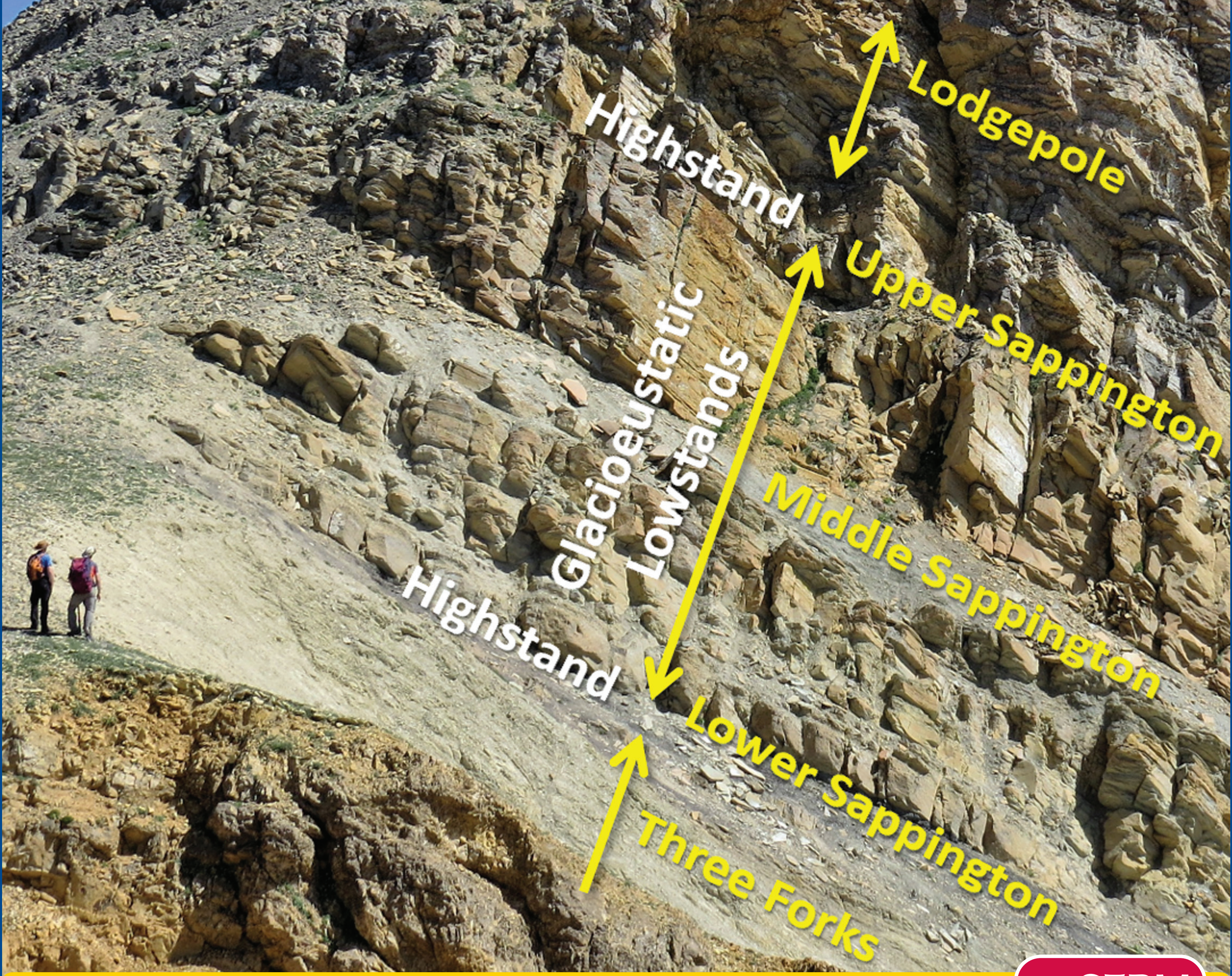
# The SEDIMENTARY Record

doi: 10.2110/sedred.2020.1
Volume 18, No. 1, March 2020

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






**INSIDE:** THE LATE DEVONIAN ICE AGE AND THE GIANT BAKKEN OIL FIELD

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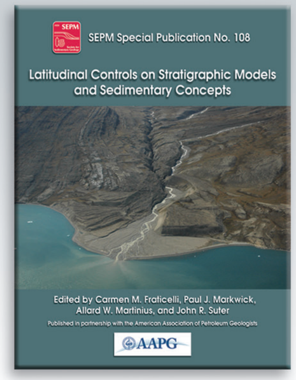


**Special Publication #108**

## Latitudinal Controls on Stratigraphic Models and Sedimentary Concepts

*Edited by: Carmen M. Fraticelli, Paul J. Markwick, Allard W. Martinius and John R. Suter*

It is self-evident that a better understanding of depositional systems and analogs leads to better inputs for geological models and better assessment of risk for plays and prospects in hydrocarbon exploration, as well as enhancing interpretations of earth history. Depositional environments—clastic and carbonate, fine- and coarse-grained, continental, marginal marine and deep marine—show latitudinal variations, which are sometimes extreme. Most familiar facies models derive from temperate and, to a lesser extent, tropical examples. By comparison, depositional analogs from higher latitudes are sparser in number and more poorly understood. Numerous processes are amplified and/or diminished at higher latitudes, producing variations in stratigraphic architecture from more familiar depositional "norms." The joint AAPG/SEPM Hedberg Conference held in Banff, Alberta, Canada in October 2014 brought together broad studies looking at global databases to identify differences in stratigraphic models and sedimentary concepts that arise due to differences in latitude and to search for insights that may be applicable for subsurface interpretations. The articles in this Special Publication represent a cross-section of the work presented at the conference, along with the abstracts of the remaining presentations. This volume should be of great interest to all those working with stratigraphic models and sedimentary concepts.

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**Special Publication #110**

## From the Mountains to the Abyss: The California Borderland as an Archive of Southern California Geologic Evolution

*Edited by: Kathleen M. Marsaglia, Jon R. Schwalbach, and Richard J. Behl*

This SEPM/PS-SEPM volume celebrates the life and scientific achievements of Donn S. Gorsline focusing on the California Continental Borderland, a region where Donn worked extensively. The 18 papers in this volume span offshore Borderland basin settings and exposures in onshore, inner Borderland regions affected by tectonic uplift. They touch on aspects of sedimentation in the modern source-to-sink sedimentary systems, encompassing some world-class Miocene to Pleistocene outcrops and the subsurface distribution of submarine fan and hemipelagic facies, as well as the structural evolution of the Borderland basins and their associated magmatic components. The broad topics covered will be of interest to a spectrum of geologists and geophysicists interested in transtensional to transpressional basin settings, the Cenozoic tectonic evolution of southern California, models of deep-marine to coastal depositional systems, as well as regional hydrocarbon exploration. Additionally, the geologic history and structure of the California Continental Borderland are connected with the distribution of modern seafloor life and marine ecosystems. This volume serves as a benchmark of current research in the region with the aim of spurring future exploration and study.

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**Special Publication #111**

## Geologic Problem Solving with Microfossils IV

*Edited by: Richard A. Denne and Alicia Kahn*

Every four years micropaleontologists from across the globe gather in Houston, Texas for the quadrennial conference of the North American Micropaleontology Section–SEPM (NAMS) to learn, share, and network on applied micropaleontology. Geologic Problem Solving with Microfossils IV was held on April 5–8, 2017 with 130 participants. Fourteen of the 95 presentations were selected for publication, which includes papers on geologic applications utilizing foraminifera (benthic and planktic), calcareous nannofossils, palynology, and conodonts, in studies of rocks and sediments ranging from the Pennsylvanian to the modern.

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**Special Publication #112**

## Carbonate Pore Systems: New Developments and Case Studies

*Edited by: Donald F. McNeil, Paul (Mitch) Harris, Eugene C. Rankey, and Jean C.C. Hsieh*

SEPM (Society for Sedimentary Geology) and the CSPG (Canadian Society of Petroleum Geologists) convened the Mountjoy II Carbonate Research Conference in Austin, Texas, from June 25-29, 2017. The conference, honoring Eric Mountjoy and his numerous contributions as a geologist and graduate student supervisor, was attended by ~140 professors, students, and industry geologists and engineers from around the world. The theme for the conference and now SEPM Special Publication 112—Carbonate Pore Systems—follows the general concept to have topics that are relevant to the petroleum industry and therefore blend the best of cutting-edge geoscience research with industry needs by offering a major publication featuring studies with significant new results in the analysis of carbonate pore systems. This new SEPM–CSPG Special Publication is timely given the renewed interest in carbonate reservoirs, including those in carbonate mudrock deposits, as well as the many new technical advances and approaches that are being utilized in diagenetic studies.

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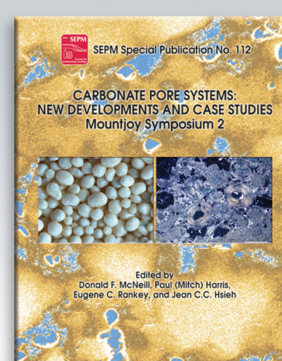

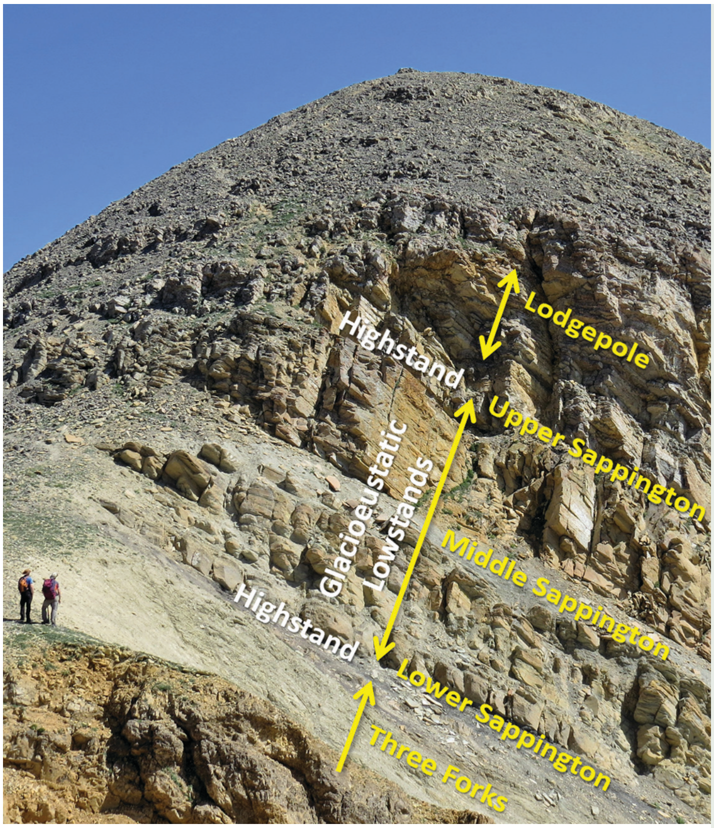


*Cover image: Outcrop of the Bakken-equivalent Sappington Formation on Sacagawea Peak in Western Montana. Stratigraphic heterogeneity in both these and other time-equivalent formations was largely driven by glacioeustacy near the end of the Devonian.*

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The Sedimentary Record (ISSN 1543-8740) is published quarterly by the Society for Sedimentary Geology with offices at 1621 S. Eucalyptus Ave., Suite 204, Broken Arrow, OK 74012, USA.





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# The Late Devonian Ice Age and the Giant Bakken Oil Field

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## ABSTRACT

The physical stratigraphy of the North American Bakken Petroleum System, in particular the Middle Bakken Member, suggests that it formed in response to eustatic fluctuations around the Devonian-Mississippian boundary. Elsewhere, in North America and globally, time-equivalent strata have stratigraphic architectures interpreted to have been linked to glacioeustacy. The Gondwanan continental glaciations responsible for the eustatic fluctuations were, at least in part, driven by changes in atmospheric composition and colonization of continental interiors by land plants over 360 Ma. This paper links global climate fluctuations to petroleum systems.

## INTRODUCTION

Links between changes to atmospheric composition, climate, and sea level are firmly established (e.g., Fairbanks, 1989; Petit et al., 1999; Joachimski and Buggisch, 2002), and there is much interest in relationships between fossil fuel consumption, atmospheric $CO_2$, greenhouse warming and rising sea levels. In this paper we suggest that deposition of the Bakken Formation, one of the world's 50 largest oil accumulations (Gaswirth et al., 2013), was driven by glacioeustacy and changes in atmospheric composition at the end of the Devonian. Our interest in the Bakken was initially spurred by reservoir characterization efforts in support of hydrocarbon development (Li et al., 2015; Edwards et al., 2016), but scientific curiosity led us to appreciate these broader links between the Bakken Petroleum System and global climate.

## THE BAKKEN PETROLEUM SYSTEM

The Bakken Petroleum System is in the Williston Basin of central North America (Fig. 1A). We focus here on two critical petroleum system elements present within that system: source and reservoir rocks. The Lower Bakken Shale (LBS) and Upper Bakken Shale (UBS) are the primary organic-rich source rocks that expelled hydrocarbons into the adjacent Middle Bakken (MB) reservoir (Fig. 2). This type of direct juxtaposition of world-class source and reservoir rocks is not common, especially when source rocks are marine shales and reservoirs are shallow-marine clastic reservoirs as described below.

## BAKKEN STRATIGRAPHY

The stratigraphy, sedimentology, and geochemistry of the Bakken have been discussed and debated by many authors previously (e.g. Smith and Bustin, 1998; Kohlruss and Nickel, 2009; Egenhoff et al., 2011; Angulo and Buatois, 2012; Egenhoff and Fishman, 2013; Scott et al., 2017; Sonnenberg et al., 2017). Despite this work, there is no consensus about environments of deposition (e.g., water depths or paleo-redox conditions during shale deposition) or the internal stratigraphic architecture of the Middle Bakken. Instead of summarizing and attempting to reconcile these different views, we highlight some specific aspects of the stratigraphy that we believe to be most germane to understanding the forcing mechanisms for Bakken deposition and summarize our sedimentologic interpretations that are broadly consistent with those of Smith and Bustin (1998), Kohlruss and Nickel (2009) and Sonnenberg et al. (2017).

The intracratonic Williston Basin was close to the equator (Fig. 1B) during Bakken deposition. Deposition spans 12 conodont zones (~ 8 to 10 MY) with the LBS being Upper Devonian (Famennian) and the UBS being Lower Mississippian (Tournaisian) (Hogencamp and Pocknall, 2018; Fig. 1C). To date, no reliable biostratigraphic or chronostratigraphic data have been retrieved from sandstones and siltstones of the MB. This absence of bio- or other chronostratigraphic evidence in the MB makes it impossible to accurately define the ages of the stratigraphic contacts between it and the adjacent shale members, or the ages of stratigraphic surfaces within.

The three primary members (the LBS, MB and UBS) can be mapped over approximately 150,000 km$^2$ using wireline logs and core (Fig. 2B). The LBS and UBS consist of organic-rich, structureless or laminated, siliceous, marine black shales having a total organic content that

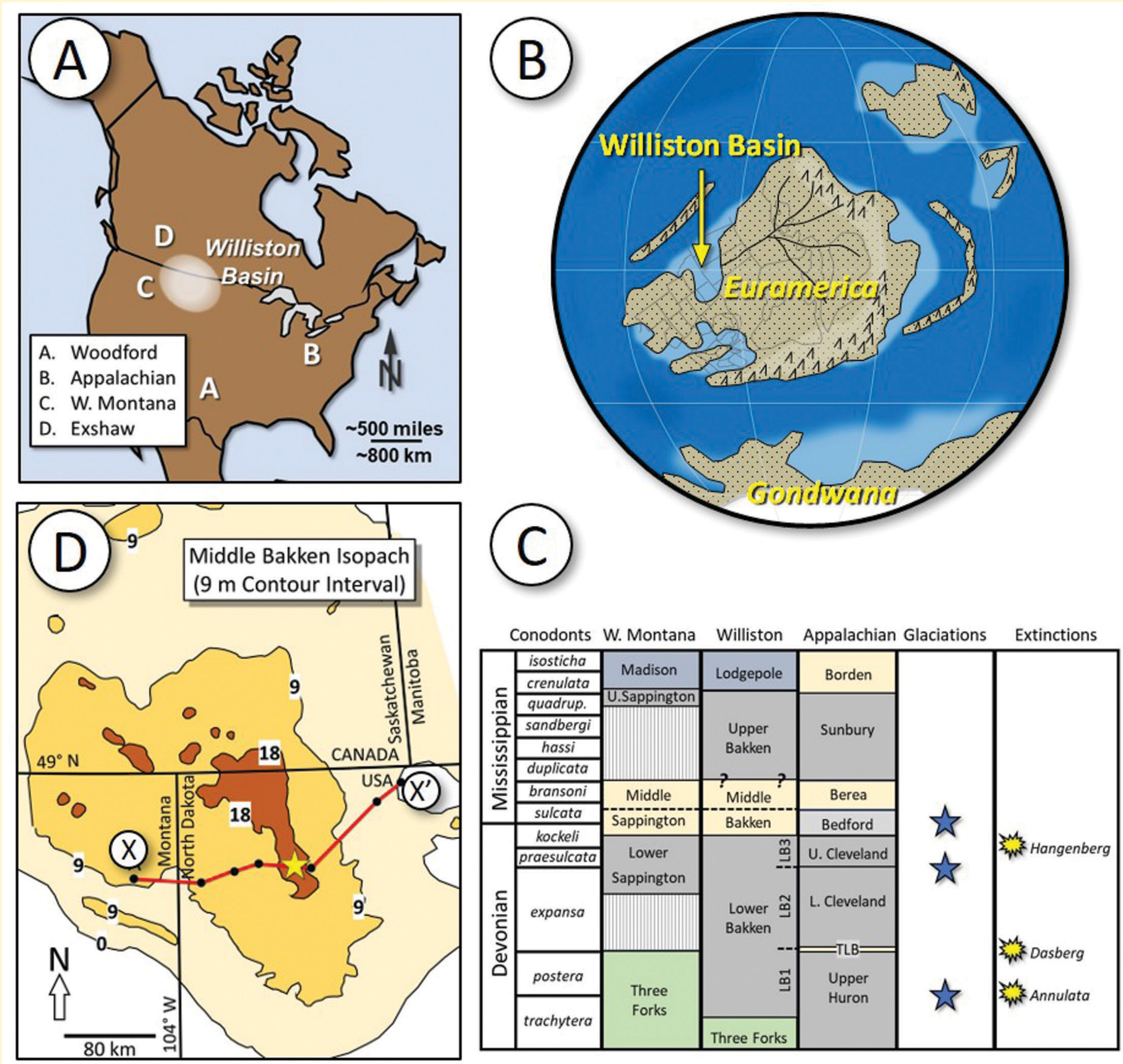


*Figure 1: Clockwise from upper left. A) Base map showing present-day geography and locations of selected Devonian-Mississippian sections referred to in the text. B) Simplified Late Devonian paleogeography showing the location of the Williston Basin and location of continental ice in Gondwana. C) Stratigraphic correlations between western Montana (di Pasquo et al., 2017), Williston Basin (Hogankamp and Pocknall, 2018), northern Appalachian Basin (Algeo and Rowe, 2012). TLB – Three Lick Bed, the distal expression of a prograding succession in the northern Appalachian Basin (Ettensohn et al., 2009). Gondwanan glaciations from Isaacson et al. (2008) and extinction events from Kaiser et al. (2015). D) Isopach map of the Middle Bakken showing location of type log (yellow star) and cross section in Figure 2.*

commonly ranges between 10 - 15% (Fig. 2A) (e.g., Hart and Steen, 2015; Sonnenberg et al., 2017). Redox-sensitive trace elements, such as molybdenum, are enriched in these shales (Fig. 2A; Hogencamp and Pocknall, 2018). The shales were mostly deposited below storm wave base that generally had anoxic to euxinic bottom (pore) waters (Scott et al., 2017; Browne et al., 2019), although sedimentologic data do not support persistent anoxia (Borcovsky et al, 2017).

In contrast, MB reservoir rocks were deposited in a shallower-marine setting than the shales (e.g., Smith and Bustin, 1998; Angulo and Buatois, 2012; Sonnenberg et al. 2017). These can be subdivided into three genetically related facies assemblages bounded by regionally significant surfaces, i.e. systems tracts MB-1 to MB-3 (Fig. 2A,B).

Middle Bakken Unit 1 (MB-1) is the lowest of the three systems tracts. It is sharply based with organic rich shales of the LBS overlain by bioclastic muddy siltstones (Figs. 2A,B, 3A). This type of abrupt facies transition and stratigraphic juxtaposition is characteristic of a regressive surface of marine erosion ("forced regression") as previously noted by Smith and Bustin (1998). Where fully developed, the overlying MB-1 interval represents an upward coarsening succession from bioclastic muddy siltstones to laminated siltstones (Figs. 3 A-C). We interpret this facies stacking as the result of progradation of a low-energy strandplain which, based on subsurface mapping (Fig. 1D), filled the entire Williston Basin.

The MB-1 is capped by a regionally mappable erosion surface we call the Middle Bakken Unconformity (MBU; Fig. 2A,B). Over much of the basin, cores show the MBU as separating the previously described low-energy strandplain deposits of MB-1 from overlying laminated and cross-bedded, fine- to medium-grained, calcareous sandstones (including bioclastic sandstones and oolites) that are locally contorted (Figs. 3D-I). These latter rocks are part of our Middle Bakken Unit 2 (MB-2) (Fig. 2). MB-2 is not present everywhere in the basin (Kohlruss and Nickel, 2009; Sonnenberg et al., 2017), but where present the grain size and sedimentary structures indicate deposition occurred under much higher energy paleoenvironmental conditions than the underlying MB-1. Around some parts of the basin margin, the MB-2 rests unconformably on the Three Forks Formation (Figs. 2B, 3G). Like Kohlruss and Nickel (2009), we interpret the abrupt facies change between MB-1 and MB-2, and the substantial erosion observed on the MBU as indicative of another regressive surface of marine erosion. We postulate that MB-2 represents a second phase of forced regression, perhaps relatively short-lived, in a

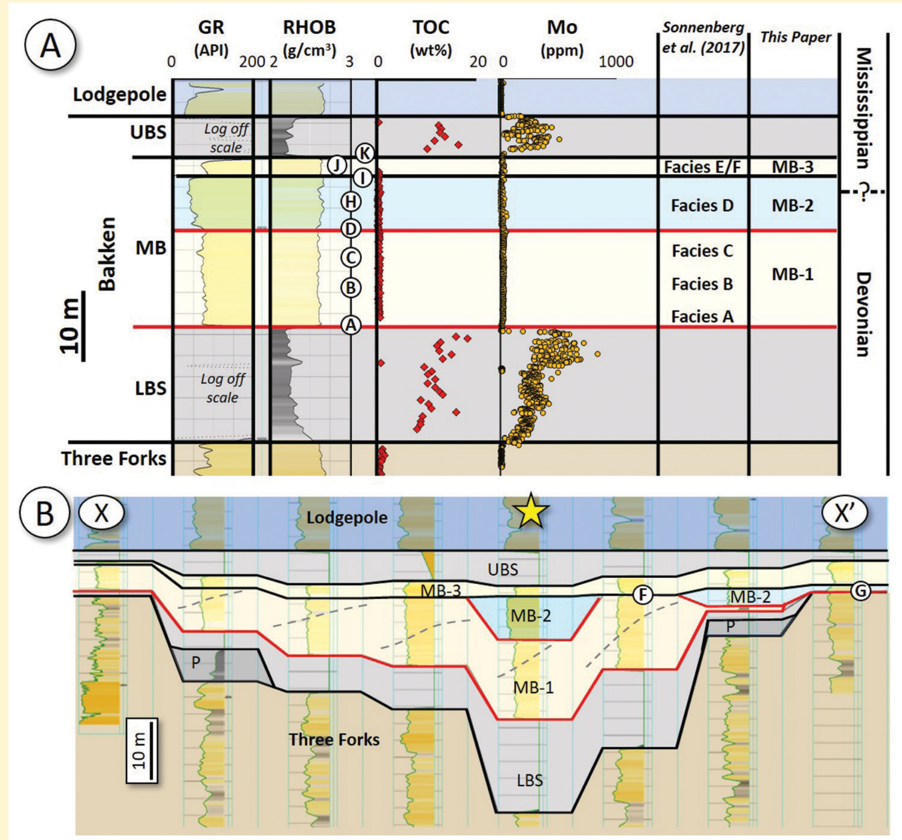


*Figure 2: A) Type log for the Bakken in North Dakota showing stratigraphic units defined in the text and relationship between our stratigraphic terminology and that of Sonnenberg et al. (2017). B) Interpreted east-west gamma-ray log cross section through the Williston Basin (location in Figure 1C). All wells on the section are cored through the entire Bakken, enabling confident assignment of facies and surface picks. Yellow star in Part B shows location of Type Log shown in 2A. Lettered circles (A-K) show location of photos in Figure 3.*

low-accommodation setting.

An abrupt change in grain size and lithology – interbedded mudstones, siltstones, and fine-grained sandstones (Fig. 3J) – accompanied with changes in sedimentary structures, higher bioturbation, and fossil content (e.g., brachiopods and crinoids; Fig. 3K) marks the contact between MB-2 and MB-3. This contact is mappable across the basin and is interpreted as a regional marine flooding surface. Locally, it is clearly associated with erosion of underlying strata (Fig. 3I). Where MB-2 is absent, this flooding surface amalgamates with the MBU (Figs. 2B, 3F). MB-3 is interpreted as the first deposits of a stepwise deepening environment with lower energy depositional conditions that culminated in the deposition of the UBS.

The black shales of the UBS are separated from the brachiopod-bearing siltstones of the underlying MB-3 along a sharp, but burrowed, contact. This surface is recognized everywhere in the basin and is interpreted as a regional flooding surface (Fig. 2A,B).

## MIDDLE BAKKEN ACCOMMODATION CYCLE AND SYSTEMS TRACTS

Different styles of shoreline progradation occur in response to varying conditions of increased sediment supply and/or a change in base level, the latter being a function of both local subsidence/uplift and eustacy. The MB sedimentology and stratigraphy indicate that it represents deposition during a relative lowstand of sea level. Both MB-1 and MB-2

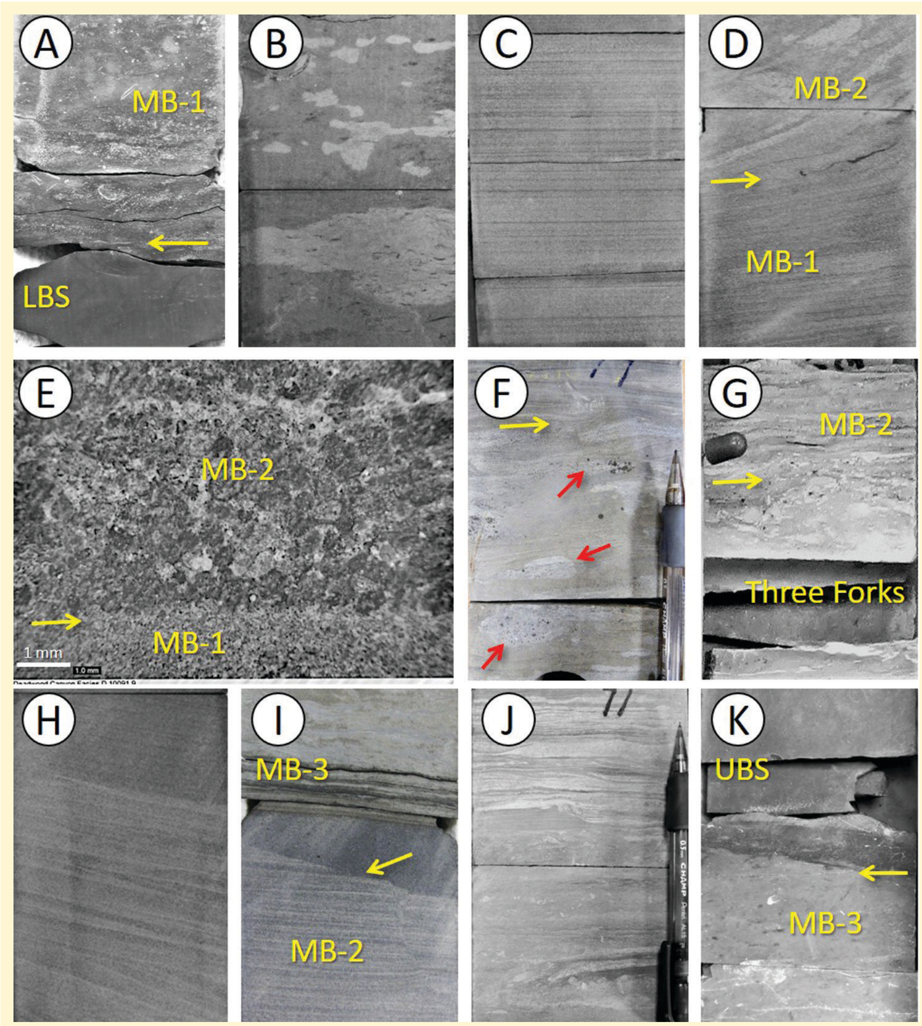


*Figure 3: Middle Bakken core photos. All (except for Parts G, I, K) are from a core taken from well shown in Figure 2A; letters on that figure show photo locations. A) Burrowed contact between the LBS and MB shown by yellow arrow. B) Pervasively bioturbated muddy siltstones. Light-grey areas represent patchy calcite cementation. C) Laminated very fine- to fine-grained sandstones. D) Erosive sand-on-sand contact (yellow arrow) of the MBU is subtle but corresponds to a distinct grain-size break and change in sedimentary structures. E) MBU (yellow arrow) in a core taken close to type log showing ooids (MB-2) overlying laminated sandstone. F) Sand-on-sand contact (yellow arrow) of the MBU. Ooids are absent above the contact but fill burrows below it. G) The MBU (yellow arrow) in this core separates MB-2 from the underlying Three Forks Formation. H) Crossbedded medium sandstone of MB-2. I) Erosive nature of the contact (yellow arrow) between MB-2 and MB-3. J) Laminated, rippled and bioturbated siltstones in MB-3. K) Flooding surface (yellow arrow) between MB-3 and the UBS.*

are underlain by regressive surfaces of marine erosion and capped by flooding surfaces. As such, in systems tract terminology, they represent falling-stage systems tracts. MB-3 is bound by flooding surfaces at its base and top and represents a transgressive systems tract.

Sea level drops, such as those inferred above, can be caused by either a eustatic drop or crustal uplift. Cratonic basins are typically characterized by broad, steady subsidence (e.g., Allen and Armitage, 2012) and Kuhn et al. (2012) suggested that the Williston Basin was undergoing a period of enhanced subsidence at the time of Bakken deposition. As such, we argue that eustatic forcing is a more likely driving mechanism for generating this forced regression than crustal uplift.

Unfortunately, the lack of biostratigraphic control for the MB makes it problematic to tie facies changes and surfaces of the MB to global events with precision. If eustacy was the primary control on facies stacking and surface development in the MB, there should be evidence of broadly time-equivalent sea level changes (i.e. lowstands) elsewhere and/or clear evidence for a driving mechanism.

## THE BAKKEN IN A GLOBAL CONTEXT

Although the Devonian is commonly referred to as the Age of Fish, it could equally well be known as the age in which land plants colonized continental interiors. At the beginning of the Devonian, terrestrial vegetation was dominated by small herbaceous plants that were mostly constrained to living in moist lowland habitats (Algeo and Scheckler, 1998). The colonization of continental interiors by forests through the Middle to Late Devonian led to a drawdown in atmospheric $CO_2$ (Berner, 2004). Burial of organic carbon in Middle to Late Devonian black shales possibly also played a role, with a global spike in organic carbon burial being associated with the Late Devonian Hangenberg Black Shale of Europe and time-equivalent black shales elsewhere (Becker et al., 2016; Kaiser et al., 2016). Atmospheric $O_2$ approximately doubled, and $CO_2$ concentrations dropped from approximately 10 – 15 times modern levels in Early Devonian time to near modern levels by the end of the Mississippian (Berner, 2004). The draw down in atmospheric $CO_2$ levels led to global cooling and, eventually, to continental glaciation in Gondwana (Fig. 1B)(e.g. Caputo et al., 2008; Isaacson et al., 2008; Streel et al., 2013). The presence of glaciogenic deposits at relatively low latitudes such as the US Appalachian Basin (e.g., Ettensohn et al., 2009; Brezinski et al., 2010) indicates that cooling was indeed global in extent.

The buildup of a continental ice sheet in Gondwana lowered global sea level by 60-100 m (Isaacson et al., 2008; Brezinski et al., 2010; Kaiser et al., 2016). These estimates are broadly consistent with estimates of sea level fall during the Pleistocene glaciations (e.g., Shackleton, 1987), implying the Devonian ice buildup was potentially similar in scale. Scott et al. (2017), based on trace elemental studies, suggested that deposition of the LBS and UBS occurred within the photic zone, but below wave base, approximately between 100-150 m water depth. Egenhoff and Fishman (2013) and Borcovsky et al. (2017) also suggested deposition of the UBS below wave base but argued that bottom-water anoxia was not permanent. The formation of the regressive surfaces of marine erosion at the base of MB-1 and MB-2, and synchronous development of erosion surfaces along the basin margins, implies a change in sea level in the Williston Basin of many 10s of meters, in agreement with the proposed global changes.

Hogancamp and Pocknall's (2018) compilation of biostratigraphic data allows us to tie our inferred sea-level history for the Bakken to other North American basins and global events (Fig. 1C). Differences in tectonic settings (e.g., foreland basins versus intracratonic basins and associated changes in subsidence patterns and rates), depositional systems (e.g., carbonate vs siliciclastic, deep-water vs shallow-water) and other factors clearly influenced the preserved stratigraphic record (lithology, ages of surfaces, etc.) from basin to basin such that one-to-one lithostratigraphic correlations are not always present. Nevertheless, the available data allow us to make a few interpretations.

Initial flooding of the Williston Basin recorded in the deposition of the organic-rich LBS is partly or wholly correlative with flooding in some other North American basins, but not outside of North America. This suggests that the flooding recorded in the LB was probably driven by forces limited to this continent, including enhanced subsidence in the Williston Basin. Deposition of the organic-rich LBS began with a flooding of the Williston Basin in the *trachytera* conodont zone (Hogencamp and Poknall, 2018; Fig. 1C). This flooding significantly predates deposition of the Hangenberg Black Shale (*praesulcata* conodont zone) and time-equivalent black shales from other parts of the globe (Kaiser et al., 2016), although Hogencamp and Poknall (2018) correlated the molybdenum-enriched uppermost portion of the LBS (their LB3; Figs. 1C, 2A) to the Hangenberg Black Shale. In North America, the LBS is partly or wholly correlative to the Lower Sappington Shale of western Montana (e.g., Phelps et al., 2018), the Exshaw Shale in Alberta (Hartel et al., 2014), and the Cleveland Shale and equivalent units in Appalachia (e.g., Algeo et al., 2007; Fig. 1C). The basal MB erosional surface, bracketed by the *expansa* and *sandbergi* conodont zones (Hogencamp and Poknall, 2018), is the most distinct evidence of a significant base-level drop in the Bakken.

Because incised valleys, subaerial unconformities, karst and other erosion features (see compilation of Kaiser et al., 2016) have been described globally within the same condont zones, we link initial forced regression of the MB to this significant eustatic drop. In North America, the MB progradation closely correlates to deposition of the Middle Sappington, Exshaw Silt, Berea Sandstone and other regressive units (Algeo et al., 2007; Hartel et al., 2014; Phelps et al., 2018; Fig. 1C). It corresponds an erosional lacuna and distinct facies change in the Woodford Shale (Over, 1992). Assuming a seafloor slope of 0.02° for the Williston Basin (measured from bathymetric maps from the Gulf of Carpenteria, a modern epicontinental sea) a eustatic fall of 100 m would have caused shorelines around the basin to prograde inward up to 290 km whereas a 60 m fall would have caused the shoreline to migrate inward approximately 170 km from all sides of the basin. Either scenario would have at least drained the US portion of the Williston Basin and probably most of the Canadian portion.

The presence of multiple regression surfaces, the MBU at the base of MB-1 and the second forced regressive surface at the base of MB-2, could also be controlled by global ice sheet dynamics. Streel et al. (2013) noted that the Late Devonian glaciation may have consisted of multiple glacial-interglacial cycles, which may account for multiple MB surfaces. Unfortunately, and as noted by other authors before us (e.g., Sandberg et al., 2002; Kaiser et al., 2016), the biostratigraphically barren nature of MB and time-equivalent coarse-grained paralic deposits elsewhere currently makes this hypothesis untestable.

The initial demise of Late Devonian Gondwanan continental glaciations is first represented by the MB-3 transgressive systems tract with melting corresponding to a eustatic highstand and deposition of the UBS in the Lower Mississippian. Although the timing of that flooding and the amount of time missing (if any) at the contact between the two members remain unresolved, the UBS is at least partly correlative to the Upper Sappington Shale in Montana (Phelps et al., 2018), the Lower Banff Formation (a shale) in Alberta (Hartel et al., 2014), the Sunbury Shale in Appalachia (Algeo et al., 2007; Fig. 1C), and appears to partly correlate to the Lower Alum Shale in Europe (Babek et al., 2016).

## CONCLUSION

Future work should test the main hypothesis put forth here that Late Devonian Gondwanan glaciation drove global sea level changes recorded in the Bakken. We emphasize that although these correlations to global events are consistent with the stratigraphic architecture of the Bakken and the latest biostratigraphic interpretations, they are not proven by them. Furthermore, parts of our narrative have been proposed before, such as the forced regressive character of the MB (e.g., Smith and Bustin, 1998) and correlation of the MB to the Berea Sandstone (e.g., Algeo et al., 2007) among others. Additionally, evidence for late Devonian glaciation from South America has been tied to global sea level changes (Isaacson et al., 2008). Our goal here has been to synthesize our stratigraphic observations of the Bakken with data and interpretations from other basins into an interpretation that is consistent with available data and explains the unusual juxtaposition of source-rocks and shallow-marine reservoir rocks in the Bakken, which was deposited in a relatively tectonically quiescent intracratonic basin. Future bio- or chemostratigraphic work could either falsify or support our working hypothesis. Finally, our hypothesis of a glacio-eustatic forcing on Middle Bakken deposition predicts that similar stratigraphic architectures could have developed in intracontinental basins during other glacial episodes in the earth's past.

## ACKNOWLEDGMENTS

The first author's reservoir characterization work on the Bakken was undertaken while he was employed at Equinor. His work to link Bakken stratigraphy to global happenings was "weekends and evenings" work in response to an invitation by AAPG and SEG to be their joint Distinguished Lecturer in 2017-18. We thank Lauren Birgenheier, Chris Fielding and an anonymous reviewer for their comments that significantly improved the format of this paper. Responsibility for errors or omissions remains with us.

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**Accepted March 2020**

THE GEOLOGICAL SOCIETY OF AMERICA®

SEDIMENTARY GEOLOGY DIVISION

# SEDIMENTARY GEOLOGY DIVISION

## Spring 2020 Newsletter


***Our Sedimentary Geology Division water bottles were a great hit at GSA 2019 - nearly as beautiful as this sedimentary scene and many times more hydrating!***

## Your 2020 Sedimentary Geology Division Officers and Student Representatives

I am pleased to introduce myself- I'm Dr. Amy Weislogel, Associate Professor at West Virginia University, and I'm excited to take the helm of the Sedimentary Geology Division as Chair for the next 2 years. A great big **THANK YOU** goes to Gary Gianniny for his time, energy and talent in moving the division forward to close out the last decade. We are glad to hang on to him as Past Chair in the two years that lie ahead.

Dr. Brian Hampton, Associate Professor at New Mexico State University, was recently elected to serve as the Division Vice Chair and we are excited to have him onboard; Brian will be working to continue building the success and popularity our joint Student Poster session with SEPM at the GSA Annual Meetings. You may hear from him soon asking for your help to advertise the poster session, recruit student participants, and perform poster judging once the meeting rolls around.

Dr. Brett McLaurin, Professor at Bloomsburg University of PA, rounds out our Division board in 2020. He did an excellent job learning the ropes as Secretary-Treasurer in his first year and in the coming years, Brett will be the point of contact for the array of awards administered by our division.

Our fearless Student Representative, Shannon Cofield, wrapped up her 2-year stint with the division in 2019. We wish her the best as she continues with her PhD work on the Mars 2020 mission – so exciting! We now have two new fearless Student Representatives: Anthony Edgington, who is working on his undergraduate degree at University of Texas-Austin, and Sharif Mustaque, who is working on his PhD at Auburn University. Beyond keeping our social media accounts streaming with lovely sedimentologic images and posting the latest in sedimentary news, our new reps are busy working to improve networking and professional development options for our student members – read on to learn more!

## Upcoming GSA Events in 2020

We hope your 2020 plans include one or more of the great opportunities to engage your fellow sedimentologists and stratigraphers in some of the community activities we love best!

This spring, GSA section meetings are being held at various locations across the US:

M**arch:**

- **South-Central Section:** March 9-10 in Ft. Worth, TX
- **Joint Northeast-Southeast Section:** March 20-22 in Reston, VA

May:

- **Rocky Mountain Section:** May 4-5 in Provo, UT
- **Cordilleran Section:** May 12-14 in Pasadena, CA
- **North-central Section:** May 18-19 in Duluth, MN

You may notice the gap in the section meetings for the month of April- this gap is there so you can be sure to participate in the **SEPM International Sedimentary Geosciences Congress 2020 meeting in Flagstaff, Arizona April 26-29**. This meeting is jointly sponsored by SEPM, the Sedimentary Geology Division of GSA and the International Association of Sedimentologists (IAS). There are 7 workshops/short-courses offered along with 6 field trips to visit rocks representing a full range of depositional settings. This in addition to three full days of speakers and presentations with something for everyone. This Congress only visits the North American continent every once in a while, so there's no better chance than this year to immerse yourself in a sea of sedimentary geology enthusiasts as they converge in Flagstaff!

## 2020 GSA Annual Meeting: Montreal


Dozens of SGD folks have submitted proposals for sessions, symposia, field trips and short courses for the GSA annual meeting in Montreal, Quebec over October 25-28, 2020, when we hope to see many of you! The Geological Society of America, and specifically the Sedimentary Geology Division in collaboration with our partner societies like SEPM, will have a major presence at the meeting. The Sedimentary Geology Division will have field trips and sessions to share new science, a joint reception for professionals and students to network and mingle and for our division to present awards, a booth as a place to pick up some SGD swag and meet up with your sedimentary friends from across the globe, and of course our student research poster competition. Watch for the abstract deadline to be announced so you can chip in your contribution to GSA's premier conference event.

## Laubach Award Call for Applications

Be on the lookout – SGD together with the Structural Geology & Tectonics division will soon have a call for applications to the **Stephen E. Laubach Structural Diagenesis Research Award**. This award is $2500 and is open to faculty, postgraduates and students of any level who are seeking support for research activities that combine structural geology and diagenesis, such as fracturing, cement precipitation and dissolution, evolving rock mechanical properties and other structural diagenetic processes that can govern recovery of resources and sequestration of material in deeply buried, diagenetically altered and fractured sedimentary rocks. The award honors the work of Dr. Stephen Laubach, who integrated techniques from structural geology and sedimentary petrology in his scientific work.

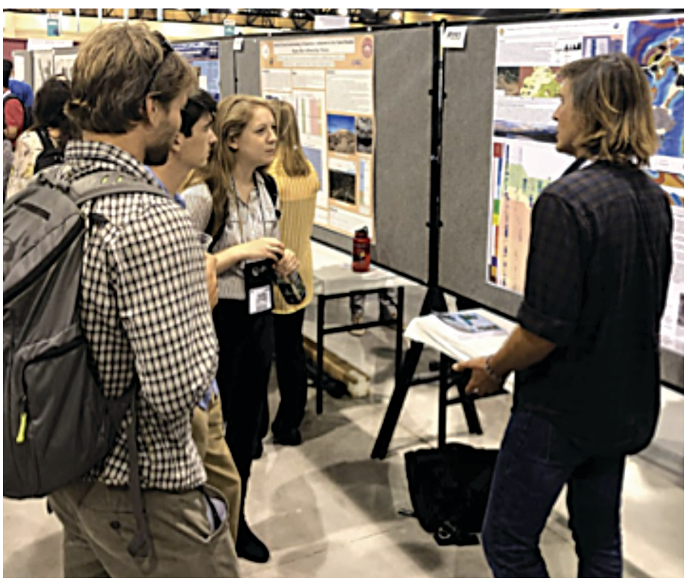
## What's New For Our Student Members?

Our Student Representatives are working to build a LinkedIn group for people looking for opportunities in sedimentary geology to find people who are offering opportunities in sedimentary geology! Search for our group on LinkedIn or look for social media posts with more information. We are hoping to cultivate this online space as a way to build and strengthen our community and its ties to outside employers, institutions, professional societies and agencies.

## Review: 2019 GSA Annual Meeting

Our division sponsored 17 sessions and 1 Pardee Symposia at the 2019Annual GSA Meeting held in the Sonoran desert metropolis of Phoenix, AZ. We again held a successful joint SEPM/SGD sponsored student poster session, which included 28 student poster presentations. Thanks to the work of 20 of our SGD membership, every poster was evaluated by multiple judges for the quality of the poster content, the significance of the research, and the effective presentation of the scientific research. From a highly competitive pool of excellent posters, four students were awarded a cash prize of $500 and recognized at our awards reception:

- **Eliel Anttila,** U. California-Santa Barbara
- **Anthony Edgington,** U. of Texas-Austin
- **Richard Hess,** U. of Georgia
- **Taylor Kelln,** Loma Linda University



***Student Poster Competition Award winner Eliel Anttila works the crowd at the joint SEPM-Sedimentary Geology poster session.***

Our Annual Joint Awards reception is no longer being branded as "Seds and Suds" at the request of GSA but that didn't stop a great turn out of folks from the intersection and interstices of interests represented by SEPM, Sedimentary Geology, and Limnogeology, to help us recognize some of our outstanding community members.

Our division awarded the **Laurence L. Sloss Award for Sedimentary Geology** to **Dr. Marjorie Chan**, a Distinguished Professor at the University of Utah. With Margie's University of Utah colleague Dr. Brenda Bowen reading the citation, it was clear we were acknowledging someone special to our community, though it was less clear perhaps if it was Margie's 40+ peerreviewed publications, her 150 invited lectures (including her 2014 tour as GSA Distinguished International Lecturer), her tenure as former Chair of the Sedimentary Geology Division (2013-2015), her service on the GSA Council or on numerous other GSA committees, or her mentorship of many sedimentary geologists throughout her career that put her over the top as an outstanding recipient of this prestigious award! Congrats again, Margie, and thank you for all you have done to build and maintain the flourishing sedimentary geology community within GSA!

***SGD Chair Gary Gianinny (right) recognizes the 2019 Sloss Award recipient, Margie Chan (left).***

At the awards reception we also recognized the 2019 recipient of the **Sedimentary Geology Division Student Research Award**, given to an outstanding student research proposal in the field of sedimentary geology and stratigraphy. **Eve Lalor** of Western Washington University took home this honor for her MS research project entitled: *"Scaling of environmental responses to multiple Eocene global warming events"*. Thanks for your fantastic work, Eve!

The Structural Geology and Tectonics Division of GSA had the honor of distributing the jointly-managed **Stephen E. Laubach Structural Diagenesis Research Award**, which in 2019 went to **Kayla Smith** for her Masters project at Utah State University, *"Geologic Characterization of the Great Unconformity Injection Interface Region from Field and Drillcore Analog Studies:*

*Implications for Midcontinent Induced Seismicity"* This award will rotate back to our division reception in the coming year – stay tuned to apply or learn who will take home the award to support their research in 2020!

***SGD Chair Gary Gianinny (right) recognizes the 2019 Sedimentary Geology Division Student Research Award recipient, Eve Lalor (left).***

Our booth at the GSA 2019 exhibit hall, we had an array of items we gave away, including the ever-useful Sedimentary Geology Sharpie, and some colorful division stickers. We gave out our attractive water bottles to meeting attendees who posted to social media, to our booth volunteers and to poster judges, to help them keep dehydration at bay while in the arid desert air of Phoenix. Watch our social media to see sneak previews of our #GSA2020 swag!

## Call for Ideas: Rebranding the "Event Formerly Known as Seds and Suds"

Since we have sunsetted the name "Seds and Suds" for our annual awards reception, we are looking for a new moniker for this social gathering to reflect the role this event plays in bringing sedimentary lovers from every corner of the geology "strata-verse" to celebrate the achievements of our members. **Do you have an idea?** Let us know on social media or reach out to us to share your great idea!s

## SGD seeks new volunteers for the Joint Technical Program Committee for 2020

We thank Ryan Morgan for agreeing to again serve our division and GSA by organizing our sponsored sessions for all of us who presented for the fifth year! **We need another member to volunteer their time and effort to this important job!** Please email Amy.Weislogel@mail.wvu.edu to learn more.

## 2020 Sedimentary Geology Division Officers:

**Chair:** Amy Weislogel

**Vice Chair:** Brian Hampton

**Secretary-Treasurer:** Brett McLaurin

**Student Representative:** Anthony Edgington,

**2nd Student Representative:** Sharif Mustaque

**Past Chair:** Gary Gianniny

## 2020 Sedimentary Geology Division Volunteers:

**Representative to GSA Council:** Marjorie Chan

**Webmaster:** Stefania Laronga

**International Student Outreach Coordinator:**
Angela Delaloye

**Ex Officio Management Board Member:**
Howard Harper, SEPM

**2020 Joint Technical Program Committee:**
Ryan Morgan (Tarleton University)

## FOLLOW US!

**@GSA.SGD**

*We had a great turn out for our 2019 Joint Sedimentary Geology Division-Limnogeology Division-SEPM Awards Reception – hope to see you at our 2020 reception at the GSA Annual Meeting in Montreal!*

## PRESIDENT'S COMMENTS

This is my first column as SEPM President, which I became on January 1, 2020. I am delighted to serve a society I have been a member of since the early 1990s, and thank all of those that have gone before me, especially Past-President Lynn Soreghan, for their service to the Society.

Lynn and others on the 2019 SEPM Council were the first to serve when office holders began and ended their terms on January 1, rather than during the annual AAPG/SEPM meeting. The other new council members for 2020 are Keriann Pederson (Secretary-Treasurer), Peter Flaig (Councilor for Research Activities), and Erin Pemberton (Web & Technology Councilor). Returning council members are Zane Jobe (Councilor for Sedimentology), Murray Gingras (Councilor for Paleontology), Emese Bordy (International Councilor), Dawn Jobe (Early Career Councilor), Kristina Butler (Student Councilor) and Rick Sarg (Foundation President). I will be the first to serve 2 years as President, so there is no President-Elect this year, and terms for other council positions have been extended to a uniform period of 3 years.

It is an exciting and challenging time for our discipline and society, as it is for many disciplines and scientific societies. I have watched sedimentary geology undergo a transformation over the course of my career from a qualitative and descriptive science focused on the stratigraphic record, to one that almost seamlessly blends modern surface processes with experimental and numerical studies, and with new creative ways to describe and quantify the insights rocks can provide to enable quantitative analyses of ancient Earth history. I do not recall a time in my career when there was so much new creative and quantitative energy and insight to deploy to answer the important questions that we ask. On the other hand, like many societies, we face serious challenges with migration to a fully digital world, with the transition to open access publications, and with declining membership. And we are all now aware of the challenges that are and will be imposed on us all from the COVID-19 outbreak.

Speaking of challenges, several weeks ago, for the first "final draft" of this column, I wrote that "one of the truly exciting events for our discipline and society is on the near horizon, the SEPM International Sedimentary Geoscience Conference (SEPM ISGC 2020), which will take place at the High Country Conference Center in Flagstaff, Arizona from April 26-29, 2020". However, while I was in Utah doing recon for a field trip for the meeting, I received the email

## PRESIDENT'S COMMENTS (continued)

from SEPM Headquarters that you all received as well, that the meeting had to be cancelled and rescheduled due to the COVID-19 pandemic. I received this email as I stood on a Book Cliffs outcrop, where I all of a sudden had remarkable reception and my phone started pinging. Until that time, I was simply standing there having thoughts that were no more complicated than whether the advancing clouds were going to produce more snow, so the skiing would be better, or whether the basal Castlegate surface was a sequence boundary or just an autogenic scour surface……

As a society, we host topic-specific Research Conferences in a wide range of locations, Research Symposia at the AAPG/SEPM Annual Meeting, and we are increasing our collaboration with the International Association of Sedimentologists (IAS). But this was to be the first sole-hosted disciplinary-scale conference since 1995, when the SEPM Congress on Sedimentary Geology was held in St. Petersburg Beach, Florida. Even though it is no longer on the near horizon, I want to mention a few details about the meeting, its origins, and the many people who had devoted much time to making this meeting a real thing.

The initial concept for SEPM ISGC 2020 was born in a workshop held in Boulder, Colorado in 2014, with a goal to reestablish a conference that would be held separate from AAPG ACE, perhaps every 3 years or so, and feature a broad spectrum of the leading research in sedimentary geosciences, as well as state-of-the-art short courses, workshops, and field trips. This was a risky decision, because there are many conferences to attend, it is difficult for societies and attendees to make them work financially, and everyone is busy. But workshop attendees felt strongly about the need for SEPM to further develop an identity separate and apart from AAPG, provide a venue that would be more focused than AAPG but broader than our Research Conferences, and provide a conference that would feature what the SEPM membership does best - lead field trips to examine and discuss current research while looking at the rocks. It was decided that SEPM's new ISGC and IAS's International Sedimentology Conference (ISC) would each be held every 4 years, but staggered with respect to each other, so there would be a major international sedimentary geoscience meeting every 2 years.

The conference had been coming together nicely, for which we can thank SEPM HQ for their efforts, especially Michelle Tomlinson, but also the original organizers, Andrea Fildani (SEPM Chair), Vincenzo Pascucci (IAS Representative Chair), Gary Gianniny (GSA Sedimentary Geology Division Representative), Devon Orme (Field Trip Chair), Jean Hsieh and Alvaro Jimenez Berrocoso (Short Course and Workshop Chairs), who were assisted by Vitor Abreu, Maria Mutti, myself, and David Bottjer. The program committee consisted of Andrea Fildani, Jean Hsieh, Alvaro Jimenez Berrocoso and Devon Orme in the same roles as above, plus Cari Johnson (Plenary Speaker Program), and the session chairs and reviewers that contributed to create the program. As of March 1, there were 368 oral or poster presentations, and 324 total registrations, with ~130 of those from students. At least 3 of the planned field trips had enough registrants to go forward: short courses had fewer registrants, and some were to be cancelled.

So now we must reboot! This is a worthy cause, and SEPM is committed to making this congress happen in the near future, so stay tuned. SEPM HQ is working with the venue in Flagstaff, as well as the organizing committee, to assess rescheduling prospects. They are also working out details for how refunds, student grants and the previously planned technical program will be handled and will be posting that information soon. I hope all of those who had planned to attend will be able to attend when it is rescheduled (and others as well), and I hope that, as a community, we use the extra time we now have to make for an even better meeting.

I closed the first "final draft" of this column by stating that "I will discuss other challenges we face as a society in future columns, but right now I will end by mentioning the COVID-19 virus". We are all now aware of the potential impact of COVID-19, so I will just hope for good health for you, your families, your workplaces, and your communities as we all get through this challenge.

**Michael Blum,**
***SEPM President***

**SEPM Society for Sedimentary Geology**
***"Bringing the Sedimentary Geology Community Together"***
***www.sepm.org***

# SEPM Science Position Statements

SEPM - Society for Sedimentary Geology has created a process to allow its membership to propose position statements that are based on major aspects of sedimentary geoscience. These statements must rely solely on the science involved. The process as approved by SEPM Council in 2019 begins with a proposed position statement which is first reviewed by Council for its appropriateness and then, if accepted, assigned to an ad hoc committee to review and draft a sucinct position statement on the topic. That draft is put out for SEPM member comments and the revised draft is reported to Council, who has the final approval or editing authority. All approved statements are published on the SEPM website.

Note that the first review of proposed position statements by SEPM is done on a quarterly basis.

In order to propose a position statement go to
https://www.sepm.org/form/SEPM%20Science%20Position%20Stmt%20Proposal%20Form

# Helpful links - sepmstrata.org

SEPM is always looking for ways to provide resources to our community to enhance their productivity and spread knowledge and education. In these difficult times, such resources are especially valuable. Academics and professionals around the world are looking for materials that they can access online and utilize in their own on-line instruction efforts. Thankfully, our community has been providing online teaching and learning materials to us and we are passing them on to you.

We greatly appreciate everyone's contributions. We compiled a list of the most useful links on www.sepmstrata.org, our online education and community website. This compilation of useful online resources is organic, and we encourage you to check it out.

Helpful links - SEPMStrata

If you know of a useful online education links for sedimentary geology, please send the link to Mr. Daan Beelen, the SEPM STRATA Fellow at (dbeelen@mines.edu). The list will be updated periodically, and we hope it is of great use.

Lesli Wood, STRATA Editor-in-Chief

Howard Harper, SEPM Executive Director

Daan Beelen, STRATA Fellow