The SEDIMENTARY Record

Volume 1, No. 2
September 2003

A publication of SEPM Society for Sedimentary Geology

INSIDE: BIOTURBATION AND EROSION SURFACES

PLUS: SPECIAL FEATURES ON “THE FUTURE OF SEPM”

PRESIDENT’S OBSERVATIONS—NSF PALEOCLIMATE WORKSHOP

COMMENTS FROM COUNCIL—HAND LENS
Simple Gifts and Buried Treasures – Implications of Finding Bioturbation and Erosion Surfaces in Black Shales

The Hand Lens—a student forum
A Muddied Perspective on the Future of Sedimentary Research

NSF-Sponsored Workshop on Deep-Time Paleoclimatology

Comments from the council
SEPM International Activities

President’s Observations
Charting a Course

Cover art: Progressive burrowing of self-compacting mud: summary of observations from trace fossils in black shale-gray shale couplets (Fig. 1, Schieber, this issue). Cross-cutting relationships show that burrows are emplaced in the following succession: “Mantle and Swirl,” Planolites, Teichichnus, Palaeophycus, and Chondrites. The axis ratio of burrow tubes shows that early burrows were emplaced in a watery and soupy substrate, whereas late burrows were emplaced into a substrate of firm consistency (see Schieber, this issue).

FREE Books for Students

Enclosed with this issue of The Sedimentary Record you should have received a “Free Books for Students” flyer. This promotion is available only to current student members in good standing.

If you are a student member just follow the instructions on the flyer to receive your free books. (If your membership has lapsed, you will need to pay your dues before participating.)

If you are no longer a student feel free to forward this offer to any geology student and encourage them to join the Society now to take advantage of this offer. They can submit a Student Membership Application along with a Free Book Order Form. Dues start at $25 a year. In addition to making them eligible for the free books, their student membership also includes a subscription to either the Journal of Sedimentary Research or Palaios. Applications for membership are available at www.sepm.org.

Upcoming SEPM Research Field Conference
August, 2004 - Colorado, USA
Be there for:
RECENT ADVANCES IN SHORELINE-SHELF STRATIGRAPHY
Modern vs. Ancient, Outcrop vs. Subsurface, Observation vs. Modeling

Gary Hampson (Imperial College London), Ron Steel (University of Wyoming), Bob Dalrymple (Queen’s University, Ontario), and Pete Burgess (Shell International E&P, Rijswijk)

Editors
Loren E. Babcock, Department of Geological Sciences, The Ohio State University, Columbus, Ohio 43210 <babcock.5@osu.edu>
Stephen A. Leslie, Department of Earth Science, University of Arkansas at Little Rock, Little Rock, Arkansas 72204 <saleslie@ualr.edu>
Marilyn D. Wegweiser, Department of Biological and Environmental Sciences, Georgia College and State University, Milledgeville, Georgia 31061 <wegweise@gcsu.edu>

SEPM Staff
6128 East 38th Street, Suite #308, Tulsa, OK 74135-5814
Phone (North America): 800-865-9765
Phone (International): 918-610-3361
Dr. Howard Harper, Executive Director <hharper@sepm.org>
Theresa Scott, Business Manager <tscott@sepm.org>
Kris A. Farnsworth, Publications Coordinator <kfarnsworth@sepm.org>
Judy Tarpley, Event and Conference Manager <jtarpley@sepm.org>
Michele Woods, Membership Services Associate <mwoods@sepm.org>
Simple Gifts and Buried Treasures – Implications of Finding Bioturbation and Erosion Surfaces in Black Shales

Jürgen Schieber
Department of Geological Sciences
Indiana University
1001 E. 10th St., Bloomington, IN 47405
jschiebe@indiana.edu

ABSTRACT: Detailed sedimentological study of Devonian black shales from the eastern USA shows that these rocks contain valuable textural clues to their depositional history, clues that hitherto have gone mostly unrecognized. Cryptic bioturbation and subtle erosional features suggest the presence, originally, of much more benthic life and bottom current activity than is commonly assumed for these deposits. Sedimentary features observed in black shales can provide prima facie evidence of depositional processes at a resolution that is hard to match with geochemical approaches. No geochemical study of black shales should be conducted without careful sedimentological evaluation because subtle sedimentary features may have a direct bearing on the applicability of proposed genetic models. Knowledge of sedimentary features is required to guide geochemical sampling so as to avoid averaging intervals of dissimilar origins, and to provide critical constraints for the interpretation of geochemical data sets.

INTRODUCTION

Fine-grained terrigenous clastics, also known as mudstones and shales, are in general a still poorly understood and understudied group of sedimentary rocks. Nonetheless, they dominate the sedimentary record in terms of rock volume and recorded time. The one exception within this category is those fine-grained siliciclastics that contain appreciable quantities of organic carbon, the so-called black shales. Although black shales constitute only a small proportion of the total volume of fine-grained siliciclastics, they have received more study than all other mudstones and shales combined. For a long time the reasons for this have been economic in nature, owing to the fact that probably more than 90 percent of the world’s recoverable oil and gas reserves were sourced from black shales (Klemme and Ulmishek, 1991).

Because organic carbon results mostly from photosynthesis by plants and algae, an atom of carbon buried in sediments implies a molecule of oxygen added to the atmosphere. Carbon burial is linked to other global biogeochemical cycles (O, S, N, P, etc.) and is a critical variable in our attempts to understand the history and evolution of the oceans and atmosphere, as well as global climate change. Over geologic time, carbon burial probably was responsible for a gradual rise in atmospheric oxygen levels. Also, by reducing the greenhouse effect it can lead to lower global temperatures and even ice ages (Berner, 1997). In that context, considering that the geological record is punctuated by global episodes of widespread black shale formation (Klemme and Ulmishek, 1991), understanding what variables are required to produce a “black shale world” is of considerable significance.

Early comparisons with black muds from the bottom of the Black Sea have long led geologists to think that ancient black shales required anoxic bottom waters for their formation, and that they typically formed in the distal and deepest portions of sedimentary basins. Recent research into black shales (e.g., Schieber, 1998; Sageman et al., 2003), however, has shown this to be a highly simplistic, though widely held, notion. Much progress has been made towards appreciating the often subtle differences between black shale formations and arriving at sophisticated appraisals of their depositional histories. Wignall (1994) provided a good overview of progress that has been made and controversies that still remain.

A central theme in black shale studies has been the detection of bottom water anoxia at the time of deposition. A variety of approaches have been tried to that end, including geochemical proxies (e.g., Raiswell and Berner, 1985; Jones and Manning, 1994), paleoecological measures (e.g., Richter, 1931; Rhoads and Morse, 1971; Kauffman and Sageman, 1988), ichnological criteria (e.g., Savrda and Bottjer, 1986; Ekdale and Mason, 1988; Wignall, 1994), sedimentological assessments (e.g., Rich, 1951; Conant and Swanson, 1961; Schieber, 1994), or combinations of approaches (e.g., Seilacher and Meischner, 1964; Heckel, 1977; Baird and Brett, 1991; Sageman et al., 2003).

In this paper, I will focus on the benefits of inferences derived from careful visual examination of black shales. I will also point out cases where geochemical proxies for the state of oxygenation clearly disagree with what the rocks themselves are telling us, and what the implications are for geochemical approaches to black shale origins. All examples are from Devonian black shales of the eastern USA. A still widespread perception of these sediments is that they were largely devoid of benthic life because of prevailing anoxic conditions (Ettenson, 1985; Cluff, 1980). Based on the observations in the following examples, a case can be made that benthic occupation and bottom current activity was probably the norm rather than the exception during the time of deposition these black shales.

Example 1: Burrows that aren’t – the importance of recognizing the traces of “sediment swimmers”

We commonly recognize burrows in sediments when they contrast visibly with the matrix (difference in color, texture, composition), and take it for granted that an excavated tunnel is filled with sediment to produce what we see. This assumption, however, is flawed. It does not take into account that very similar looking features are also produced when worms swim through liquid mud. Being able to differentiate traces of “sediment swimmers” from those of “tunnel builders” can result in a completely different interpretation of the depositional setting of a shale.

Figure 1A shows alternating beds of black and greenish-gray shale from the Dowelltown Member (Conant and Swanson, 1961) of the Chattanooga Shale (Devonian) in central Tennessee. Visible bioturbation (traces filled with gray shale) diminishes in intensity downwards into the black bed, suggesting at first glance that the seafloor was only hospitable to benthos at times of gray shale deposition. By default this implies anaerobic/anoxic conditions for the black shale beds, an interpretation that characterizes other studies of comparable black shale/gray shale alternations (e.g., Cluff, 1980; Beier and Hayes, 1989; Hasenmueller, 1993; Calvert et al., 1996).

However, the fact that there is also bioturbation (though not immediately obvious) in the lower portions of black shale beds (Fig. 2) complicates matters. Because the traces in Fig. 2 are filled with black mud, they are practically “invisible” without image enhancement.
Lobza and Schieber (1999) demonstrated through a combination of experiments and textural studies how some traces in black shales (Figs. 1, 2) were formed. Many of the “burrows” illustrated in Figure 1A formed when worms “swam” or “wiggled” through a soft-soupy substrate with high water content (-70-75%). Rather than being sediment-filled tunnels, these “burrows” represent instead mixing structures produced by worms that dragged mud of one color into adjacent mud layers of different color (Figs. 1B, 1C). From a process perspective, they are biodeformational structures (e.g., Wetzel, 1991a; Wetzel and Uchman, 1998) and, for lack of a better name, we called them “mantle and swirl” traces (Lobza and Schieber, 1999). Now, as long as mud of contrasting color is dragged along by moving worms, these traces show up nicely (Fig. 1). Yet, if a worm moves only in one layer, its trace will be filled with similar material and there will be no color contrast (Fig. 2). This kind of “black on black” trace will be essentially “invisible” (Fig. 2). Likewise, after some distance from crossing the color boundary (e.g., gray to black), the gray mud that the worms dragged behind will run out and there will be no more color contrast.

Proper identification of “sediment swimmer” traces matters. It tells us that the erstwhile black muds contained benthic life at the time of deposition, and not at some unspecified later time. Experiments on self-compaction of freshly deposited muds (Barrett and Schieber, 1999) indicate that it will take from a few days to weeks of consolidation to arrive at a water content of around 70%. Therefore, the organisms that produced the traces in Figures 1 and 2 must have done so shortly after deposition of these muds. They actually lived in carbonaceous surface muds, and that makes it highly unlikely that anoxic conditions were the norm when the black shale layers were deposited. Thus, recognizing “sediment swimmer” traces in these black shales mitigates against the prevalent assumption of anaerobic conditions.

**Example 2:** Counterintuitive lessons from pyrite – not so anoxic after all

Round to elliptical pyritic features (Fig. 3A) are common on broken or cut surfaces of black shales, and are commonly interpreted as concretionary in origin. Pyrite concretions are not only common in black shales, but they also evoke images of anoxic conditions, especially when associated with a laminated appearance. In combination, these features of black shales (pyritic, laminated) are often thought to indicate anoxic conditions and an absence of benthos.

In our example, however, X-radiographs reveal a more interesting story. What looked like concretions in cross section turns out to be pyritic trails in plan view (Fig. 3C). These trails may follow chaotic loops, turn sharply through 360 degrees, and rise and fall through the sediment (Fig. 3B). The traces, which resemble *Spirophycos* or *Nereites*, were evidently produced by small organisms that zigzagged their way through the mud in search of food. This forces us to rethink our initial assumptions of anoxic conditions for certain black shale deposits. Such pyritic trails may be much more common in black shales than we currently appreciate.

While deducing oxygenated bottom waters from pyritic trails (Fig. 3) does not require a great leap of faith, proposing that pyrite concretions in black shales may actually be indicators of oxygenated bottom waters probably would meet considerable resistance. Yet, from a geochemical perspective, oxygenated waters above the seabed seem to be a prerequisite for forming localized pyrite concentrations in the bottom sediments. This is so because under fully anoxic conditions, with an excess of H\(\text{S}\) in the sediment, all the iron that was released from terrigenous grains would be precipitated immediately in the form of disseminated and tiny iron sulfide grains. Under oxic bottom waters, however, anoxic, organic-rich sediments are typically non-sulfidic in the surface layer (Berner, 1981), and thus allow for localized accumulation of pyrite. In such settings, iron oxyhydroxide coatings on terrigenous grains of the surface sediment would be a ready source of easily solubilized iron that would keep pore waters free of H\(\text{S}\) via pyrite formation (Canfield and Raiswell, 1991; Canfield et al., 1992). Simultaneously, bacterial decay of organic matter would remove downwardly diffusing oxygen from the pore waters. Under the ensuing combination of anoxic and non-sulfidic conditions, iron should be able to migrate through the sediment, making possible the localized accumula-

![Figure 1: (A) Cut and ground (1000 grit) surface of shale that consists of alternating black and greenish-gray beds. Note the downward-diminishing abundance of gray burrow fills in the central black bed. (B) Close-up of “mantle and swirl” traces in the upper portion of the black bed. These traces are produced when worms move/swim through the soft watery substrate (~70% water content) and drag gray mud downwards into black muds. (C) Close-up of equivalent traces (white arrows) that were produced when worms moved into the underlying gray layer and dragged black mud behind them.](image1)

![Figure 2: (A) Seemingly undisturbed black mud with some silt laminae (white arrows). (B) The same image with serious image enhancement applied (contrast enhancement with Adobe PhotoshopTM). With contrast enhancement, lighter colored oval-shaped features (white arrows) turn out to be compressed “mantle and swirl” traces. Under normal conditions they are “invisible” because they are filled with black mud. (C) Thin-section photomicrograph illustrating the subtle nature of black shale filled traces. Gray shale-filled traces (blue arrows) are easily be observed on ground surfaces (Fig. 1); yellow arrows outline a black shale filled trace that has little color contrast with the surrounding black shale.](image2)
burrowing could result in a laminated black shale fabric! Work on the New Albany Shale (Devonian of Indiana) has uncovered evidence for just such a mechanism at work.

Figure 4 shows a fairly typical specimen of New Albany black shale. Horizontal streaks of silt (Fig. 4A) extend in many instances across the width of a thin section, giving it a laminated character that compares well to many other laminated black shales (O’Brien and Slatt, 1990). On initial inspection, this specimen appears to represent a laminated black shale from an anoxic setting. However, silt streaks and laminae that were slightly non-parallel and showed variable orientation across the specimen surface cast doubt on this interpretation. Enhancing Fig. 4A with Adobe Photoshop TM highlighted the silt streaks and laminae (Fig. 4B), and furthermore revealed subtle discontinuities and disruptions of laminae (Fig. 4C). Were these features due to scouring by bottom currents, or were they due to bioturbation? Lateral tracing of these features would have been helpful, but large study specimens are rarely available. Drill core material is too narrow, and in outcrop specimens, even the slightest weathering completely obscures the features in question. Persistence, however, uncovered several specimens that established that the type of black shale shown in Figure 4 (“black shale with silty streaks”) was actually a product of bioturbation (Fig. 5).

Figure 5 shows “black shale with silty streaks” penetrating and crossing a preexisting black shale with homogenous appearance (Fig. 5D). The burrowers seem to have moved through the sediment more or less horizontally, producing “sheets” of reworked material that usually extend beyond the diameter of the core (~10 cm). In so doing, the burrowers produced what one might call a “burrow-laminated” fabric, causing grain segregation (silty streaks). Lamina disruptions (Figs. 4, 5D) suggest that burrowers reworked the sediment more than once, possibly a reflection of the high organic matter content.

In the New Albany Shale, black shale intervals ranging up to four meters in thickness may show pervasive “burrow-laminated” fabric (Fig. 4), indicating almost complete reworking (Fig. 5) of an organic-rich mud. In places where gray shale beds are intercalated, other burrows, most commonly Zoophycos, penetrate downwards into “burrow-laminated” black shale. Apparently, the bioturbation that gave rise to “burrow-laminated” fabric occurs early in the depositional history when the sediment still has a high water content. The horizontal mining habit of the burrowers, combined with substantial subsequent compaction (down to 30-40% of original thickness), produced a horizontally laminated fabric.

The Zoophycos traces observed in “burrow-laminated” black shales consist of closely spaced horizontal sheets. One may speculate whether the organisms that produced the “burrow-laminated” fabric also produced the subsequent Zoophycos burrows, and whether the difference in appearance reflects a lower water content of the sediment at the time of Zoophycos emplacement. Bioturbators produce different burrows depending on substrate consistency (e.g., Bromley, 1996). The notion that “burrow-laminators” may be related to the organisms that produce Zoophycos style traces also receives support from a study of Devonian shales in the Catskill Delta of New York. There, gray mudstones are completely reworked by Zoophycos, yet the Zoophycos morphology is largely subsumed by the now “burrow-laminated” character of the sediment (Schieber, 1999).

Example 4: Erosive features in black shales suggest bottom currents, water column mixing, and a stratigraphic record littered by gaps. Erosive features in black shales are recognizable from the outcrop scale down to the microscopic scale (e.g., Baird, 1976; Baird and...
The burrows in the second black layer (#3) reveal a comparable story (Fig. 6C). They are cut by erosion (ES2) and have a gray fill that differs in composition from the gray shale above. As above, this indicates yet another gray shale layer (#4) that was eroded prior to deposition of the gray shale layer that we see now (#5). Basically, although we can recognize only three layers of shale, we have to conclude that there were at least five (or more) layers originally.

Erosion of this gray layer preceded deposition of the next black layer (#3). Erosive interludes as revealed in Figure 6 suggest that powerful bottom currents may have been much more common in black shale settings than commonly assumed. This reinforces the conclusions drawn from prior examples: namely that water column mixing and oxygenation of bottom waters was the norm rather than the exception.

The surface relief of these erosion surfaces (ES1 and ES2) indicates that what was eroded were semiconsolidated muds, "stiff" enough to resist eroding currents. The degree of compaction observed in Chondrites burrows, suggesting a water content of about 45% (cover art), confirms this assessment. Because the Chondrites burrows occur next to "mantle and swirl" traces that were emplaced at water contents of around 75% (cover art), they were obviously emplaced later in the depositional history and probably at a greater depth in the sediment. Judging from studies of deep sea muds (Ekdale et al., 1984; Wetzal, 1991a), the organisms that produce Chondrites may penetrate to depths of about 35 cm. In our example, the mud had a water content of about 45% at the time Chondrites was emplaced; thus those 35 cm would be reduced to a 20 cm layer of consolidated shale. In Figure 6, all that remains of two such mud layers are the bottom portions with Chondrites burrows. If these two layers are essentially what is missing from the specimens in Figure 6, then our 5-cm-thick sample (Fig. 6) may be all that is left of nearly 50 cm of potential rock record. In the context of other examples of intermittent erosion in black shales and marine mudstones (e.g., Baird, 1976; Baird and Brett, 1991; Schieber, 1998, 1999) it may well be that, just like it is true for sandstones and carbonates, the shale portion of the sedimentary record is dominated by gaps rather than by record.

**IMPLICATIONS**

Because it is commonly assumed that oxygen content or organic productivity of marine waters exerts the main control on black shale formation, discussion of their origin has largely been dominated by geochemical arguments (e.g., Beier and Hayes, 1989; Calvert et al., 1996). Geochemists have devised geochemical proxies that may provide insight into the formative conditions of black shales (notably, indices that allow us to determine the oxygenation state of the water column and the presence of anoxia; Jones and Manning, 1994). Although I have no problem with geochemistry (indeed, it is an integral part of my studies of Devonian black shales), it is clear from information summarized here that there are many conflicts between what sedimentary features tell us and what geochemical proxies would suggest. For example, the most widely employed anoxia proxy, degree of pyritization (DOP; Raiswell et al., 1988), indicates anoxic conditions for most of the samples that we analyzed. This interpretation is not supported by the erosive features and various intensities of bioturbation that these same samples contain. Sedimentological and petrographical study of the samples reveals that intermittent erosion and reworking caused hydraulic pyrite enrichment in silty laminae and lag deposits, causing artificially high DOP values (Schieber, 2001). Comparable problems exist with regard to other proxies.

As the DOP example illustrates, uncritical reliance on geochemical data and proxies is risky. Sedimentological aspects of shale deposition need to be considered in the formulation of realistic geochemical models. Another inherent problem is that geochemical models for black shale formation are typically based on bulk analyses of homogenized samples representing stratigraphic intervals ranging from centimeters to tens of centimeters in thickness. In distal Devonian black shales a 10 cm interval of shale may represent a time span of as much as 100,000 years (Schieber, 1998), and much can happen to an original deposit over such a long time span. Sedimentological evaluation is a necessary prerequisite for successful geochemical studies because prima
facile knowledge of depositional processes places critical constraints on the interpretation of geochemical data sets, and is a requirement for sensible geochemical sampling (e.g., in order to avoid averaging intervals of dissimilar origins).

**CONCLUSIONS**

Black shales may seem to be featureless initially, but careful study can reveal a wealth of sedimentological detail that has a direct bearing on which genetic models are permissible, and which ones are unacceptable. As illustrated in the four examples above, careful examination of black shales can help to: (1) establish whether bioturbation features are syngenetic with a black shale horizon (example 1); (2) extract information about paleo-oxygenation from pyrite aggregates (example 2); (3) resolve whether laminated fabric is a primary depositional feature or a secondary feature due to bioturbation (example 3); (4) reveal erosive features that provide information about bottom currents, water-column mixing, and oxygenation, as well as information about the completeness (or lack thereof) of the stratigraphic record in shales (example 4).

Although this list is necessarily incomplete, it serves to make my main point—it pays to look at your shales. A sedimentological inventory of a black shale succession, developed through study of outcrops, hand specimens, core samples, and thin sections, can greatly advance our understanding of these rocks. Such an inventory should be conducted before the decision is made to engage in costly and time-consuming geochemical studies.

**ACKNOWLEDGMENTS**

Over the past 15 years I have benefited from discussions with numerous colleagues on a range of issues related to shale sedimentology. I would like to thank in particular P. Potter, D. Kinsley, K. Bohacs, H. Blatt, N. O’Brien, F. Ettenssohn, G. Retallack, M. Reed, P. Binda, G. Baird, C. Brett, K. Grimm, K. Milliken, J. Comer, J. Macquaker, and A. Wetzel for generously sharing their perspectives and insights on a broad range of questions. In addition, I would like to thank A. Basu and E. Kauffman for constructive criticism of an earlier draft of this contribution, and reviewers G. Baird and M. Miller for suggesting improvements to the manuscript. L. Babcock, S. Leslie, and K. Polsak provided editorial advice. Research on shale sedimentology over the years has been supported through grants and logistical support provided by NSF, ACS-PRF, ExxonMobil, and Chevron Texaco.

**REFERENCES**


Below, I review some exciting recent developments, with far-reaching implications, derived from new field-lab integrative approaches to muds. Breakthroughs like these have enhanced my appreciation of fine-grained rocks that comprise the bulk (>60%) of the sedimentary record (Potter et al., 1980), but comparatively few pages of sedimentology textbooks. An enormous amount of time, energy, and money has been poured into research seeking the causes of, and controls on, organic carbon preservation, leading ultimately to oil formation. In recent decades, debate has focused on two primary factors: 1. effects of anoxia, and 2. rates of productivity, sedimentation and burial. A new model (Kennedy et al., 2002) suggests that there is a relationship between preservation of organic carbon and surface area of the reactive interlayers of clay minerals. Clay minerals, especially smectites, apparently adsorb amorphous organic matter from the water column, storing it safely from the action of microbes. The study showed that much of the organic matter in the Cretaceous Pierre Shale is bound within smectite interlayers, and that this amorphous organic matter is far more abundant than the particulate organic matter retained in the rock. While other factors are clearly important in the genesis of organic-rich mudstones, this model proposes that trends in detrital clay mineralogy exert a first-order control on storage of organic carbon in marine rocks. Driven in no small part by the fact that they are the most important petroleum source rocks, black shales have been the focus of a disproportionate amount of attention. Traditionally they have been regarded as representative of deposition under sustained anoxic conditions. Abundant black shales are characteristic of certain intervals of time (e.g., Late Devonian, Cretaceous), and have been suggested to signify “oceanic anoxic events,” a concept which would, if correct, have radical implications for the biosphere-ocean system during these times. Schieber (1994) threatened the anoxic paradigm by demonstrating that macroscopic bioturbation, representing the activities of aerobically metabolizing metazoans, is common in some black shales. This straightforward finding indicates that these deposits do not necessarily represent episodes of basin-wide stagnation. Furthermore, macroscopic bioturbation has been documented in black shale horizons bearing preservation of originally nonmineralized fossil tissues (by pyrite replacement; Sutcliffe et al., 1999). Preservation of nonmineralized tissues in black shales has long been considered to require anoxia. Thus, this finding has important paleoecological implications, most importantly, that such fossils may be preserved in situ under habitable (oxic) benthic conditions, and do not require transport. In recent years, basinal mudstones have been the focus of an increasing body of paleoceanographic research that has tapped into the high-resolution record they provide. Throughout the last decade, increasing analytical precision has allowed isotopic analysis of ever-smaller samples. One of the most startling ramifications of such study has been the recognition that profound climate change is not necessarily a slow, steady process, but can operate on timescales ranging down to the decadal scale. Such rapid change may involve multiple feedback mechanisms. One such mechanism is the destabilization of methane hydrates, which are stored in solid form in organic-rich sediments under cool conditions, but which release (greenhouse) methane gas when oceanic warming occurs (Kennett et al., 2003). Importantly, some mudstones may now be dated directly. Until recently, siliciclastic rocks were dated using either detrital zircons, which come with their own set of problematic assumptions, or using rare intercalated ash beds or lava flows and various means of stratigraphic correlation. Recent work by Creaser et al. (2002) has demonstrated that some organic-rich mudstones may be dated using the rhenium-osmium trace element isotope system as a geochronometer. These are only a few examples of recent breakthroughs from the mudstone record that serve to remind me of the wealth of information locked in mudrocks. Although wading into thixotropic paleoenvironments can seem daunting, the effort can clearly be rewarding, and I think it’s safe to assume that we will be hearing a great deal from this part of the sedimentary record in coming years.

Robert R. Gaines; Geology Department, Pomona College, Claremont, CA, 91711

robert.gaines@pomona.edu

REFERENCES


Twenty-two geoscientists, including a healthy contingent of sedimentologists, sedimentary geochemists and paleontologists in addition to climate modelers, converged on Arlington, VA in May (2003) to discuss the status and future of research on Earth’s “deep-time” (pre-Quaternary) climate record.

Earth’s deep-time geologic record preserves the results of multiple large-scale experiments in environmental change. Although studies of recent climate states can capture a resolution commonly lacking in deep-time studies, they fail to capture the full range of climate-system behavior. In contrast, deep-time studies showcase environmental disturbances unknown from the recent, as well as feedbacks that occur on longer time scales and in response to perturbations that are different from those observable in the recent. Although some of the processes that can be studied in deep time may exceed human time scales, through feedbacks and thresholds, they can affect those climate processes that do operate on human time scales. Until we can understand these processes, gaps in our ability to understand climate on shorter time scales will remain, contributing to climate-prediction uncertainty.

Workshop discussions highlighted the following key points:
• Study of the Earth’s climate record at all spatial and temporal scales is needed in order to comprehend the full range of variability represented in the climate system. The deep-time geologic record preserves numerous examples of past climate transitions between states more extreme than those represented in instrumental data, in historical records, or even by Quaternary standards. Critically, some of these transitions show evidence of having occurred abruptly, a major societal concern in light of the large changes that are now occurring in our current climate system. Understanding the details of large-scale climate transitions and, more importantly, the processes involved could very well be critical to an informed assessment of future climate change.

Continued on next page
It has been just a few months since I assumed office as your President. Fortunately for me, I follow on the heels of Peter McCabe, who put our society on a solid course during his term. My biggest job will be to keep the ship on a steady course. Perhaps the greatest accomplishment of Peter’s administration was the creation of The Sedimentary Record. This new publication will hopefully establish a stronger link between our members and the society.

One of the biggest challenges currently facing us is that of declining membership. This decline is, in large part, due to the demographics of the geoscience profession. Many of us are getting older. To offset the decline we must encourage student membership and become a truly global society.

Council has spent many hours discussing student involvement in SEPM and has done a number of things to encourage student membership. We now have a $25 student membership that includes online access to both of our journals, as well as, our regular member discounts on publications and the semi-annual free books to students events. With all of these efforts, I must confess that I am still puzzled by the relatively low numbers of student members in the society, given the fact that sedimentary geology is still very much a principle component of the Earth Sciences. I was encouraged by my advisors to join professional societies and did so as a student. From that time on I began to feel more connected with the profession. I continue this important effort with my own students and even go so far as to purchase their first year’s membership for them (at $25 it is a real bargain for me).

Today, with low membership costs and high benefits for students, I can’t see why more students are not taking advantage of society membership. Maintaining a strong, dynamic and young membership is vital to our society and to the science. We must all work harder at increasing membership. Let me know if you have suggestions in this area.

This past year one of my graduate students and I attended the SEPM Incised Valley Research Conference in Casper, Wyoming. This was an excellent conference, well attended, packed with high quality talks, wonderful field trips and opportunities to interact with colleagues and friends. We both came away with new ideas and were energized for addressing our own research projects. In my opinion, research conferences are one of the greatest services our society offers. I have attended several over the years and have, without exception, had experiences similar to those of the Casper meeting. I would like to see us doing more conferences on a greater range of themes.

Did you know that there are SEPM staff who are dedicated to helping with the organization and running of research and field conferences? Have you ever thought about running such a conference? It is probably easier than you think and the rewards are great. Check out the SEPM web site to find out how you can propose a conference, or contact Judy Tarpley at SEPM headquarters and get one started.

One of the other great benefits of our society is the Special Publications program. The Society is always looking into ways to expand and hasten the turn-around time for special publications. Our web site now provides information to authors of special publication articles that allow them to track their papers through the system (http://www.sepm.org/publishing/upcoming.htm). We are working hard to speed up the review, editing and printing process. We are currently investigating using online submission and review. Our goal is to reduce the turn around time to as little as possible. Ranging from the traditional print to electronic media, advanced level compendium to college level course material, I would encourage anyone to think about publishing with SEPM. If you are interested in proposing a special publication, contact Laura Crossey (lcrossey@unm.edu) at the University of New Mexico, who is SEPM’s Special Publications Editor.

The sedimentary geology community will play a key role in the future of the Earth Sciences and our society must remain strong or the science will suffer. I encourage you all to take a more active role in the society. Join a committee, attend annual meetings and research conferences and encourage new members. This is a great society of fascinating people with a common interest in the sedimentary record of Earth’s history.

John Anderson
President, SEPM
johna@rice.edu
The Encyclopedia of Sediments & Sedimentary Rocks

...A vital Reference for all Sedimentologists, Geologists, Stratigraphists and Civil Engineers worldwide

By Gerard V. Middleton Mc Master University, Canada

Take advantage of the special extension on our introductory offer for the members of the Society for Sedimentary Geology:

Valid until 30 September 2003: € 275.00/$ 269.00/£ 175.00

- More than 250 entries by some leading 180 eminent contributors from all over the world.
- Up to date and authoritative. The first single volume encyclopedia to cover this field in such a comprehensive manner.
- Individual entries range in length from definition articles of around 500 words through to extensive articles of over 8,000 words.
- Excellent indices (including an index of all cited authors), cross references, extensive bibliographies.
- Now also available online at www.eseo.com with a 30 day free trial!

See www.wkap.nl/prod/b/1-4020-0872-4 or free previews and table of contents.