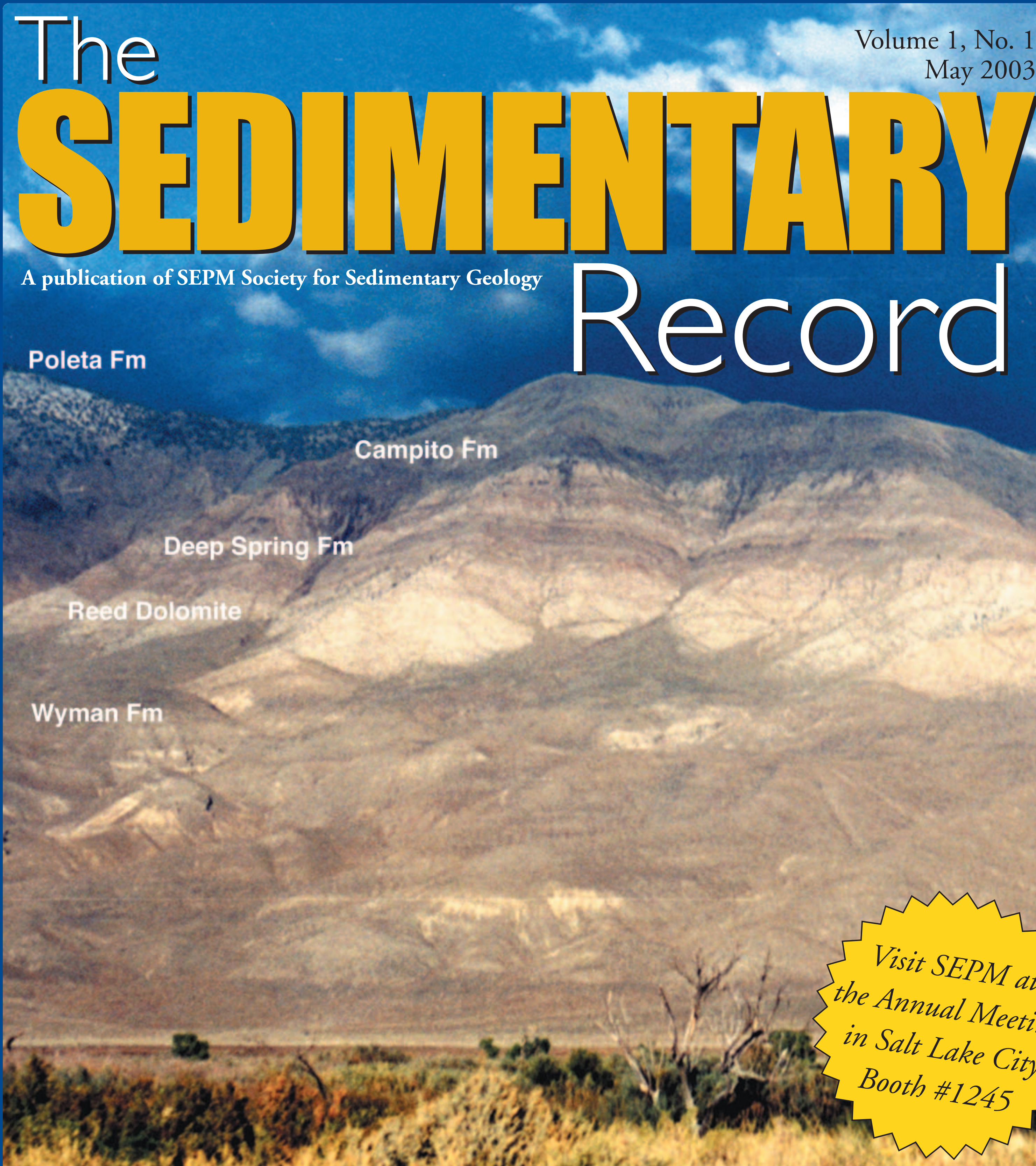
Volume 1, No. 1
May 2003

The SEDIMENTARY Record

A publication of SEPM Society for Sedimentary Geology



Visit SEPM at the Annual Meeting in Salt Lake City Booth #1245

INSIDE: PRECAMBRIAN-CAMBRIAN BOUNDARY

PLUS: SPECIAL FEATURES ON "WHAT IS SEDIMENTARY GEOLOGY"
FIELD NOTES - HAND LENS - DIRECTOR'S CHAIR
COMMENTS FROM COUNCIL - PRESIDENT'S OBSERVATIONS

1926 SEPM Society for Sedimentary Geology

ENERGY
OUR MONUMENTAL TASK

AAPG/SEPM
Annual Meeting
May 11-14, 2003
Salt Lake City, UT
Salt Palace Convention Center

SEPM Business Meeting and Luncheon

Date: Tuesday, May 13^{h}
Time: 11:30 a.m.-1:30 p.m.
Location: The Salt Lake City Marriott Hotel Downtown
Fee: $30

This year SEPM's distinguished speaker is Henry W. Posamentier, General Manager of Geoscience and Technology at Anadarko Canada, Inc. Dr. Posamentier specializes in sequence stratigraphy and facies analysis of depositional systems.

The title of Posamentier's presentation is "Bringing Stratigraphy into the 21st century–Extraction of Stratigraphic and Geologic Facies Information from 3D Seismic Data Sets."

The SEPM Luncheon will begin with a cash bar reception at 11:30 a.m., followed by lunch shortly after. The Business Meeting will start once lunch has been served with the speaker's presentation to begin after lunch. Luncheon tickets are $30 per person and may be purchased on-site at the AAPG Registration Desk.

SEPM President's Reception and Awards Ceremony

Date: Tuesday, May 13
Time: 7:00-8:30 p.m.
Location: The Salt Lake City Marriott Hotel Downtown

SEPM President Peter McCabe and the Council of the Society invite you to an evening of celebration to honor the 2003 awardees of the Society for Sedimentary Geology (SEPM):

Twenhofel Medal
Gerard Middleton
Raymond C. Moore Medal
George Pemberton
Pettijohn Medal
Lawrence Hardie
Francis P. Shepard Medal
Harry Roberts
Wilson Award
Samuel Bentley
Honorary Membership
Edward B. Picou, Jr.
Outstanding Paper in JSR, 2001:
Stephen Meyers, Bradley Sageman and Linda Hinnov
Outstanding Paper in PALAIOS, 2001:
T.D. Olszewski, and M.E. Patzkowsky
Excellence of Oral Presentation, 2002:
A.R. Sprague, P.E. Patterson, R.E. Hill, C.R. Jones, K.M. Campion, J.C. Van Wagoner, M.D. Sullivan, D.K. Larue, H.R. Feldman, T.M. Demko, R. W. Wellner, and J.K. Geslin
Excellence of Poster Presentation, 2002:
D.C. Twitchell, V.A. Cross, and M. Rudin

SEPM will also be recognizing the members of the 2003 Local Organizing Committee and student winners.

The reception will begin at 7:00 p.m., with cash bars and hors d'oeuvres. The ceremony will start at 7:30 p.m.

Research Groups

2pm-5pm, Sun. May 11:
- **Clastic Diagenesis**

7:00-10pm, Mon. May 12:
- **Carbonates**
- **Marine Micropaleontology**
- **Quantitative Stratrigraphy**
- **Sequence Stratrigraphy**

6-7pm, Tues. May 13:
- **CRER-Working Group IV**

7:30-9:30pm, Tues. May 13:
- **Deep Water**

SEPM Foundation Activities

9-10am, Mon. May 12
Foundation Board Meeting
10-11am, Mon. May 12
Foundation Members Meeting
6-7pm, Tues. May 13
Foundation Donors Reception

The SEPM Council
2002 - May 2003:

President:
Peter McCabe
President-Elect:
John B. Anderson
Secretary-Treasurer:
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Councilor for Paleontology:
Thomas W. Dignes
Councilor for Sedimentology:
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Dawn Sumner

We look forward to seeing you in Salt Lake City!

***Cover photo**: Precambrian-Cambrian boundary interval in the White-Inyo succession, White Mountains, view to the east from Highway 395 between Bishop and Big Pine, California (see Corsetti and Hagadorn, this issue). Photo by F.A. Corsetti.*

Welcome to *The Sedimentary Record*

This is the inaugural issue of *The Sedimentary Record*, a new series published quarterly in both online and paper format by SEPM (Society for Sedimentary Geology). *The Sedimentary Record* contains peer-reviewed science articles on topics of broad and current interest to the membership of SEPM, as well as shorter, editor-reviewed articles addressing a variety of topics, including society business and media reviews. We welcome written contributions from members of the Society for inclusion in the journal. We also look forward to receiving suggestions concerning how *The Sedimentary Record* should evolve in order to meet its dual goals of serving 1) as an outlet for communicating information important to the Society; and 2) as a focal point for discussion of current topics, and topics pertinent to the future of sedimentary geology.

Manuscripts to be considered for publication should be submitted to the editors in electronic format, and preferably by e-mail. Upon acceptance, it is anticipated that papers will be published quickly. Publication will include online availability through the SEPM website.

We are proud to be associated with this new publication venue of SEPM, and look forward to working with many of you in the membership of the Society to bring important, current topics to publication in a rapid manner.

— The Editors

CONTENTS

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

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The Precambrian-Cambrian Transition in the Southern Great Basin, USA

Frank A. Corsetti
Department of Earth Science
University of Southern California
Los Angeles, CA 90089-0740
fcorsett@usc.edu

James W. Hagadorn
Department of Geology
Amherst College
Amherst, MA 01002
jwhagadorn@amherst.edu

ABSTRACT: The Precambrian-Cambrian boundary presents an interesting stratigraphic conundrum: the trace fossil used to mark and correlate the base of the Cambrian, *Treptichnus pedum*, is restricted to siliciclastic facies, whereas biomineralized fossils and chemostratigraphic signals are most commonly obtained from carbonate-dominated sections. Thus, it is difficult to correlate directly between many of the Precambrian-Cambrian boundary sections, and to assess details of the timing of evolutionary events that transpired during this interval of time. Thick sections in the White-Inyo region of eastern California and western Nevada, USA, contain mixed siliciclastic-carbonate lithofacies, and therefore promote correlation between these classic, well-studied lithologic end-members. An integrated stratigraphic approach was applied to the White-Inyo succession, combining lithologic, paleontologic, and chemostratigraphic data, in order to address the temporal framework within the basin, and to facilitate worldwide correlation of the boundary. Results from the southern Great Basin demonstrate that the negative $\delta^{13}C$ excursion that is ubiquitous in carbonate-dominated successions containing small shelly fossils occurs within stratigraphic uncertainty of the first occurrence of *T. pedum*. This global geochemical marker thus provides a link with the primary biostratigraphic indicator for the Precambrian-Cambrian boundary.

INTRODUCTION

The Precambrian-Cambrian (PC-C) transition records one of the most important intervals in the history of life, because it encompasses the appearance and diversification of metazoans, the invasion of the infaunal realm, the advent of biomineralization and predation, as well as dramatic isotopic and atmospheric changes (Lipps and Signor, 1992; Bengtson, 1994; Knoll and Carroll, 1999; Bottjer et al., 2000; Knoll, 2000; Babcock et al., 2001; Fig. 1). Here we draw a distinction between the PC-C *transition*, represented by the post-glacial terminal Proterozoic through the early Cambrian (ca. 600-520 Ma), and the PC-C *boundary*, a chronostratigraphic boundary represented by a point in rock (Global Standard-stratotype Section and Point, or GSSP) in the Fortune Head, Newfoundland, section (Landing, 1994). The GSSP section is composed predominantly of siliciclastics (Narbonne et al., 1987), and the fossil chosen to coincide with the boundary, *Treptichnus* (or *Phycodes*) *pedum*, is restricted to siliciclastic facies. *T. pedum* recently has been demonstrated to occur ~ 4 m below the GSSP (Gehling et al., 2001). Approximately 70% of all PC-C boundary successions are siliciclastic (Landing, 1994). However, many carbonate successions around the world have been more intensely studied because they record the advent of widespread biomineralization and easily obtainable $\delta^{13}C$ chemostratigraphic records (summarized in Kaufman et al., 1997; Shields et al., 1997; Bartley et al., 1998; Shields, 1999; Corsetti and Hagadorn, 2000; Shen and Schidlowski, 2000). Due to endemic biotas and facies control, it is difficult to correlate directly between siliciclastic- and carbonate-dominated successions. This is particularly true for the PC-C boundary interval because lowermost Cambrian biotas are highly endemic and individual, globally distributed guide fossils are lacking (Landing, 1988; Geyer and Shergold, 2000).

Determination of a stratigraphic boundary generates a large amount of interest because it provides scientists with an opportunity to address a variety of related issues, including whether the proposed boundary position marks a major event in Earth history. Sometimes the larger-scale meaning of the particular boundary can be lost during the process of characterization. This is demonstrated in a plot of PC-C boundary papers through time (Fig. 2): an initial "gold rush" to publish on the boundary occurred after the formation of the working group on the PC-C boundary in the early 1970s; papers trailed off though the 1980s, and plummeted after the GSSP was ratified by the International Union of Geological Sciences (IUGS) in 1992 (Rowland and Corsetti, 2002). As our understanding of this interval of Earth history grows, we focus more on the "bigger picture" issues (e.g., evolution and diversification of the Metazoa), and focus less on the "boundary issues." However, we will inevitably seek tie points with which to link fossils from siliciclastic sections to the geochemical and climate-change data from carbonate-dominated sections so that we can improve our understanding of this critical interval.

Mixed siliciclastic-carbonate successions become crucial in the search for stratigraphic tie points. Although a number of important lower Cambrian sections containing mixed siliciclastic-carbonate successions are

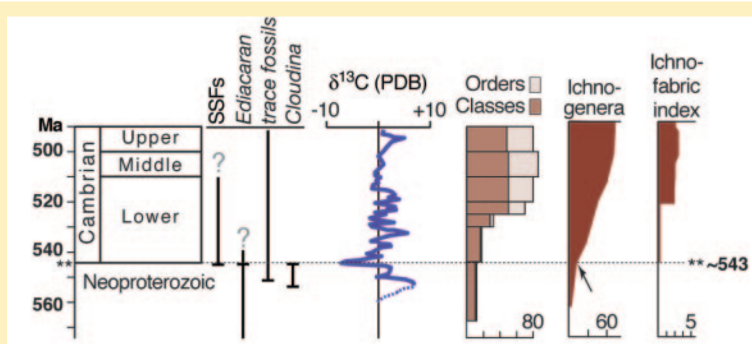

Figure 1. Summary of pertinent features associated with the PC-C transition (data compiled principally from Droser and Bottjer, 1988; Crimes, 1992; Droser et al., 1999, 2002; Knoll and Carroll, 1999; McIlroy and Logan, 1999), demonstrating the biospheric changes represented in this interval. SSFs: small shelly fossils. Arrow denotes the first appearance of vertically-oriented bioturbation.

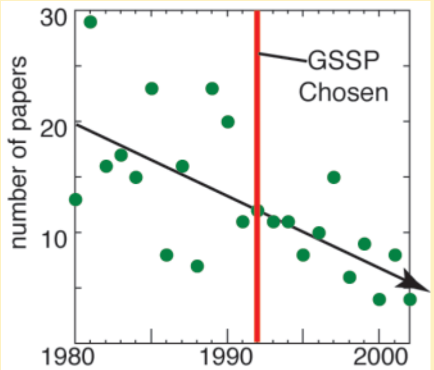

Figure 2. PC-C boundary publications through time (constructed by searching GEOREF for 'Precambrian-Cambrian,' 'Proterozoic-Cambrian,' and 'Neoproterozoic-Cambrian' in the title).

known (e.g., Mongolia, Brasier et al., 1996; Olenik uplift, Siberia, Knoll et al., 1995; Mackenzie Mountains, northwestern Canada, Narbonne and Aitken, 1995; southern Great Basin, Corsetti and Hagadorn, 2000), not all of these contain the PC-C boundary. Also, not all the sections contain an appropriate juxtaposition of carbonate- and trace-fossil-rich siliciclastic strata. Thick, relatively complete, well-exposed, and easily accessible successions in the southern Great Basin contain siliciclastic units and the boundary-marking fossil, *T. pedum*, in association with carbonate units recording a complete $\delta^{13}C$ chemostratigraphic profile (Corsetti and Kaufman, 1994; Corsetti et al., 2000; Corsetti and Hagadorn, 2000; Hagadorn and Waggoner, 2000). The southern Great Basin sections provide an excellent opportunity to compare results from a variety of stratigraphic approaches that have emerged as useful for correlating potential stage and series boundaries within the Cambrian (e.g., Geyer and Shergold, 2000).

GEOLOGIC BACKGROUND

From the time of Walcott (1908), the thick, superbly exposed, and highly fossiliferous Lower Cambrian strata from the southwestern United States (Figs. 3, 4, cover photo) have proved instrumental for understanding the Cambrian biotic explosion, and have even been suggested for a potential basal Cambrian stratotype (Cloud, 1973). Proterozoic—lower Paleozoic strata in the southern Great Basin were deposited on a thermally subsiding trailing margin created through rifting of the Laurentian craton in the Neoproterozoic (e.g., Stewart, 1966, 1970; Stewart and Suczek, 1977; Armin and Mayer, 1983; Bond et al., 1985).

Neoproterozoic-Cambrian strata in the southwestern United States thicken from southeast to northwest, and can be grouped into four distinct but interfingering successions: Craton, Craton Margin, Death Valley (proximal-shelf), and White-Inyo (proximal- to mid-shelf) successions (Stewart, 1970; Nelson, 1976, 1978; Mount et al., 1991; Corsetti and Hagadorn, 2000; Fedo and Cooper, 2001; Fig. 3). An erosional disconformity removed the PC-C boundary interval in the Craton and Craton Margin successions (Fedo and Cooper, 1990, 2001). This sequence boundary is traceable from the Craton Margin through the Death Valley succession to the White Inyo succession, and probably represents the "Sauk I" disconformity (Palmer, 1981). The boundary interval resides below this unconformity where incision was limited. The Death Valley succession records both appropriate trace fossil biostratigraphy and carbon isotope data (Corsetti and Hagadorn, 2000). However, the sections are relatively thin and the carbonates from which the $\delta^{13}C$ record was recovered are particularly thin. The White-Inyo succession is thickest, but, until now, has been considered poorly fossiliferous with respect to earliest Cambrian guide fossils (e.g., Signor and Mount, 1986). Trilobites, which are important guide fossils in Lower Cambrian sections in the Great Basin (e.g., Nelson, 1976; Palmer, 1981, 1998; Hollingsworth, 1999), make their first appearance well above this interval (Hollingsworth, 1999).

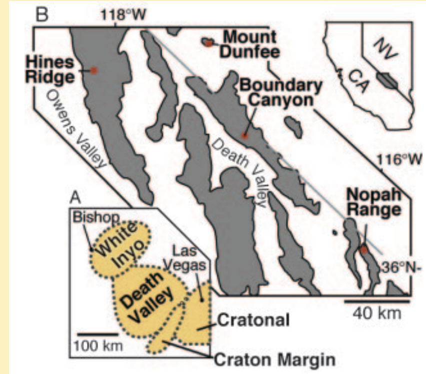

Figure 3. A. Map showing distribution of four interfingering facies successions that span the PC-C interval in the southern Great Basin; successions become progressively thicker to the northwest, the offshore direction (after Nelson, 1978; Corsetti et al., 2000; Fedo and Cooper, 2001). B. Shaded area represents the approximate PC-C outcrop belt in the southern Great Basin (after Stewart, 1970); the Mt. Dunfee section was offset to its present position by post-Cambrian transtensional faulting.

White-Inyo Succession

In ascending order, the White-Inyo Succession consists of the Wyman Formation, Reed Dolomite, Deep Spring Formation, Campito Formation, Poleta Formation, Harkless Formation, and the Mule Spring Limestone (Nelson, 1962; Fig. 4). The White-Inyo Mountains have been the focus of intense PC-C boundary study, but the paucity of earliest Cambrian fossils has been problematic (e.g., Cloud and Nelson, 1966; Taylor, 1966; Alpert, 1977;

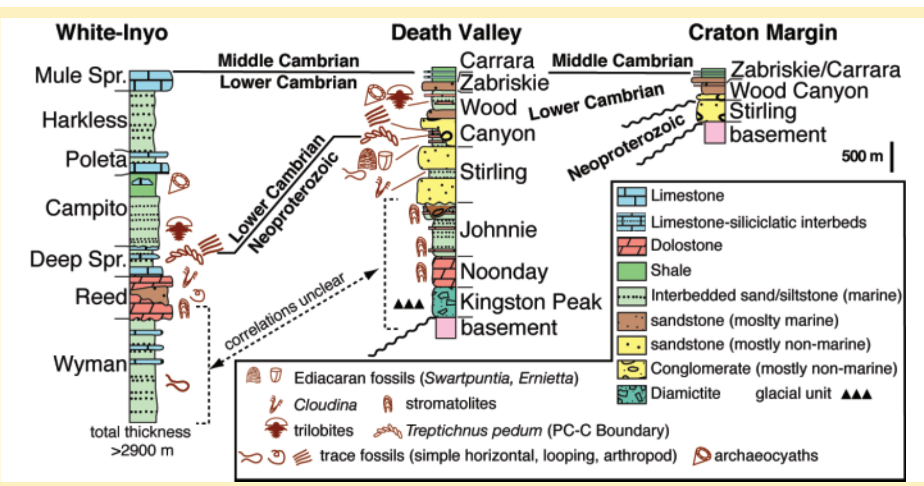

Figure 4. Generalized lithostratigraphic columns for the PC-C transition interval in the southern Great Basin (after Nelson, 1962, 1976; Stewart, 1970; Fedo and Cooper, 2001). Whereas the Lower Cambrian portion is well constrained and correlated between the intervals, correlations between Neoproterozoic strata are less well constrained. Base of the Sauk I Sequence removes some of the Neoproterozoic-Lower Cambrian interval in more proximal (Craton Margin) settings. The Death Valley succession contains a Neoproterozoic glacial-cap-carbonate succession, but no known correlatives exist in the White-Inyo succession. Fossil symbols represent first occurrences of key taxa.

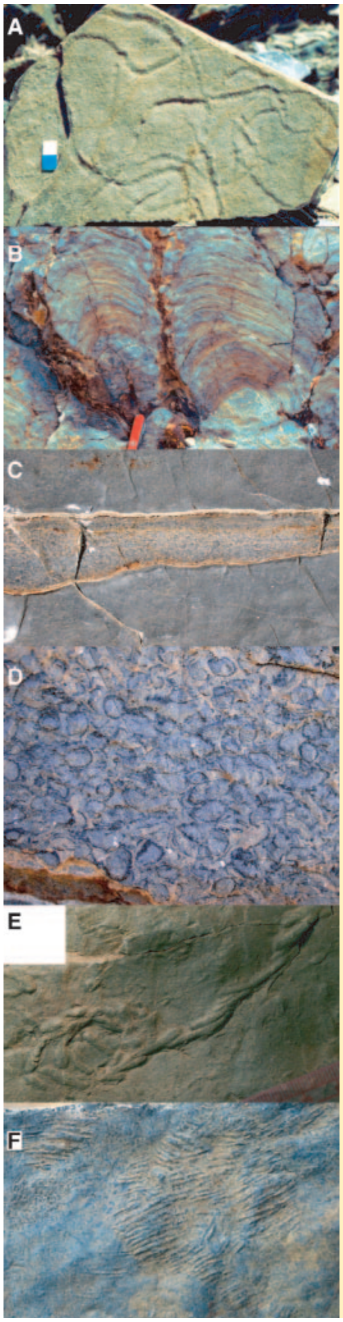

Figure 5: A. Helminthoidichnites on bed sole, Wyman Formation, south of Hines Ridge, Andrews Mountain, California (scale bar=1 cm increments). B. Domal stromatolites, Middle Deep Spring Formation, Mt. Dunfee, Nevada (knife ~8 cm long). C. Packstone lag bed composed mostly of Cloudina riemkeae (across middle of photo), Lower Deep Spring Formation, Mt. Dunfee, Nevada (field of view ~32 cm wide). D. Close-up of area shown in Fig. 5C showing C. riemkeae debris (field of view ~5 cm wide). E. Treptichnus pedum, Upper Deep Spring Formation, Andrews Mountain, California (field of view ~9 cm wide). F. Cruziana and Diplichnites, Upper Deep Spring Formation, Hines Ridge, California (field of view ~9 cm wide).

Nelson, 1976, 1978; Mount et al., 1983; Signor et al., 1983; Gevirtzman and Mount, 1986; Signor and Mount, 1986; Droser and Bottjer, 1988; Corsetti and Kaufman, 1994; Fritz, 1995; Hagadorn and Bottjer, 1999; Hagadorn et al., 2000). Because the PC-C boundary paradigm has changed over the last three decades, the inferred position of the boundary in the succession has changed as well. New fossil evidence (Fig. 5) is consistent with the position of the boundary. More comprehensive biostratigraphic information is contained in the cited references.

The Wyman Formation consists of interbedded mudrock, siltstone, and quartzite, with lensoidal oolitic, pisolitic, and oncolitic carbonate layers that increase in number upsection. Near Andrews Mountain in the Inyo Range, the formation exceeds 3000 meters in thickness (Nelson, 1962). The section primarily represents shallow marine deposition. The base of the formation is not exposed, so the nature of any underlying contact in not known (Nelson, 1962). The Reed Dolomite rests unconformably on the Wyman at most localities and is divided into three members: the Lower Member, Hines Tongue, and the Upper Member. The Lower Member is characterized by coarsely-crystalline pink dolostone with cross-bedded oolitic horizons, and minor domal stromatolite horizons. This suggests subtidal to intertidal marine deposition. The Hines Tongue is a southward-thickening siliciclastic unit consisting of hummocky-crossbedded sandstone and minor siltstone with minor carbonate interbeds. Thus suggests deposition below normal wave base but above storm wave base. The Hines Tongue is thickest in the Hines Ridge area of the Inyo Range, and thins dramatically to the north in the White Mountains and Esmeralda County, Nevada. The Upper Member is characterized by massive dolostones. Minor karstification is present at the contact with the overlying Deep Spring Formation at some localities.

The Deep Spring Formation is formally divided into the Lower, Middle, and Upper Members, each consisting of a siliciclastic-carbonate couplet (Gevirtzman and Mount, 1986; Mount et al., 1991). The siliciclastic half-cycle of each member contains green, ripple cross-laminated siltstones, and quartzites with hummocky cross-stratification, indicating deposition in relatively shallow water above storm wave base. The boundary between the siliciclastic and carbonate half-cycle is transitional at most localities. The carbonate half-cycle is commonly characterized by rhythmically interbedded carbonate wackestone and siliciclastic-rich siltstone, crossbedded oolite, and intraclastic grainstone; a high-energy, shallow-water depositional environment is indicated. The top of each carbonate half-cycle is commonly dolomitized, and often shows minor karstification; periodic emergence is indicated. Overall, sedimentary stacking patterns, sedimentary structures, and facies associations suggest that each member represents a shallowing-upward parasequence. Sharp disconformities divide the members (but see Mount et al., 1991). The Campito, Poleta, Harkless (and Saline Valley), and Mule Spring formations record similar shallow marine, mixed-siliciclastic carbonate strata (e.g., Moore, 1976; Mount and Bergk, 1998), and have similar sedimentary origins.

The White-Inyo succession contains a number of body and trace fossils. We have identified bed-parallel tubular trace fossils, including *Helminthoidichnites* and *Planolites* (Fig. 5A), in the Wyman Formation; we cannot falsify the hypothesis that some of these are body fossils. The Hines Tongue of the Reed Dolomite contains a depauperate suite of bed-parallel trace fossils, such as *Helminthoidichnites*, *Planolites*, and *Torrowangea*, and the Upper Member contains packstones of the body fossil *Cloudina*. Carbonates of the Lower and Middle Members of the Deep Spring Formation contain *Cloudina* (in skeletal lags and isolated occurrences; Figs. 5C, D). These fossils were initially identified as Cambrian small shelly fossils (Signor et al., 1983) but were subsequently reinterpreted as the Neoproterozoic *Cloudina* (Grant, 1990). It remains unclear whether all of the forms reinterpreted as *Cloudina* are, in fact, *Cloudina* or whether some are small shelly fossils. Siliciclastics of the Middle Member also contain rare examples of *Cloudina* and bed-parallel trace fossils, including *Planolites* and *Plagiogmus*. *Treptichnus pedum* (Fig. 5E), which delineates the PC-C boundary, occurs near the top of the Middle Member in the Mt. Dunfee area and at the base of the Upper Member in the White Mountains; in the latter case, *T. pedum* is associated with a moderately diverse ichnofossil assemblage (including *Cruziana* and *Rusophycus*, Fig. 5F). The Campito Formation contains trilobites characteristic of the *Fallotaspis* and *Nevadella* zones (see Hollingsworth, 1999), abundant trace fossils, and limited archaeocyathid bioherms (Nelson, 1976, 1978).

δ^{13}C CHEMOSTRATIGRAPHY

Faunal data are broadly useful for correlation across the PC-C interval in the southern Great Basin, but δ^{13}C chemostratigraphy provides another important technique for constraining intrabasinal and interre-

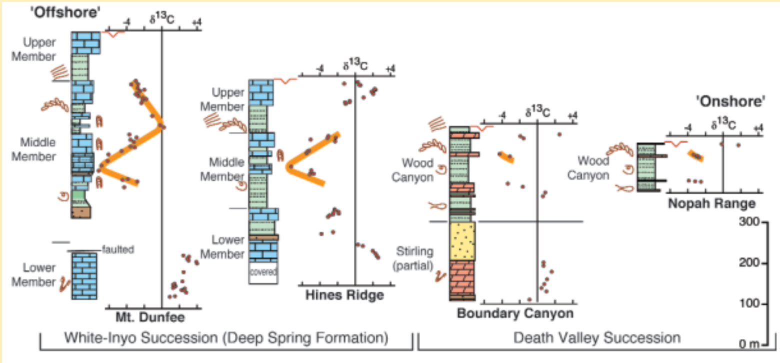

Figure 6. Integrated chemostratigraphy and biostratigraphy for the PC-C interval in the southern Great Basin (data from Corsetti and Kaufman, 1994; Corsetti and Hagadorn, 2000 and references therein; this study). The $\delta^{13}C$ record is most complete at the Mt. Dunfee section (the most offshore section), where T. pedum *occurs in the upper part of the Middle Deep Spring Formation. The $d^{13}C$ record is progressively less complete towards the craton. Stromatolites occur in the White-Inyo succession in association with the $\delta^{13}C$ nadir.*

gional correlations. The Neoproterozoic-Cambrian $\delta^{13}C$ record has been relatively well characterized and includes many positive and negative excursions (e.g., Magaritz et al., 1991; Brasier et al., 1994, 1996; Strauss et al., 1992; Corsetti and Kaufman, 1994; Shields, 1999; Corsetti et al., 2000; Montanez et al., 2000) reflecting secular variation and recognizable globally. Although most $\delta^{13}C$ data are recovered from carbonate dominated successions, it is possible to analyze organic-rich siliciclastic successions for $\delta^{13}C_{org}$. To be effective, this procedure requires that the analyzed section did not experience significant heating, and that rules out many sections from serious consideration (e.g., Strauss et al., 1992). Thus, robust $\delta^{13}C$ data from siliciclastic-dominated sections have remained elusive. A carbon isotope reference curve does not exist for the PC-C interval, but broadly similar chemostratigraphic patterns exist among many PC-C sections (Shields, 1999). Ignoring low amplitude variations, the major $\delta^{13}C$ trends include: 1, a latest Neoproterozoic major positive carbon isotope excursion (slightly older than 548 Ma; Grotzinger et al., 1995), associated with *Cloudina*, simple horizontal trace fossils, and Ediacaran-type fossils; followed by 2, a pronounced negative carbon isotope excursion nearly coincident with the PC- C boundary, at ca. 543-542 Ma (Bowring et al., 1993; Grotzinger et al., 1995). The precise position of the negative excursion with respect to the paleontologic marker of the boundary was unclear for a number of years, although it was commonly assumed that the negative excursion coincided with the boundary horizon. Corsetti and Hagadorn (2000) demonstrated that *T. pedum* does in fact occur within one negative- $\delta^{13}C$ shift of the boundary horizon in the Death Valley succession, and this potentially resolves the question.

The relative synchronicity of the first appearance of *T. pedum* and the negative $\delta^{13}C$ excursion in the southern Great Basin can be further tested by comparing samples from the thinner Death Valley succession to samples from the much thicker, carbonate-rich White-Inyo succession. High-resolution sampling for carbon isotope chemostratigraphy was conducted though the Deep Spring Formation at multiple sections across the basin, in concert with biostratigraphic sampling (Fig. 6). Most of the Lower Deep Spring Formation, where *Cloudina* is present, shows a positive isotopic excursion (to ~+4‰ PDB). The excursion is progressively omitted in the onshore direction, and reaches only ~+2‰ in more onshore sections. A negative excursion, commonly down to ~-5‰, is recorded from the top of the Lower Member through the middle of the Middle Member. Cloudina also occurs in this interval. The negative excursion is most pronounced in offshore sections, where isotopic compositions plummet to ~-7‰. Curiously, the isotopic nadir is associated with unusually abundant stromatolite and thrombolite development (Oliver and Rowland, 2002). At Mt. Dunfee, which represents the most offshore section, $\delta^{13}C$ values rise to near 0‰, then return to mildly negative values beneath the Middle-Upper Deep Spring contact. This excursion is missing from the other, less complete sections in the onshore direction. *T. pedum* occurs in association with this return to negative $\delta^{13}C$ values. The Upper Deep Spring Formation records a positive excursion to ~+2‰. Thus, the presence of *T. pedum* in association with the negative excursion is verified in the White-Inyo succession, and it provides a global tie-point useful for correlations between siliciclastic-dominated sections and carbonate-dominated sections.

In addition to providing a tool for chronostratigraphic work, secular variation in the $\delta^{13}C$ record can be used to address issues of basin scale. For example, if we use the $\delta^{13}C$ record as a chronostratigraphic tool, there is a progressive omission of the $\delta^{13}C$ record in the onshore direction. The most complete isotopic and stratigraphic records are present in the most offshore sections. This trend is not unexpected. However, previously it was not possible to determine the *magnitude* of stratal omission using available lithostratigraphic or biostratigraphic information.

GLOBAL IMPLICATIONS

Integrated biostratigraphic and chemostratigraphic information from the southern Great Basin demonstrate that the first occurrence of *T. pedum*, the trace fossil used to correlate the PC-C boundary, co-occurs with the ubiquitous negative carbon isotope excursion recorded in carbonate-dominated successions around the world. It is beyond the scope of this paper to correlate between all the carbonate- and siliciclastic-dominated section because endemism, hiatuses, and diagenesis complicate the global picture. Using the trace fossil and chemostratigraphic records from the Great Basin as a bridge, however, it appears that the first occurrence of small shelly fossils was relatively synchronous with the first appearance of *T. pedum*. If we ignore potential facies control on the first appearance of *T. pedum* in the Mt. Dunfee section, it could be argued that small shelly fossils just barely predate *T. pedum* because the first small shelly fossils appear in association with relatively negative $\delta^{13}C$ values (Knoll et al., 1995). Given the relatively small amount of stratigraphic uncertainty, the debate regarding the choice of trace fossils vs. small shelly fossils as the stratotype marker is, in our view, rendered moot. The PC-C transition is well calibrated (Bowring et al., 1993; Grotzinger et al., 1995), and the duration of the negative excursion is constrained to less than one million years. This implies that phosphatic biomineralization and vertically-oriented burrowing developed quickly and nearly synchronously (probably in less than one million years). Interestingly, the $\delta^{13}C$ and trace fossil biostratigraphic records from the Mt. Dunfee area closely match the hypothetical, composite reference section proposed by Shields (1999).

CONCLUSION

Stratigraphic sections in White-Inyo Mountains, California-Nevada, provide a well-exposed and easily accessible PC-C boundary interval through a mixed siliciclastic-carbonate succession. In this succession, $\delta^{13}C$ chemostratigraphy has been combined with biostratigraphy to provide well-constrained correlations, and these correlations have application for correlating between siliciclastic- and carbonate-dominated successions globally. The ubiquitous negative $\delta^{13}C$ excursion near the base of the Cambrian is confirmed to coincide with the first occurrence of *T. pedum* in multiple sections across the southern Great Basin. From the time of Walcott to the present day, the Neoproterozoic-Cambrian succession in the southwestern United States continues to provide important data on one of the most interesting intervals in Earth history.

ACKNOWLEDGMENTS

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REFERENCES

Alpert, S.P., 1977, Trace fossils and the basal Cambrian boundary, *in* Crimes, T.P., and Harper, J.C., eds., International Symposium on trace fossils, Seel House Press, p. 1-8.

Armin, R.A., and Mayer, L., 1983, Subsidence analysis of the Cordilleran miogeocline; implications for timing of late Proterozoic rifting and amount of extension: Geology, v. 11, p. 702-705.

Babcock, L.E., Zhang, W.T., and Leslie, S.A., 2001, The Chengjiang Biota: record of the early Cambrian diversification of life and clues to exceptional preservation of fossils: GSA Today, v. 11, no. 2, p. 4-9.

Bartley, J.K., Pope, M., Knoll, A.H., Semikhatov, M.A., and Petrov, P.Y., 1998, A Vendian-Cambrian boundary succession from the northwestern margin of the Siberian Platform; stratigraphy, palaeontology, chemostratigraphy and correlation: Geological Magazine, v. 135, p. 473-494.

Bengtson, S., 1994, The advent of animal skeletons, *in* Bengtson, S., ed., Early life on Earth: Columbia University Press, New York, p. 412-425.

Bond, G.C., Christie-Blick, N.H., Kominz, M.A., and Devlin, W.J., 1985, An Early Cambrian rift to post-rift transition in the Cordillera of western North America: Nature, v. 315, p. 742-746.

Bottjer, D.J., Hagadorn, J.W., and Dornbos, S.Q., 2000, The Cambrian substrate revolution: GSA Today, v. 10, no. 9, p. 1-7.

Bowring, S.A., Grotzinger, J.P., Isachsen, C.E., Knoll, A.H., Pelechaty, S.M., and Kolosov, P., 1993, Calibrating rates of Early Cambrian evolution: Science, v. 261, p. 1293-1298.

Bowring, S.A., Grotzinger, J.P., Isachsen, C.E., Knoll, A.H., Pelechaty, S.M., and Kolosov, P., 1993, Calibrating rates of early Cambrian evolution: Science, v. 261, p. 1293-1298.

Brasier, M.D., Shields, G., Kuleshov, V.N., and Zhegallo, E.A., 1996, Integrated chemo- and biostratigraphic calibration of early animal evolution; Neoproterozoic-Early Cambrian of southwest Mongolia: Geological Magazine, v. 133, p. 445-485.

Cloud, P.E., 1973, Possible stratotype sequences for the basal Paleozoic in North America: American Journal of Science, v. 273, p. 193-206.

Cloud, P.E., and Nelson, C.A., 1966, Phanerozoic-Cryptozoic and related transitions; new evidence: Science, v. 154, p. 766-770.

Corsetti, F.A., Awramik, S.M., Pierce, D.L., and Kaufman, A.J., 2000, Using chemostratigraphy to correlate and calibrate unconformities in Neoproterozoic strata from the southern Great Basin of the United States: International Geology Review, v. 42, p. 516-533.

Corsetti, F.A., and Hagadorn, J.W., 2000, Precambrian-Cambrian transition; Death Valley, United States: Geology, v. 28, p. 299-302.

Corsetti, F.A., and Kaufman, A.J., 1994, Chemostratigraphy of Neoproterozoic-Cambrian units, White-Inyo Region, eastern California and western Nevada; implications for global correlation and faunal distribution: Palaios, v. 9, p. 211-219.

Crimes, T.P., 1992, Changes in the trace fossil biota across the Proterozoic-Phanerozoic boundary: Journal of the Geological Society of London, v. 149, p. 637-646.

Droser, M.L., and Bottjer, D.J., 1988, Trends in depth and extent of bioturbation in Cambrian carbonate marine environments, western United States: Geology, v. 16, p. 233-236.

Droser, M.L., Gehling, J.G., and Jensen, S., 1999, When the worm turned; concordance of Early Cambrian ichnofabric and trace-fossil record in siliciclastic rocks of South Australia: Geology, v. 27, p. 625-628.

Droser, M.L., Jensen, S., Gehling, J.G., Myrow, P.M., and Narbonne, G.M., 2002, Lowermost Cambrian Ichnofabrics from the Chapel Island Formation, Newfoundland: Implications for Cambrian Substrates: Palaios, v. 17, p. 3-15.

Fedo, C.M., and Cooper, J.D., 1990, Braided fluvial to marine transition; the basal Lower Cambrian Wood Canyon Formation, southern Marble Mountains, Mojave Desert, California: Journal of Sedimentary Petrology, v. 60, p. 220-234.

Fedo, C.M., and Cooper, J.D., 2001, Sedimentology and sequence stratigraphy of Neoproterozoic and Cambrian units across a craton-margin hinge zone, southeastern California, and implications for the early evolution of the Cordilleran margin: Sedimentary Geology, v. 141-142, p. 501-522.

Fritz, W.H., 1995, *Esmeraldina rowei* and associated Lower Cambrian trilobites (1f fauna) at the base of Walcott's Waucoban Series, southern Great Basin, U.S.A: Journal of Paleontology, v. 69, p. 708-723.

Gehling, J.G., Jensen, S., Droser, M.L., Myrow, P.M., and Narbonne, G.M., 2001, Burrowing below the basal Cambrian GSSP, Fortune Head, Newfoundland: Geological Magazine, v. 138, p. 213-218.

Gevirtzman, D.A., and Mount, J.F., 1986, Paleoenvironments of an earliest Cambrian (Tommotian) shelly fauna in the southwestern Great Basin, U.S.A: Journal of Sedimentary Petrology, v. 56, p. 412-421.

Geyer, G., and Shergold, J., 2000, The quest for internationally recognized divisions of Cambrian time: Episodes, v. 23, p. 188-195.

Grant, S.W.F., 1990, Shell structure and distribution of *Cloudina*, a potential index fossil for the terminal Proterozoic: American Journal of Science, v. 290-A, p. 261-294.

Grotzinger, J.P., Bowring, S.A., Saylor, B.Z., and Kaufman, A.J., 1995, Biostratigraphic and geochronologic constraints on early animal evolution: Science, v. 270, p. 598-604.

Hagadorn, J.W., and Bottjer, D.J., 1999, Restriction of a late Neoproterozoic biotope; suspect-microbial structures and trace fossils at the Vendian-Cambrian transition: Palaios, v. 14, p. 73-85.

Hagadorn, J.W., Fedo, C.M., and Waggoner, B.M., 2000, Early Cambrian Ediacaran-type fossils from California: Journal of Paleontology, v. 74, p. 731-740.

Hagadorn, J.W., and Waggoner, B., 2000, Ediacaran fossils from the southwestern Great Basin, United States: Journal of Paleontology, v. 74, p. 349-359.

Hollingsworth, J.S., 1999, The problematical base of the Montezuman Stage: should the Laurentian fallotaspidids be in a non-trilobite series?, *in* Palmer, A.R., ed., Laurentia 99: V Field Conference of the Cambrian Stage Subdivision Working Group, International Subcommission on Cambrian Stratigraphy, Institute for Cambrian Studies, Boulder, Colorado, p. 5-9.

Kaufman, A.J., and Knoll, A.H., 1995, Neoproterozoic variations in the C-isotopic composition of seawater; stratigraphic and biogeochemical implications: Precambrian Research, v. 73, p. 27-49.

Kaufman, A.J., Knoll, A.H., and Narbonne, G., M., 1997, Isotopes, ice ages, and terminal Proterozoic Earth history: Proceedings of the National Academy of Sciences (USA), v. 94, p. 6600-6605.

Knoll, A.H., 2000, Learning to tell Neoproterozoic time: Precambrian Research, v. 100, p. 3-20.

Knoll, A.H., and Carroll, S.B., 1999, Early animal evolution; emerging views from comparative biology and geology: Science, v. 284, p. 2129-2137.

Knoll, A.H., Grotzinger, J.P., Kaufman, A.J., and Kolosov, P., 1995, Integrated approaches to terminal Proterozoic stratigraphy: an example from the Olenek Uplift, northeastern Siberia: Precambrian Research, v. 73, p. 251-270.

Landing, E., 1994, Precambrian-Cambrian boundary global stratotype ratified and a new perspective of Cambrian time: Geology, v. 22, p. 179-182.

Lipps, J.H., and Signor, P., 1992, Origin and Early Evolution of the Metazoa: Topics in Geobiology, v. 10: New York, Plenum, 570 p.

Magaritz, M., Holser, W.T., and Kirschvink, J.L., 1986, Carbon-isotope events across the Precambrian/Cambrian boundary on the Siberian Platform: Nature, v. 320, p. 258-259.

McIlroy, D., and Logan, G.A., 1999, The impact of bioturbation on infaunal ecology and evolution during the Proterozoic-Cambrian transition: Palaios, v. 14, p. 58-72.

Montanez, I.P., Osleger, D.A., Banner, J.L., Mack, L.E., and Musgrove, M., 2000, Evolution of the Sr and C isotope composition of Cambrian oceans: GSA Today, v. 10, no. 5, p. 1-7.

Moore, J.N., 1976, Depositional environments of the Lower Cambrian Poleta Formation and its stratigraphic equivalents, California and Nevada: Brigham Young University Research Studies, Geology Series, v. 23, p. 23-38.

Mount, J.F., and Bergk, K.J., 1998, Depositional sequence stratigraphy of Lower Cambrian grand cycles, southern Great Basin, U.S.A: International Geology Review, v. 40, p. 55-77.

Mount, J.F., Gevirtzman, D.A., and Signor, P.W., III, 1983, Precambrian-Cambrian transition problem in western North America; Part I, Tommotian fauna in the southwestern Great Basin and its implications for the base of the Cambrian System: Geology, v. 11, p. 224-226.

Mount, J.F., Hunt, D.L., Greene, L.R., and Dienger, J., 1991, Depositional systems, biostratigraphy and sequence stratigraphy of Lower Cambrian Grand Cycles, southwestern Great Basin, *in* Cooper, J.D., and Stevens, C., eds., Paleozoic paleogeography of the Western United States; II, SEPM Pacific Section Book 67, p. 209-226.

Narbonne, G.M., and Aitken, J.D., 1995, Neoproterozoic of the Mackenzie Mountains, northwestern Canada: Precambrian Research, v. 73, p. 101-121.

Narbonne, G.M., Myrow, P.M., Landing, E., and Anderson, M.M., 1987, A candidate stratotype for the Precambrian-Cambrian boundary, Fortune Head, Burin Peninsula, southeastern Newfoundland: Canadian Journal of Earth Sciences, v. 24, p. 1277-1293.

Nelson, C.A., 1962, Lower Cambrian-Precambrian succession, White-Inyo Mountains, California: Geological Society of America Bulletin, v. 73, p. 139-144.

Nelson, C.A., 1976, Late Precambrian-Early Cambrian stratigraphic and faunal succession of eastern California and the Precambrian-Cambrian boundary, *in* Moore, J.N., and Fritsche, A.E., eds., Depositional environments of lower Paleozoic rocks in the White-Inyo Mountains, Inyo County, California: SEPM, Pacific Section, Los Angeles.

Nelson, C.A., 1978, Late Precambrian-Early Cambrian stratigraphic and faunal succession of eastern California and the Precambrian-Cambrian boundary: Geological Magazine, v. 115, p. 121-126.

Oliver, L., and Rowland, S.M., 2002, Microbialite reefs at the close of the Proterozoic Eon: The Middle Member Deep Spring Formation at Mt. Dunfee, Nevada, *in* Corsetti, F.A., ed., Proterozoic-Cambrian of the Great Basin and Beyond, SEPM Pacific Section Book 93, p. 97-122.

Palmer, A.R., 1981, Subdivision of the Sauk Sequence. U.S. Geological Survey, Open-File Report 81-743, p. 160-162.

Palmer, A.R., 1998, A proposed nomenclature for the stages and series for the Cambrian of Laurentia: Canadian Journal of Earth Sciences, v. 35, p. 323-328.

Rowland, S.M., and Corsetti, F.A., 2002, A brief history of research on the Precambrian-Cambrian boundary in the southern Great Basin, *in* Corsetti, F.A., ed., Proterozoic-Cambrian of the Great Basin and Beyond, SEPM Pacific Section, Book 93, p. 79-85.

Shen, Y., and Schidlowski, M., 2000, New C isotope stratigraphy from Southwest China; implications for the placement of the Precambrian-Cambrian boundary on the Yangtze Platform and global correlations: Geology, v. 28, p. 623-626.

Shields, G., 1999, Working towards a new stratigraphic calibration scheme for the Neoproterozoic-Cambrian: Eclogae Geologicae Helvetiae, v. 92, p. 221-233.

Shields, G., Stille, P., Brasier, M.D., and Atudorei, N.-V., 1997, Stratified oceans and oxygenation of the late Precambrian environment; a post glacial geochemical record from the Neoproterozoic of W. Mongolia: Terra Nova, v. 9, p. 218-222.

Signor, P.W., III, McMenamin, M.A.S., Gevirtzman, D.A., and Mount, J.F., 1983, Two new pre-trilobite faunas from western North America: Nature, v. 303, p. 415-418.

Signor, P.W., and Mount, J.F., 1986, Position of the Lower Cambrian boundary in the White-Inyo Mountains of California and in Esmeralda County, Nevada: Newsletters on Stratigraphy, v. 16, p. 9-18.

Stewart, J.H., 1966, Correlation of Lower Cambrian and some Precambrian strata in the southern Great Basin, California and Nevada: U.S. Geological Survey Professional Paper, 0550-C, p. C66-C72.

Stewart, J.H., 1970, Upper Precambrian and Lower Cambrian strata in the southern Great Basin, California and Nevada, U.S. Geological Survey Professional Paper, 0620, p. 1-206.

Stewart, J.H., and Suczek, C.A., 1977, Cambrian and latest Precambrian paleogeography and tectonics in the western United States, *in* Stewart, J.H., Stevens, C.H., and Fritsche, A.E., eds., Paleozoic paleogeography of the western United States:, SEPM Pacific Section, Book 7, p. 1-17.

Strauss, H., Bengtson, S., Myrow, P.M., and Vidal, G., 1992, Stable isotope geochemistry and palynology of the late Precambrian to Early Cambrian sequence in Newfoundland: Canadian Journal of Earth Sciences, v. 29, p. 1662-1673.

Taylor, M.E., 1966, Precambrian mollusc-like fossils from Inyo County, California: Science, v. 153, p. 198-201.

Walcott, C.D., 1908, Cambrian sections of the Cordilleran area, Smithsonian Miscellaneous Collections: v. 53, p. 167-230.

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PRESIDENT'S OBSERVATIONS

A Global Earth

We live in difficult times. In many locations around the world terrorism is replacing political discussion, thuggery is replacing democracy, conflict is replacing diplomacy, and civil liberties are being trampled by some espousing freedom. While for the majority of us these events have resulted only in inconveniencies and anxieties, others have been profoundly affected. A friend of mine, for example, suddenly found himself helping in the recovery efforts after the Bali bombing last October. In such a troubled world it is tempting to turn inward and worry only about what is going on in our local community. To do so is dangerous. The world is too small to ignore what is going on elsewhere.

Scientists are used to thinking of a global community. We value creative minds and innovative thinkers regardless of their nationality, gender, age, or any other factor that may define the individual. A different perspective is seen as an asset rather than a threat. Scientific societies believe that their health and vitality is dependant on attracting a membership of highly qualified individuals from around the world. The SEPM Society for Sedimentary Geology began in the United States over 75 years ago but today it is truly an international society. We have members in many countries and, although our membership is still dominated by geologists living in the U.S., the majority of our new members are from outside the U.S. As the society membership evolves, it is important that the society itself adapts and provides better services to members around the world. We always welcome your suggestions as to how we can better serve you.

SEPM is committed to being a leader in providing communication within the global sedimentary geology community. This first issue of the Sedimentary Record is an initial step in creating what I hope will become a forum for the SEPM membership to learn about news and recent developments in our community. I urge you to see this publication as a forum to let others know about exciting developments in your area. We all know communication is vital to a thriving global scientific community — here is your opportunity. Maybe in a small way we can set an example by showing that international cooperation benefits all participants. I wish the Sedimentary Record every success and let us hope that the coming months bring more peace to the world.

Peter J. McCabe, President
pmccabe@usgs.gov

COMMENTS FROM THE COUNCIL

The SEPM Foundation

The goal of the SEPM Foundation is to raise and distribute funds in support of SEPM (Society for Sedimentary Geology) activities. The Foundation is essentially the fund raising arm of the Society. Because our students are the future of our science, one of our most important areas is the support of student research in sedimentary geology. This year we are supporting a student research section that was organized by Dave Budd and Toni Simo at the SEPM/AAPG Annual Meeting (P80). A total of 16 student posters will be presented on Tuesday morning (13 May). Each student presenter is supported by a travel grant from the ***Mobil Foundation Student Participation Fund***. The abstracts, available online at http:// aapg.confex.com/aapg/sl2003/techprogram/session_2020.htm, show the amazing diversity and strength of current student research in sedimentary geology. If you are at the annual meeting, I strongly encourage you to make time for this session. You will not be disappointed.

Our other area of support for students is research grants. We are pleased to announce that in 2003 the Foundation has awarded four research grants from the Robert and Ruth Weimer, John Sanders funds, and for the first time the Gerald Friedman Fund.

Funds were provided to the following students:

Stephen A. Welch, University of Tennessee (Friedman Fund)
Deciphering Eustatic and Tectonic Influences during Parasequence Development in the Mesoproterozoic Helena/Wallace Formations, Belt Supergroup

Diane C. Jorgensen, James Cook University, Australia (Sanders Fund)
Quaternary Paleowinds and Paleoclimates of Western Australia

Elizabeth Leslie, University of Wisconsin (Weimer Fund)
The Climatic Signature of the Golden Valley Formation (Western North Dakota): Implications for Carbon Cycling During the Initial Eocene Thermal Maximum

Jesse T. Korus, University of Wisconsin (Weimer Fund)
The Alluvial Wasatch Formation, Green River Basin, Wyoming: A Bridge in the Gap between Lacustrine Stratigraphy and Drainage Basin Dynamics

Congratulations to these students. However, this year funding requests for student research greatly exceeded available funding. Please consider contributing in support of the sedimentary geologists of the future. If you wish to create an enduring tribute, consider establishing a fund in the name of a beloved mentor or colleague. More information on how you can assist the Foundation is available online or from headquarters or me at any time.

Tim Carr, President, SEPM Foundation, Inc.
tcarr@kgs.ukans.edu

The Hand Lens—a student forum

The Evolution of the Multi-Hat Head

Sedimentology is a constantly changing discipline. It is ironic that the Greek philosopher Herotodus, a man of many talents, assigned the name *delta* to the mouth of the Nile River (c. 490 BC) because of its resemblance to the Greek symbol. Although little was known about deltas during the time of Herodotus, the deltaic system represents one of the most dynamic and diverse environments on this planet, not unlike the man who originally proposed the name.

The classic work on sediment we as geologists are all familiar with was mostly performed during the early to middle 1900s. Many experiments, with some of the results still important today, were performed during the early part of the last century. These include the work of Zingg (1935) and Powers (1953), both of whom contributed to the classification of individual sediment particles. Understanding the behavior of sediments at the onset of suspension was the work of Hjulstr˚m (1935) and Shields (1936), both of whom constructed diagrams, still in use today, that relate grain size to the onset of suspension. The middle 1900s witnessed a shift from studying individual sediment grains to studying the classification of those grains after lithification. The most well-known classification systems of this era are the work of Dunham (1962) and Folk (1962). Each proposed a different classification for carbonate rocks, with the former being more useful in the field and the latter being more useful in the laboratory. The late 1900s witnessed yet another change regarding the way sediments are studied. Studies of individual grains and the whole rocks evolved into a method of analyzing an entire depositional system. The work of industry research groups became important and influential throughout the 1970s and 1980s. The classic work of the Exxon Group (Vail et al., 1977) is probably one of the more important contributions to the field of sedimentology and stratigraphy during the last century. Seismic stratigraphy, which later evolved into sequence stratigraphy, changed the basic ideas of sedimentary relationships and stacking patterns on a basin-wide scale. With the advent of sequence stratigraphy, sedimentology came to be interpreted in a more lateral fashion, although vertical detail was also enhanced. Miall (1985) proposed the idea of architectural element analysis. This idea put forth a given set of geometries for a fluvial setting. Architectural element analysis involved a characteristic succession of sedimentary structures used in identifying a fluvial succession. This model made it more convenient for geologists to understand individual sedimentary geometries and relationships at the kilometer scale.

The true purpose of this essay is to inform graduate students who are planning careers in sedimentary geology, primarily sedimentology, as to what is needed to be successful. During a precious few years in graduate school, a student needs to carefully map out what it will take to make himself or herself more 'marketable' upon completion of a degree. As a graduate student, many things are out of one's control; however, there are some things that canbe controlled by the individual graduate student, that I think are necessary to maximize one's marketability after school.

Geologic research today is multifaceted. It is rare to see a graduate student write a thesis on "the settling velocity of a quartz sand grain." In universities today, graduate student research often covers several subdisciplines. Primarily sedimentologic studies are often combined with stratigraphy, sequence stratigraphy, paleontology, and structural studies. Graduate students today must be able to develop not only a strong geologic background in the field and the classroom, but they also need to develop a *multi-hat head*. This *multi-hat head* will make an individual much more marketable when it comes time for the employment search, whether it be industry or academia.

As history has shown, sedimentology will continue to change over the next decade. In the literature today, it is rare to find an article centered on the application of one subdiscipline to a sedimentary succession (primarily sedimentology) to a given study. Even in sedimentology-based journals (i.e., *Journal of Sedimentary Research, Sedimentology*, etc.) recent titles include studies that relate sedimentary structures, sequence stratigraphy, glacio-eustasy, and basin analysis to basic sedimentologic studies. Broad-based skills mentioned in some of these titles are impossible to completely master. This leads to the next trend in sedimentology studies, the multi-author paper. The single author, peer-review paper is not completely extinct, but there are many more multi-author papers in today's literature. The evolution of the *multi-hat head*, when involved in a multi-author paper, requires the individual to have more than a general understanding of all concepts of the paper. This may include not only your sedimentological analysis, but also a general understanding of sequence stratigraphy, structural response, and ground water movements. This capacious mode of understanding can be started in graduate school, not only through the required coursework and seminars, but also through staying 'up to date' on the current literature. Of course, one should read the articles that relate directly to one's own research, but also take time to scan titles, and get a general idea of the kind of research that is being carried in other fields.

My own research started out trying to construct a palynostratigraphic framework of the Borden Delta (Mississippian of the midwestern USA). However, once the research started, I had to gain a more complete knowledge of the sedimentologic history, at which point I decided to apply sequence stratigraphic concepts and chemostratigraphic data to gain a better understanding of the factors that controlled the deposition of the Borden sediments. Throughout my years as a graduate student, as my title lengthened and my expertise expanded, my reading list became longer. I found myself reading not only papers on palynology, but also papers on sequence stratigraphy, siliciclastic sedimentology, and Paleozoic glaciations. All these articles contributed to the evolution of my *multi-hat head*. Today, my collection of hats includes my primary and most worn hat, palynology; however, my closet also contains a sequence stratigraphy hat, a sedimentology hat, a Paleozoic glaciation hat, and a deltaic hat.

Whether you are starting a graduate career or are well into the thick of one, be sure to develop, slowly, through your time as a student, a collection of hats. Remember, today you have to be a *jack-of-all-trades, master of one!*

Jeffery G. Richardson; Department of Geological Sciences; The Ohio State University; Columbus, Ohio 43210
richardson.141@osu.edu

References

Dunham, R. J., 1962. Classification of carbonate rocks according to depositional textures, *In* W. E. Ham, (ed.), Classification of carbonate rocks: American Association of Petroleum Geologists Memoir 1, p. 108-121.

Folk, R. L., 1962. Spectral subdivision of limestone types, *In* W. E., Ham, (ed.), Classification of carbonate rocks: American Association of Petroleum Geologists Memoir 1, p. 62-84.

Hjulstr˚m, F., 1935. The morphological activity of rivers as illustrated by Rivers Fyris. Bulletin of the Geological Institute of Uppsala, v. 25, (ch. III).

Miall, A. D., 1985. Architectural element analysis: a new method of facies analysis applied to fluvial deposits. Earth Science Reviews, v. 22, p. 261-308.

Powers, M. C., 1953. A new roundness scale for sedimentary particles. Journal of Sedimentary Petrology, v. 23, p. 117-119.

Shields, A., 1936. Anwendung der Ahnlickeitsmechanik und Turbulenzforscheng auf die Geschiebebewegung, Mitteilung Preussag Versuchsanstalt, Wasserbau, Erd, Schiffbau, Berlin, no. 26.

Vail, P. R., Mitchum, R. M., Jr., and Thompson, S., III, 1977. Seismic stratigraphy and global changes of sea level, part 3: relative changes of sea level from coastal onlap. American Association of Petroleum Geologist, Memoir 26, p. 63-82.

Zingg, T., 1935. Beitr‰ge zur Schotteranalyse:Schweizerische Mineralogische und Petrographische Mitteilungen, v. 15, p. 39-140.

FIELD NOTES

Industry Viewpoints

Q: Has your view of sedimentary geology changed over the past decade?

A: Yes. The real change in the industry occurred approximately 20 years ago with the theories relating to Sequence Stratigraphy. The industry has had time to put these theories to a test through out the world and they have worked quite well. On a smaller field wide basis, the complexities of the sedimentary world are much more profound and harder to evaluate unless you have an abundant amount of data such as well bores with modern logs or detailed outcrop data. This data is hard to come by in these older fields such as Elk Basin.

Q: How is sedimentary geology important in your daily working life?

A: It is very important. I deal with it everyday, being a petroleum geologist working in the development of older mature fields. We are always looking at the depositional histories and environments of potentially new reservoirs in these old and very large fields. These reservoirs have been bypassed for many years by the original owners of the fields, and when new owners come along, new ideas are looked at and old biases about the reservoirs are forgotten. We have been very successful at doing this and hope to continue applying new ideas and technology to these old fields.

Q: Finish the following sentence. If I taught sedimentary geology to undergraduates, the most important things that I would stress are....

A: No matter how complex the model you predict is, in real life it will be exponentially more complex if you could really see the whole picture.

Always step back and look at the regional picture before you try and evaluate down to the local level. "You need to try and understand the whole picture before you can understand a smaller piece."

Always try to find an example in today's world that will relate back to what you are trying to hypothesize. We use this in the petroleum industry to help us understand what could be happening in the subsurface.

Always keep your mind open to new ideas. No matter how hard and long you work on a problem, there is always another way to look at it. Don't get into the Oil Business. Become a Lawyer or Doctor. Just kidding. It has been a tremendous and rewarding experience being a petroleum geologist and I would highly recommend it to your students.

Michael Shourd, Senior Staff Geologist
Anadarko Petroleum, Houston, TX
832-636-1551
michael_shourd@anadarko.com

FROM THE DIRECTOR'S CHAIR

Future of Sedimentary Geology

I remember reading a sci-fi story where intergalactic survey teams were dominated by geologists. I was hooked on the story when the first chapter had the team leader classifying the planet based on the degree of plate tectonic activity. In this future, the best people to estimate the value of a new planet were those that understood earth science. This is of course only one possibility of the future of geology and geologists (stick them all in space ships). What do you think about the future role of geology and geologists and especially the future of sedimentary geology?

For some of my time at ARCO, I was assigned to a study to forecast geoscience technologies. Essentially, we were asked to predict the future improvement of technology and its impact on the petroleum industry. ARCO had done a similar study about 5 years prior to this one. A part of the new study was to evaluate the accuracy of the previous predictions. Overall, the predictions were about 25% correct. About half of the predictions had quantitatively overestimate or underestimated improvements in specific technologies. The rest of the predictions, however, included technologies that either had never developed or conversely had completely missed identifying, something that was having a major impact in 1995.

The question of the future of sedimentary geology or aspects of it has also been evaluated several times over that last few years.

I, respectfully, decline to put my own particular view on the future in print (I will only discuss it in very small groups and it changes each time). However, I will give you a very nice, small, package of references putting forth group and individual attempts to describe visions of the future. Some include a tapestry of the past improvements, telling the story of how sedimentary geology got to be what it is today, it's impacts along the way and what it might be tomorrow. Each of you is, of course, responsible for your own vision of the future but I think all the thoughts expressed by these papers should give you lots of food for thought or indigestion.

These papers are located at the listed links. I think discussing them would make a very interesting graduate seminar.

Howard Harper, Executive Director, SEPM
hharper@sepm.org

1. Sedimentary Systems in Space and Time (1999) NSF www.geo.nsf.gov/ear/programs/sedgeology.doc
2. Dynamic History Of The Earth-Life System (1999) NSF www.geo.nsf.gov/ear/programs/PaleoSocWorkshop.doc
3. A Vision for Geomorphology and Quaternary Science Beyond 2000 (1999) NSF www.geo.nsf.gov/ear/programs/Geomorph.doc
4. *The Future of Applied Sedimentary Geology.* (2000) W. Schlager. www.sepm.org/sedrecord/reference/schlager.pdf.
5. *Sedimentology and the Oil and Gas Industry.* (2001) W. Schollnberger. www.sepm.org/sedrecord/reference/schollnberger.pdf.

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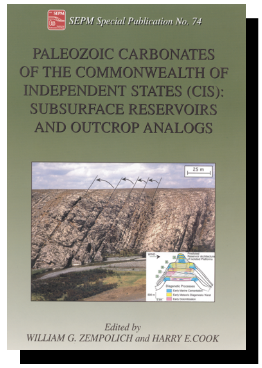

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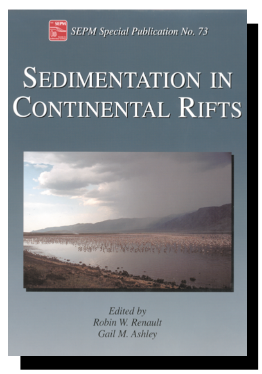

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