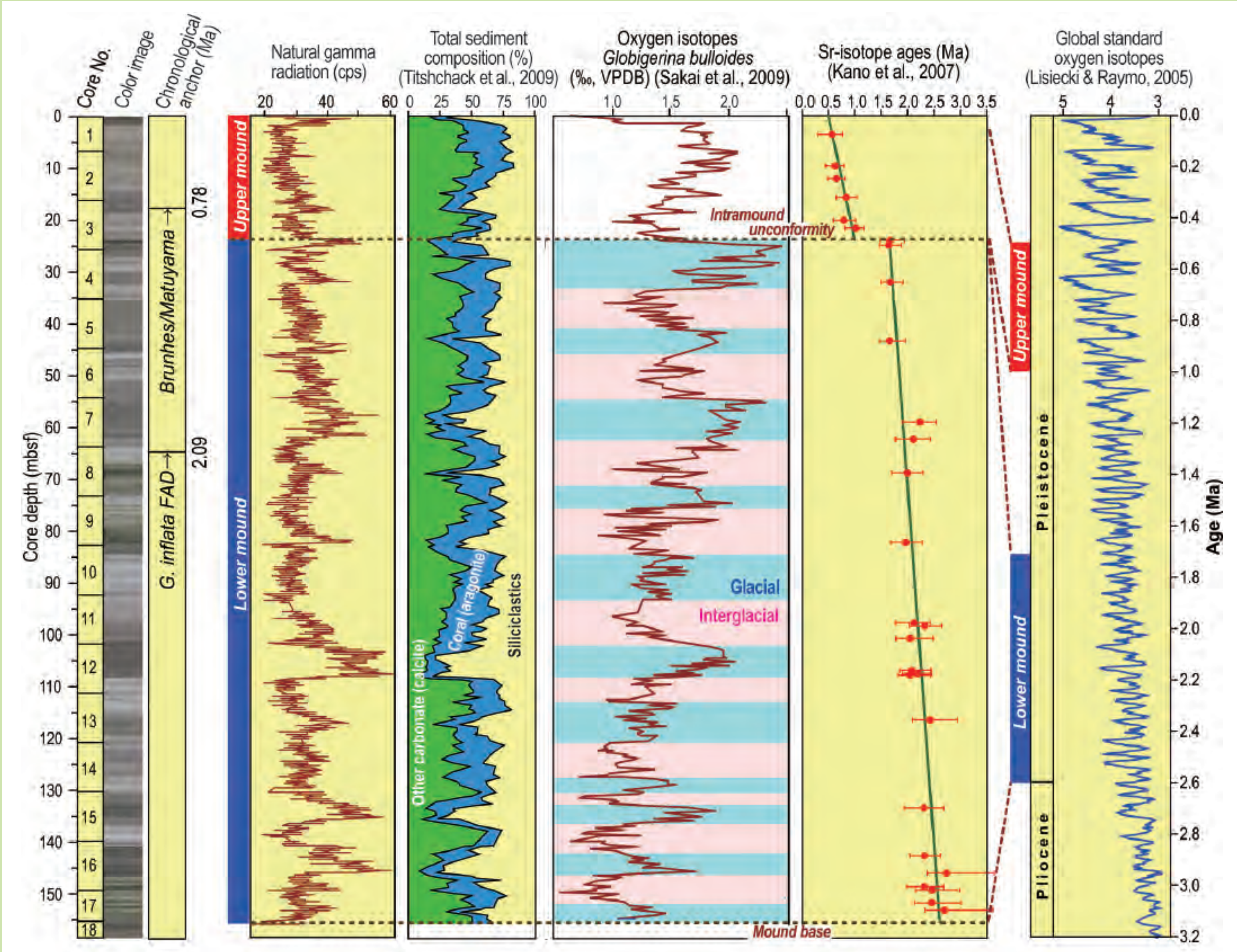

*Figure 4. Stratigraphic and geochemical profiles of the mound sequence at Hole U1317E.*


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**Accepted November 2010**

COUNCIL'S COMMENTS

# A Paleontological Perspective of SEPM

Although SEPM is now the Society for Sedimentary Geology, its origin is deeply rooted in paleontology. In fact, you may have wondered about the acronym, since the letters do not correspond to the society's name! Well, the "P" in SEPM stands for Paleontologists, which refers to the society's founding name - The Society for Economic Paleontologists and Mineralogists - which was used from 1926 until 1989, when the Society became an independent incorporated organization and the name was changed to the Society for Sedimentary Geology with SEPM remaining the organization's icon.

The history of the Society started 84 years ago with a small group of micropaleontologists within AAPG that was frustrated that the AAPG Bulletin did not adequately serve their needs to publish papers about their discipline. On March 26, 1926, nineteen of the group's leaders got together over dinner and decided to ask AAPG to sponsor a new organization along with a new journal on micropaleontology. AAPG immediately approved the request, and within a year the constitution and bylaws were completed and officially adopted, with the new organization named The Society of Economic Paleontologists and Mineralogists (SEPM). The name selected was broadened to include other specialists that were becoming active in the petroleum industry.

SEPM's first publication, the *Journal of Paleontology (JP)*, was a quarterly journal focused on micropaleontology. The new journal received a large number of manuscripts and began publication in 1927.

As the membership grew and diversified, SEPM started the *Journal of Sedimentary Petrology (JSP)* in 1931 to publish non-paleontological papers. At this time, Raymond C. Moore served as editor for both journals. By the Society's tenth anniversary in March of 1936, membership totaled 275 and both journals were well known and regarded as outstanding in their fields. Later, the format and content of JSP evolved into the current *Journal of Sedimentary Research (JSR)* with its first issue under that name released in 1994.

After 1935, SEPM and The Paleontological Society partnered to jointly publish *JP*. By 1980, *JP* had become primarily focused on taxonomy and it no longer fulfilled the needs of many of the Society's paleontologists. The Councilors for Paleontology, beginning with Léo Laporte, began arguing for a new paleontological journal focused on paleoecology and biostratigraphy. A membership questionnaire sent out in 1984 showed there was strong interest in such a journal. In response, SEPM sold its *JP* rights to The Paleontological Society and started the journal *PALAIOS* in 1986. The objective of this new journal was to publish original papers emphasizing the use of paleontology to answer important geological and biological questions aimed at understanding Earth's history. Today, *PALAIOS* is the journal of choice to publish innovative research on all aspects of past and present life as reflected in the sedimentary record. The journal focuses on finding solutions to problems decoded from geological, biological, chemical, and atmospheric processes.

SEPM's first published book was a small one entitled *Bibliography of Otoliths (Special Contribution No. 1)*, compiled by Robert Campbell. The Society is still receiving small revenues for the sale of this little paleontological book on fish ear bones after its reissue on CD in 2008. Today, the Society continues to publish high quality books (Special Publications, Short Course Notes and Core Workshop Notes) that highlight a variety of relevant themes focused on sedimentology and paleontology. Some recent paleontological books include *Cretaceous Rudists & Carbonate Platforms* (SP 87), *Sediment-Organism Interactions, a Multifaceted Ichnology* (SP 88), *Geologic Problem Solving with Microfossils* (SP 93), *Continental Trace Fossils* (SC 51), and *Applied Ichnology* (SC 52).

Raymond C. Moore was the first recipient in 1973 of the William H. Twenhofel Medal, the highest award of the Society, for a career of Outstanding Contributions to Sedimentary Geology. At that time, the Society recognized that no one had done more for it than Twenhofel and Raymond Moore. Ray started *JSP* and 'Twenny' nursed it through 17 of its developing years. In 1979, SEPM named the Moore Medal in honor of Raymond C. Moore for his personal contributions to paleontology and his remarkable career that included being one of the founders of SEPM, initiator of *JSP*, and Director and Editor for the *Treatise on Invertebrate Paleontology*. Established for "Excellence in Paleontology," this award's first recipient was Norman Newell in 1980.

Today, SEPM is the largest and premier society emphasizing sedimentary geology and paleontology in the world with a significant international membership. It continues to disseminate information through its journals, *PALAIOS* and *JSR*, Special Publications, Short Courses, Field Trips, Research Groups, technical sessions at conventions, and Research Conferences, such as the North American Micropaleontology Section, SEPM (NAMS) conferences on "Geologic Problem Solving with Microfossils I and II" in 2005 and 2009, "Ichnological Applications to Sedimentological and Sequence Stratigraphic Problems" in 2007 and "Microbial Mats - Sediments" held in May of 2010.

The "P" in SEPM is alive and well. In all of its activities, the Society honors the legacy of its outstanding paleontologic founders and those who followed them. Our society will continue to be a leader in sedimentary geology and paleontology, working with our sister societies, industry, academia, and the public through **S**ponsorship, **E**ducation, **P**artnership, and **M**entoring - - **SEPM**!

***From SEPM Council Members***
***Nancy Engelhardt-Moore, Edith L. Taylor, Stephen Hasiotis, and Paul (Mitch) Harris***

# 2011 SPRING SEPM SECTION MEETINGS


## NORTHEASTERN/NORTH-CENTRAL SECTIONS GSA JOINT MEETING- WITH THE EASTERN AND GREAT LAKES SECTIONS OF SEPM

**http://www.geosociety.org/Sections/ne/2011mtg/**

The joint SEPM (Eastern and Great Lakes Sections) and Paleontological Society Reception and Keynote Address are scheduled for 6:00 to 8:00 pm on Sunday, March 20th, 2011 during the Pittsburgh NE/NC GSA Meeting. The keynote address will be given by the SEPM Secretary-Treasurer Diane Kamola from the Department of Geology at the University of Kansas.

The following are **SEPM Section sponsored events** at the spring regional Geological Society of America meetings.

**Abstract Deadlines are December 14, 2010.**

## NORTHEASTERN GSA MEETING

**Pittsburgh, Pennsylvania, 20-22 March 2011**

Chairs: NC - Daniel K. Holm (dholm@kent.edu), and NE - Patrick Burkhart (patrick.burkhart@sru.edu)

**Theme Sessions:**

- Mesozoic/Cenozoic Vertebrate Paleontology
- Quaternary History of the Great Lakes
- The Effect of Late Paleozoic Tectonics on the Devonian Shales
- Provenance of Organic Content in the Marcellus Shale
- Life's Footprint: New Frontiers in Field and Experimental Trace Fossil Research

**Workshop:**

**Sequence Stratigraphy for Graduate Students - Sat-Sun, March 19-20, 2011**

Instructor: Vitor Abreu (Senior Technical Consultant - Hydrocarbon Systems, ExxonMobil Upstream Research Company)

Description: This course is designed to teach graduate students the principles, concepts and methods of sequence stratigraphy. Sequence stratigraphy is an informal chronostratigraphic methodology that uses stratal surfaces to subdivide the stratigraphic record. This methodology allows the identification of coeval facies, documents the timetransgressive nature of classic lithostratigraphic units and provides geoscientists with an additional way to analyze and subdivide the stratigraphic record. Using exercises that utilize outcrop, core, well log and seismic data, the course provides a hands-on experience to learning sequence stratigraphy. Fee: $25; limited to 20 graduate students

## SOUTHEASTERN GSA MEETING:

**http://www.geosociety.org/Sections/se/2011mtg/**

**Wilmington, North Carolina, 23-25 March 2011**

Chairs: Richard Laws (laws@uncw.edu) and Bill Harris (harrisw@uncw.edu)

**Symposia:**

- Coastal Response to Sea Level and Climate Changes; A Tribute to the Career of Stan Riggs
- Coastal Response to Tidal Inlets: A Tribute to the Career of Bill Cleary

**Theme Sessions:**

- Karst Geology and Hydrology
- Surficial and Subsurface Geology and Hydrogeology of the Cape Fear River Basin
- Energy Sources and Issues: "Offshore and Unconventional"
- Reducing Carbon Dioxide Emissions in the Southeast: Advances in Geologic Carbon Sequestration and
- CO2-Enhanced Oil Recovery

**Field Trip:**

**Natural Gas Potential of the Sanford Sub-Basin, Deep River Basin, North Carolina.**

Kenneth Taylor (kenneth.b.taylor@ncdenr.gov) and Jeff Reid (jeff.reid@ncdenr.gov), North Carolina Geological