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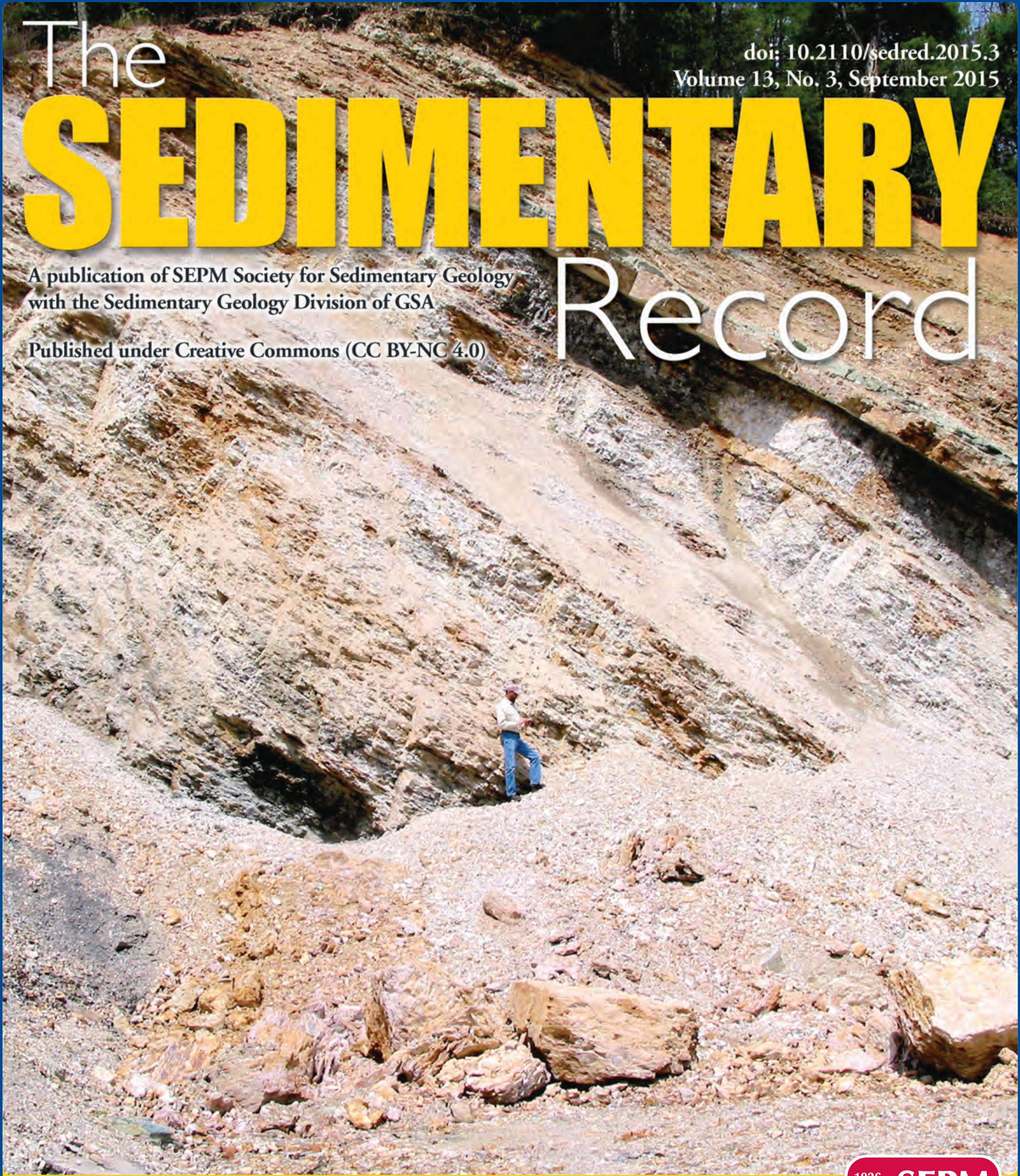

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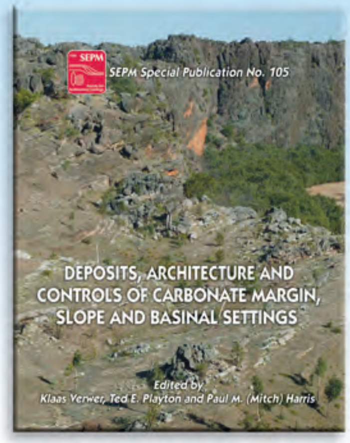

Special Publication #105

Deposits, Architecture, and Controls of Carbonate Margin, Slope, and Basinal Settings

Edited by: Klaas Verwer, Ted E. Playton, and Paul M. (Mitch) Harris

Carbonate margin, slope and basinal depositional environments, and their transitions, are highly dynamic and heterogeneous components of carbonate platform systems. Carbonate slopes are of particular interest because they form repositories for volumetrically significant amounts of sediment produced from nearly all carbonate environments, and form the links between shallow-water carbonate platform settings where prevailing in situ factories reside and their equivalent deeper-water settings dominated by resedimentation processes. Slope environments also provide an extensive stratigraphic record that, although is preserved differently than platform-top or basinal strata, can be utilized to unravel the growth evolution, sediment factories, and intrinsic to extrinsic parameters that control carbonate platform systems. In addition to many stimulating academic aspects of carbonate margin, slope, and basinal settings, they are increasingly recognized as significant conventional hydrocarbon reservoirs as well. The papers in this volume, which are drawn from the presentations made at the AAPG Annual Meeting in Long Beach, California (USA), in May 2012, as well as solicited submissions, provide insights into the spectrum of deposit types, stratal configurations, styles of growth, spatial architectures, controlling factors behind variations, and the hydrocarbon reservoir potential observed across the globe in these systems. The sixteen papers in this Special Publication include conceptual works, subsurface studies and outcrop studies, and are grouped into sections on conceptual works or syntheses, margin to basin development and controlling factors, architecture and controls on carbonate margins, and carbonate distal slope and basin floor development.

Articles for this volume are available for purchase at the SEPM Online First webpage! http://www.sepm.org/OnlineFirst.aspx

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Concepts in Sedimentology and Paleontology 11

Phanerozoic Paleoclimate: An Atlas of Lithologic Indicators of Climate

By: Arthur J. Boucot, Chen Xu, and Christopher R. Scotese, with contributions by Robert J. Morley

This publication combines the interpretations of two major sets of data. One is the geophysical data that is used to interpret the position of the tectonic plates through geologic time. The other is based on a long time search of the geological literature to find, record, and evaluate the lithologic descriptions of countless reports around the globe; paying careful attention to those lithologies that have climatic implications. The introduction to this volume includes a detailed discussion of the lithologies, mineralogies and biogeographies that are considered to be the most reliable in identifying the climatic conditions existing during their formation and how they are used or not used in this compilation. Global paleoclimatic zones based on the climatically interpreted data points are identified during twenty-eight time periods from Cambrian to Miocene using paleotectonic reconstructed maps. The paleoclimate of each time period is summarized and includes a discussion of the specific referenced data points that have been interpreted to be the most reliable available for that time period and location.

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Mudstone Primer: Lithofacies Variations, Diagnostic Criteria, and Sedimentologic–Stratigraphic Implications at Lamina to Bedset Scales

By: Remus Lazar, Kevin M. Bohacs, Juergen Schieber, Joe Macquaker, and Timothy Demko

More than two-thirds of the sedimentary record is composed of rocks dominated by grains smaller than 62.5 micrometers. These fine-grained sedimentary rocks serve as sources, reservoirs, and seals of hydrocarbons, influence the flow of groundwater, and can be rich in metals. These rocks have long been mined for clues into the past global carbon, oxygen, sulfur, and silica cycles, and associated climate and oceanography. These rocks are heterogeneous at many scales and formed via a range of depositional processes. Recent developments in drilling and completion technologies have unlocked significant hydrocarbon reserves in fine-grained sedimentary rocks and have triggered an explosion of interest in the sedimentology, stratigraphy, and diagenesis of these rocks. This Mudstone Primer covers this variability to better characterization and interpretation of mudstones. Definitions of key terms and a naming scheme for mudstones are provided followed with practical steps for studying mudstones in thin sections. Additional guidelines and a set of tools that facilitate consistent, repeatable, and efficient (time wise) description and capture of mudstone variability at thin section, core, and outcrop scale are included in seven appendices. This Mudstone Primer includes hundreds of Paleozoic to Tertiary examples of physical, biological, and chemical features that illustrate mudstone heterogeneity at lamina to bedset scales. The authors hope that individual workers will take the provided examples and interpretations and use them to enhance their own investigation strategies.

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Cover image: Devonian (Emsian) Huntersville Chert near Frost, WV. The chert overlies an unconformity at the top of the Lochkovian Oriskany Sandstone. The unconformity merges to the west with the Early Devonian hiatus that resulted in the sub-Kaskaskia 1 sequence boundary of Sloss (1988). The primary source of the silica for Early Devonian and early Middle Devonian cherts is interpreted to be the result of aeolian deposition of dust derived from arid climate deserts that likely blanketed much of Laurentia during the hiatus that delineates the sub-Kaskaskia 1 sequence boundary.

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Paleoclimate and the Origin of Paleozoic Chert: Time to Re-Examine the Origins of Chert in the Rock Record

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INTRODUCTION: THE CHERT PROBLEM

Paradigms regarding the origin of sedimentary chert have remained largely unchanged for decades. Extant paradigms generally focus on some aspect of biogenic extraction and precipitation of silica from seawater without explicitly addressing the primary source of silica (e.g., Gutschick and Sandberg, 1983; Maliva, et al., 1989; Beauchamp and Baud, 2002; Pope and Steffen, 2003). The primary sources of silica in modern oceans have been attributed predominantly to river input with lesser amounts coming from submarine groundwater discharge, dust, seafloor weathering, and hydrothermal vents respectively (Tréguer and De La Rocha, 2013). However, any changes in the order of predominance among these sources through time are unknown. In this paper I reintroduce a rarely discussed paradigm that attributes the predominant source of silica for Paleozoic chert to aeolian deposition of siliceous sediments (hereinafter, dust) (Haught, 1956; Banks, 1970; Cecil, 2004). The dust hypothesis also may help explain chert of nonmarine origin, as will be discussed subsequently. The dust hypothesis is based in part on an apparent empirical correlation between chert occurrence and paleoaridity (Cecil, 2004)*. The empirical correlation between chert occurrence and paleoaridity is further developed herein by comparing multiple depositional environments for Paleozoic chert parent material (CPM) across the conterminous United States (North America craton; NAC) to the paleoclimate maps of Boucot et al., (2013)**. Inferred depositional environments for CPM are derived from the literature (e.g., Hein and Parrish, 1987, Appendix 2-1; among many others), or personal experience. Where applicable, I also present ancillary observations on the relation between arid paleoclimates and the temporal and spatial distribution of quartz arenites whose textural and mineralogical maturity may, in part, be attributed to ancient aeolian processes (e.g., Dott, 2003), regardless of the final depositional environment; such processes could have been major producers of dust.

CPM Depositional Settings

CPM depositional settings discussed herein partially illustrate the myriad of water depths and hydrologic conditions associated with chert occurrence. Depositional interpretations for Paleozoic CPM examples include the following: a) inferred deep marine along paleo-continental margins, b) shallow shelves and epicontinental seas, c) supratidal environments, and d) nonmarine chert associated with aeolinites. Chert that may have formed on abyssal plains has been lost to subduction. I compare chert examples for each of these settings to paleoclimate interpretations of Boucot et al., (2013).

CHERT: CAMBRIAN TO PERMIAN

Cambrian and Ordovician chert

Examples of CPM in inferred deep water include the Middle and Late Ordovician Bigfork*** and Maravillas cherts in the Ouachita-Marathon structural trend (Goldstein, 1959), and Ordovician chert in the Cordilleran basin margin in Nevada and Idaho (Ketner, 1969). Virtually all these cherts contain dispersed detrital quartz sand and silt (Goldstein, 1959; Ketner, 1969) suggesting aeolian deposition. An arid paleoclimate prevailed across the NAC during the Cambrian and Ordovician (Boucot et al., 2013; Maps 1-4) when CPM was deposited. The source of silica for much of the late Middle and Late Ordovician chert I refer to as deep water has been attributed to upwelling on subtidal ramps (Pope and Steffen, 2003). However, chert is common throughout Cambrian and Ordovician strata across the NAC (Hein and Parrish, 1987) where upwelling does not appear to reasonably account for CPM deposition far removed from inferred zones of upwelling or for detrital quartz in chert.

Both bedded and nodular cherts also occur in Cambrian and Ordovician shallow water carbonates (Hein and Parrish, 1987). In the Appalachian basin (AB), shallow water carbonates contain silicified oolites (Upper Cambrian Mines Dolomite Member, Gatesburg Formation; Early Ordovician Nittany Dolomite, Beekmantown Group; Centre Co. PA), and silicified intraclastic carbonate with pellet structure (Early Ordovician Axemann Limestone of Beekmantown Group, Centre Co., PA) (e.g., Folk and Pittman, 1971) and the Middle Ordovician Lincolnshire Formation in Virginia (Figure 1A). In addition to shallow water chert, Montañez

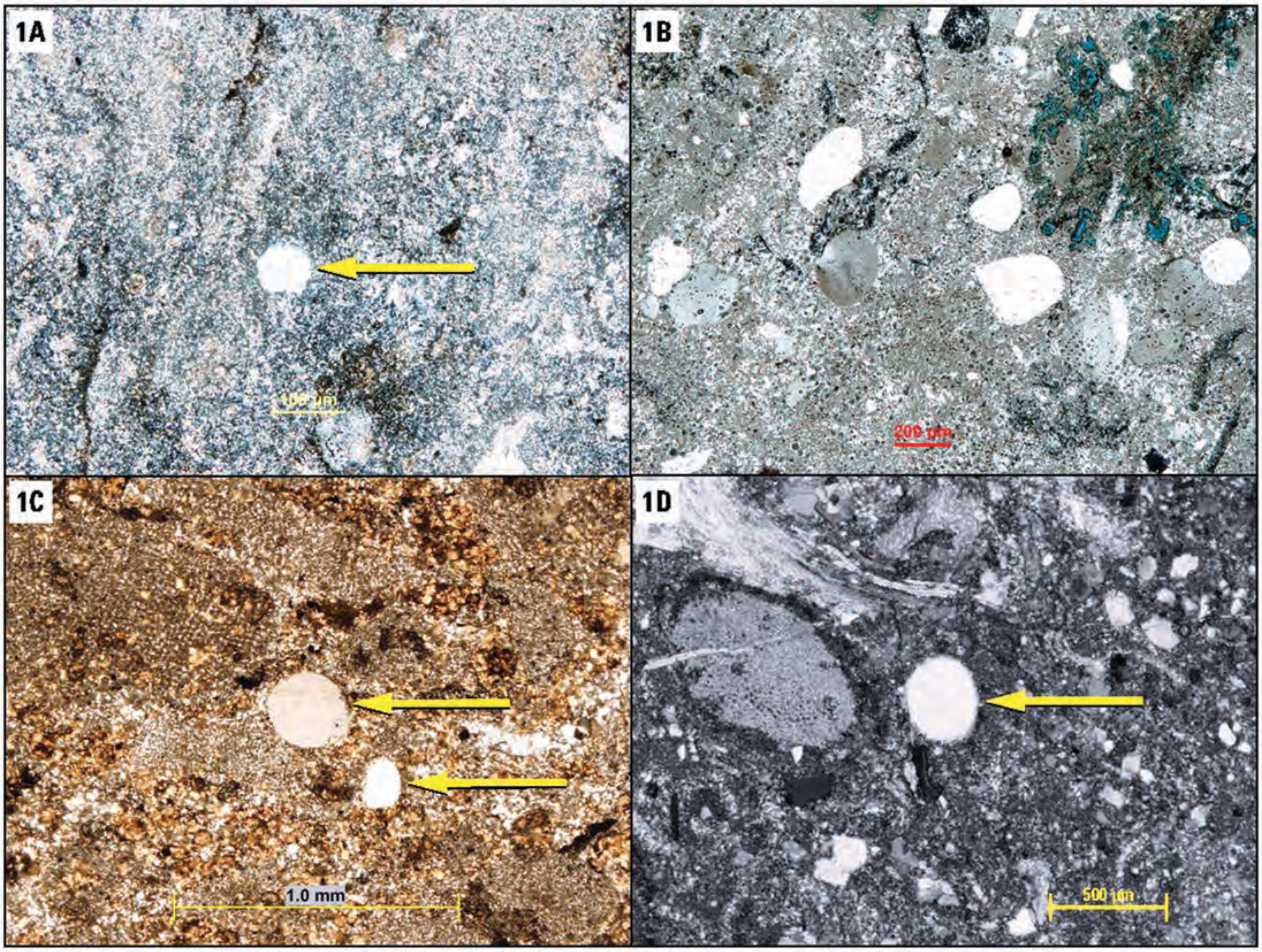

Figure 1: Photomicrographs of chert with quartz detritus floating in chert matrices. The primary source of silica for chert parent material, including detritus, is interprted to be the result of atmospheric deposition of siliceous dust. 1A. Chert in Middle Ordovician (Blackriveran) Lincolnshire Formation, Rich Patch, VA. Rounded quartz sand grain floating in the chert matrix (arrow). Scale bar is 100 µm. 1B. Devonian (Lochkovian) Shriver Chert, Goshen, VA. Rounded quartz sand grains floating in a chert matrix. Scale bar is 200 µm. Blue color in upper right is light transmitted through mounting medium. 1C. Mississippian (Visean; late Osagean to Meramecian) Warsaw Formation. Sample from road cut, Interstate 55, south of St Louis, MO. Rounded quartz sand grains (arrows) floating in a calcareous chert matrix. Scale bar is 1.0 mm. 1D. Photomicrograph, Permian (Wordian) Rex Chert Member, Phosphoria Formation. Rounded quartz sand grain (arrow) floating in a calcareous chert matrix. Numerous quartz silt grains are also present. Scale bar is 500 µm.

and Read (1992) documented chert replacement of gypsum (cauliflower chert) in supratidal sabkha environments (Late Cambrian to Early Ordovician Upper Knox Group; Maryland, Virginia, and Tennessee). They also noted the presence of quartz silt, and rounded sand grains in the supratidal dolomites (Isabel Montañez, personal communication) consistent with aeolian deposition. The supratidal chert occurrences indicate a probable aeolian source of silica.

ANCILLARY OBSERVATIONS ON ORDOVICIAN SANDSTONES

The origin of Middle to Late Ordovician supermature quartz arenites appears to be related to aeolian processes (e.g., Kelly et al., 2007; Dott, 2003). Well-rounded quartz grains in the St. Peter Sandstone are thought to be indicative of arid aeolian processes (Kelly et al., 2007). Deposition of the St. Peter was approximately coeval with deposition of much of the Simpson Group to the south, including supermature sandstones in the Arbuckle Mountains, Oklahoma (Dapples, 1955; Ethington, et al., 2012) in settings that were not far removed from the inferred deep water Ordovician chert in the Ouachita-Marathon trend. The sand of the Middle to Late Ordovician Eureka Quartzite (i.e., quartz arenite) in the western NAC is nearly identical to that of the coeval St. Peter and Simpson (Ketner, 1966). These approximately coeval, and morphologically identical supermature sands overlie the sub-Tippecanoe I Sequence boundary of

Sloss (1988), an exposure surface where vast deserts likely existed from the Early Ordovician through most of the Middle Ordovician, a time span of more than 20 myr. Hypothetically, dust derived from Early to Middle Ordovician sand seas may have supplied the CPM in the deep-water settings, as well as shallow water cratonic seas and adjacent sabkhas.

Silurian chert

The Silurian paleoclimate was arid (Boucot et al., 2013; Map 5). Silurian age chert occurrences are relatively minor compared to other time periods (Hein and Parrish, 1987), and will not be discussed further here.

DEVONIAN-EARLY CARBONIFEROUS (MISSISSIPPIAN)

Deep-water chert

Water depth is uncertain in the Ouachita/Marathon structural trend during CPM deposition for the Devonian-Mississippian Arkansas Novaculite (Hass, 1951) and Caballos Novaculite (McBride and Thompson, 1970). McBride and Thompson (1970) suggest water depth in the Marathon basin during Caballos CPM deposition "was probably greater than 300 feet (~90 meters [m]) and may have been several thousand feet (meters) deep". Hass (1951) recognized three divisions of the Arkansas novaculite; an Early to Middle Devonian lower division, a middle division spanning the Devonian-Carboniferous boundary, and a Mississippian (late Kinderhookian to Osagean) upper division. CPM deposition for the lower division (pure novaculite) was approximately coeval with aridity (Boucot et al., 2013; Maps 6 and 7) and the Early Devonian hiatus that resulted in the sub-Kaskaskia 1 sequence boundary of Sloss (1988). The impure middle division spans the Devonian-Mississippian boundary, when deposition was coeval with the late Famennian and Tournaisian pluvial event in the eastern Laurentia (Appalachian basin) (Cecil, 1990; Cecil, et al., 2004; Brezinski, et al., 2009). Unlike the pure novaculite comprising the lower division when the climate was arid, shale and impure chert characterizes the middle division when the climate was relatively humid. Relatively pure CPM deposition resumed for the upper novaculite division when the NAC became arid during the Viséan (Osagean).

Deposition of CPM ceased in the Ouachita-Marathon structural trend with the onset of a humid climate over the central and eastern NAC in the Serpukhovian (Mississippian, late Chesterian) (Edgar and Cecil, 2003). CPM deposition in the Ouachita basin was replaced by an influx of siliciclastics (Late Mississippian Stanley Group, the Early Pennsylvanian Jackfork Sandstone, and the early Middle Pennsylvanian Atoka groups respectively). The Caballos Novaculite stratigraphy (Folk and McBride, 1976) is consistent with a similar climatic change interpretation.

Figure 2: Devonian (Eifelian) Huntersville Chert, Frost, WV. Variations in bed thicknesses are interpreted to be the result of fluctuations in dust storm duration and intensity. Person for scale in photo center.

Devonian Shallow Water Chert

Early and early Middle Devonian shallow water cherts are widespread across the NAC (Dennison, 1961) when the climate was arid (Boucot et al., 2013, Maps 6, 7, and 8). The examples discussed herein focus on the AB where chert is common from southwestern Virginia into New York. Chert commonly occurs in strata that underlie and overlie the sub-Kaskasia I sequence of Sloss (1988). These accumulations were coeval with the deep-water CPM deposition of the lower division of the Arkansas and Caballos Novaculite. Bedded chert below the sequence boundary in the AB includes the Shriver Chert (Oriskany Group) and the chert-bearing Corriganville Limestone (Helderberg Group) in Maryland and West Virginia, and time equivalent chert in adjacent states. The Huntersville Chert (Figure 2) overlying the sequence boundary consists of relatively pure chert in north central West Virginia (Sheppard and Heald, 1984), grading into chert with minor argillaceous material in southeastern West Virginia. According

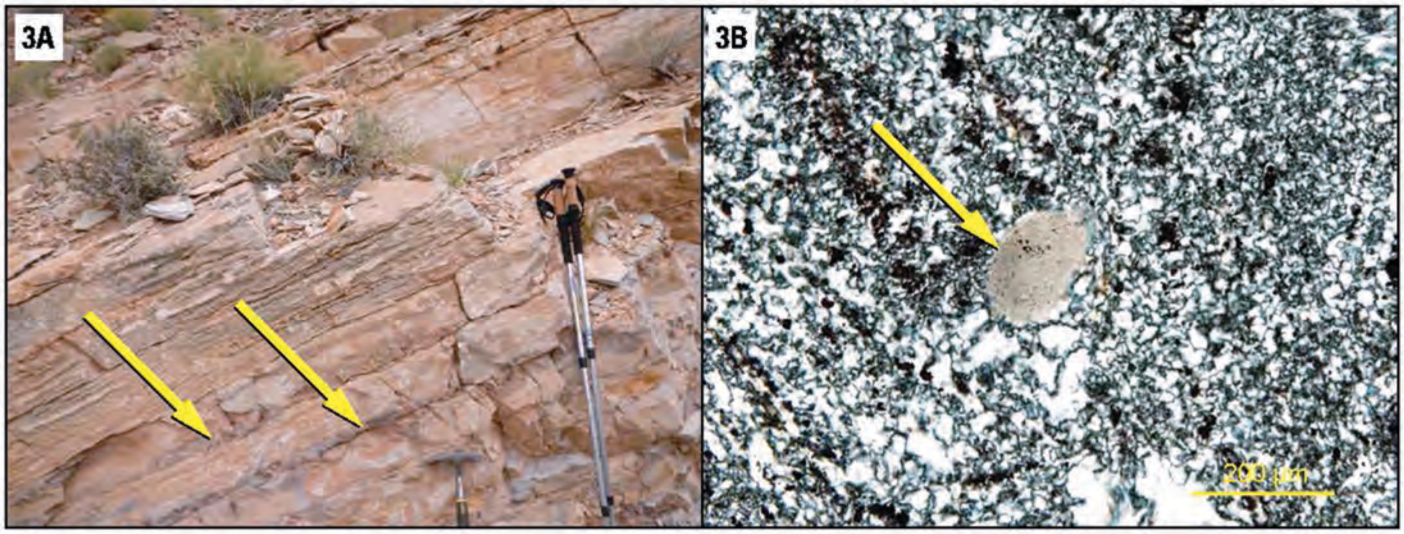

Figure 3: Pennsylvanian (Desmoinsian) Honaker Trail Formation; San Juan River Gorge, Raplee Anticline; Mexican Hat, Utah. A. Outcrop photo of cm-scale chert beds (arrows) in peritidal carbonate (walking sticks on right side of photo and hammer, bottom right, for scale). B. Round quartz sand grain floating in the chert.

to Sheppard and Heald (1984), "even the cleanest chert in the Huntersville has at least small amounts of dolomite and silt-size (quartz) detritus," as does the Shriver Chert (Figure 1B). The quartz detritus is consistent with dust as the source of silica.

ANCILLARY OBSERVATIONS ON DEVONIAN SANDSTONES

Devonian quartz arenites (Oriskany, Rocky Gap, and Healing Springs Sandstones, AB; Sylvania Sandstone, Michigan Basin; Dutch Creek and Hoing Sandstones, Illinois basin) underlie and overlie the sub-Kaskaskia I sequence boundary of Sloss (1988). These quartz arenites appear to have been derived from reworking of sand seas during sea level rise (Carman, 1936; Grabau, 1940; Cecil et al., 1991), indicating these sand seas could have supplied quartz-rich dust for chert.

Mississippian shallow water and supratidal chert

The humid climate that developed over the eastern NAC in the late Famennian continued through the Tournaisian (Cecil et al., 2004; Brezinski et al., 2009; Boucot et al., 2013). Chert formation ceased or was greatly diminished in cratonic seas of eastern Laurentia. With the return of aridity in the Viséan (Osagean, Meramecian, and early Chesterian) (Boucot et al., 2103, Map 10), major CPM deposition resumed across the NAC. CPM deposition sites included the Appalachian basin (Greenbrier Limestone and Fort Payne Formation), mid-continent (Fort Payne, Boone Formation, Burlington, Keokuk, and Warsaw Limestones) and the western U.S. (Redwall, Leadville, and Madison Limestones) (Gutschick and Sandberg, 1983) among many other occurrences. Early Viséan (Osagean) chert is common in environments interpreted as carbonate shelf, shelf edge, and basin/trough (Gutschick and Sandberg, 1983). These authors attributed the primary source of CPM during the late Osagean to upwelling. However, their inferred paleowind direction is not consistent with upwelling. Furthermore, detrital quartz in chert as well as deposition of CPM in epicontinental seas that were far removed from possible upwelling zones also makes upwelling an unlikely source.

Banks (1970) described syngenetic chert in Osagean dolostones within the Leadville Limestone in Colorado and noted abundant aeolian sand (quartz) in the dolostone members. Banks suggested that the aeolian quartz sand was the most likely, if not the only, source of silica for the syngenetic chert.

Osagean evaporites in subtidal to peritidal carbonates of the Burlington and Keokuk were replaced syngenetically by silica, now in the form of geodes (e.g., Chowns and Elkins, 1974). Chowns and Elkins (1974) noted detrital quartz silt and sand in Fort Payne and Warsaw Formation supratidal dolomites, but they suggested sponge spicules as the source of silica for chert replacement of evaporate nodules. However, detrital quartz sand and silt (Figure 1C), suggests that syngenetic alteration of dust may have been the primary source of silica for biogenic silica as well as chert replacement of evaporites in supratidal, peritidal, and subtidal environments. As with the deep-water chert, CPM deposition ceased in eastern NAC basins with the onset of a humid climate in the late Mississippian (Serpukhovian) (Boucot et al., 2013; Map 11). CPM deposition in cratonic environments (central and eastern NAC) was replaced by accumulations of parent materials for shale, sandstone, and coal.

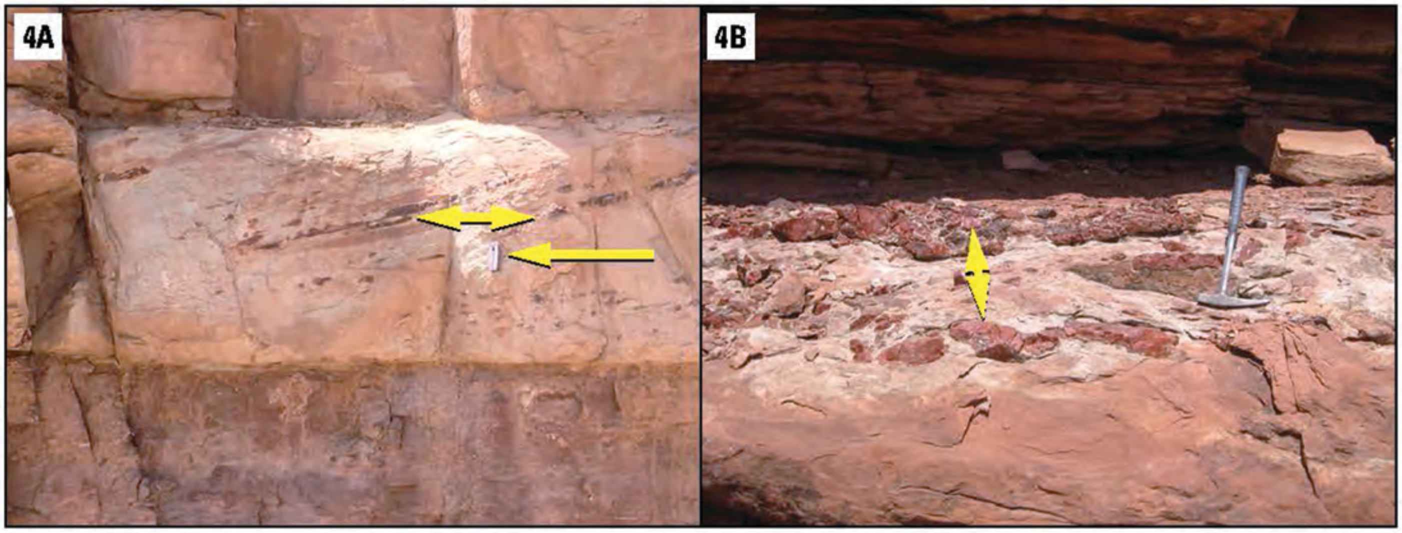

Figure 4: Early Permian, Cutler Group, Cedar Mesa Formation. A. Photo of Mokie Dugway road cut (UT RT 261), SE Utah. Dark red bands of chert (jasper) are along interpreted sand sheet facies bedding planes. Two of the chert bands are indicated with double arrow. Knife for scale (single arrow) is 8 cm. B. Two beds (double arrow) of red chert (jasper), Indian Creek drainage, SE Utah. Lower chert directly overlies dune facies; upper chert is at or near the top of inter-dune sabkha facies. Hammer, including handle, is 38 cm.

Late Carboniferous (Pennsylvanian) chert

A general perhumid ("everwet") climate (Boucot et al., 2013, Map 12) prevailed across the eastern and central part of the NAC during most of the Bashkirian and Moscovian (Morrowan, Atokan, and Desmoinesian Series). These humid conditions essentially eliminated low-stand deserts, as evidenced by intense chemical weathering and humid climate paleosols across the NAC (Boucot et al., 2013, p. 113-115). These paleosols delineate the Sub-Absaroka sequence boundary of Sloss (1988).

Pennsylvanian aridity and deserts were restricted to far western Pangea (e.g., Parrish and Peterson, 1988; Soreghan, 1992; Boucot et al., 2013, Map 12) where chert is common in Pennsylvanian marine carbonates. Two examples presented here include the Middle Pennsylvanian Honaker Trail Formation, Paradox Basin, Utah (Condon, 1997), and the Bird Spring Formation, Arrow Canyon Nevada (Cecil et al., 2003; Bishop et al., 2010).

Loope (1985) attributed nonmarine sandstones in marine/nonmarine cycles in the upper part of the Hermosa Formation (Honaker Trail?) in Canyon Lands National Park, Utah, to aeolian deposition. I observed similar sedimentary cycles in the upper part of the Hermosa Group (Honaker Trail Fm) in exposures along the San Juan River trail near Mexican Hat, Utah, in the Paradox basin. These Missourian (?) age strata contain lowstand nonmarine sandstones (aeolianites) in marine/nonmarine cycles, whereas thin (cm scale) rhythmically bedded red chert occurs in the marine carbonates. The aeolinites in the nonmarine parts of the cycles suggest dust as a possible source of silica for these red chert beds as does detrital quartz in chert matrices (Figure 1D).

Pennsylvanian 4th order sequences in Arrow Canyon, Nevada, are replete with bedded chert, cherty limestones, and decimeter scale fine-grained sandstones interpreted as aeolinites (Bishop et al., 2010; Cecil et al., 2003). Subaerial crusts and microkarst weathering on the unconformity exposure surfaces of marine carbonates suggest a relatively humid weathering during a hiatus in deposition following exposure. Following the weathering interval, fine-grained sandstones and siltstones, interpreted as loessites, were deposited (Cecil et al, 2003). The loessite overlying the sequence boundary is interpreted to be the result of aeolian sediment delivery initiated by increasing atmospheric high pressure, wind speeds, and climate drying as sea level first began to rise. The loess was ultimately flooded as sea level continued to rise, and is sequentially overlain by peritidal cherty limestone, impure chert, and a cherty open marine limestone capped by an unconformity, the upper 4th order sequence boundary.

Paleowind directions interpreted from aeolian cross-stratification, and paleoclimate modeling (Parrish and Peterson, 1988) indicate that Pennsylvanian strata in Arrow Canyon were deposited down-wind of sand seas in Wyoming, Colorado, and Utah. These sand seas were probable dust sources of proximal loessites (20-80 µm dust size fraction) overlying the 4th order sequence boundaries, as well as chert derived from aeolian dust (< 20 µm fraction) deposition in ever expanding distal marine environments as sea level rose.

ANCILLARY OBSERVATIONS ON PENNSYLVANIAN SANDSTONES

The quartzose sandstones that overlie the Sub-Absaroka sequence boundary in the Eastern Interior and Appalachian basins are fluvial and relatively immature (Siever, 1957). This textural and mineralogical maturity contrasts sharply with the supermature sandstones associated with older Sloss sequence boundaries that formed under arid paleoclimates. CPM deposition was nearly nil in the humid regions of central and eastern Pangea where there is no evidence for aridity. Sand seas were restricted to western Pangea (e.g., Weber and Tensleep Sandstones) where chert is common in marine carbonates.

Permian chert

CPM for the widespread Permian (Wordian) Rex Chert Member of the Phosphoria Formation (Idaho, Utah, Montana and Wyoming) accumulated in western Pangea under arid conditions when the NAC was situated between 0° and 30 N (Boucot et al., 2013, Map 15). The phosphate, chert, and other constituents in the Phosphoria Formation have been attributed to upwelling (c.f., McKelvey, 1946; Hein et al., 2004). Ketner (2009) suggested that upwelling could not have extended across the broad cratonic expanse of the Rex Chert occurrence. Other workers attribute quartz siltstones in the Phosphoria to aeolian deposition (loess?) in the Phosphoria shelf environments (Carroll et al., 1998). Whether or not there was upwelling in the Phosphoria seaway remains equivocal. Deposition of < 63 µm aeolian dust (siltstones), and in particular the < 20 µm fraction (chert) may have been the primary and predominant source of siliceous sediments in the Phosphoria as well as for the nutrients delivered to the Phosphoria shelf during Late Permian CPM accumulation.

Nonmarine chert

Chert is not restricted to marine environments. Red chert (jasper) occurs in the Early Permian Cedar Mesa Formation in the Paradox Basin, Utah (Loope, 1985; Mountney and Jagger, 2004). Red chert commonly overlies facies interpreted as inner dune sabkhas or ponds (Mountney and Jagger, 2004) and both underlie and overlie the red dune facies of the Cedar Mesa Formation (sandstone), Utah (Figure 3). Chert also occurs within a facies I interpreted as a sand sheet (Figure 4). The occurrence of chert in this continental setting provides compelling field evidence that dust was the source of silica for CPM rather than upwelling, volcanics, or diagenesis of marine organisms. Dust apparently collected through adhesion to moist silty mud surfaces or was deposited in very shallow saline interdune ponds, as well as the sand sheet facies. It is noteworthy that the dust paradigm is consistent with dust as the source of silica for silcretes (paleosol chert duricrust) that formed under arid to semiarid conditions (Summerfield, 1983).

CONCLUSIONS

When compared to the paleoclimate scenarios included in Boucot et al. (2013), the Cambrian to Permian chert examples herein illustrate that CPM deposition was restricted to regions of paleo-aridity, regardless of age or depositional environment. In contrast, chert is rare or nonexistent when and where the paleoclimate was relatively humid. The empirical correlation between chert occurrence and paleo-aridity is probably not coincidental. The chert-aridity correlation supports the hypothesis that quartz-rich dust might be the primary and predominant source of silica for chert. Furthermore, the enhanced solubility of quartz dust* is a plausible source of silica for silica secreting organisms. Upwelling (e.g., Hein and Parrish, 1987; Maliva et al., 1989) and volcanic processes (e.g., Goldstein 1959) are not as uniformly applicable to the wide variety of CPM depositional models as is dust. Conceivably, CPM dust was deposited under atmospheric high pressure, which might have driven offshore winds and upwelling along continental margins. Conversely, it seems highly unlikely that upwelling could have supplied silica to the vast cratonic shelves and basins far removed from continental margins. Provenance regions for quartz arenites that owe their textural and mineralogical maturity to aeolian processes are interpreted as probable sources of this quartz rich dust for CPM. Consequently, dust needs to be further considered as a viable source for CPM based on the empirical correlation between paleoaridity and chert occurrences as developed herein.

* Discussion of the importance of enhanced solubility of quartz dust, and dust diagenesis could not be included in this paper because of space limitations (see Cecil, 2004, for a brief overview).
** Paleoclimate maps could not be included in this paper because of space limitations.
*** In so far as possible, geologic names and ages used are in accordance with the US Geological Survey (URL:http://ngmdb.usgs.gov/Geolex/search)

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PRESIDENT'S COMMENTS

SEPM was founded over 75 years ago as a division of AAPG. Although we are an independent scientific society, our links with AAPG remain strong. SEPM is headquartered near to AAPG in Tulsa, and our annual meeting forms a significant component of AAPG's annual convention. Since becoming President-elect I have had numerous discussions with the present AAPG leadership as well as with SEPM members, council, and staff about our future with AAPG. As a long-standing member of both societies I am keen to make sure that our relationship with AAPG is beneficial to both organizations. Despite the fact that SEPM routinely sponsors about 50% of the technical program at the annual meeting, I was rather alarmed to find out about our revenue sharing agreement with AAPG. Historically, $10 of the $300+ registration fee is given to SEPM for attendees that indicate they have an affiliation with SEPM, but this is capped at a maximum of $5,000, per meeting. Clearly, this is unacceptable and SEPM President Kitty Milliken and I last year wrote a letter to AAPG president Randi Martinsen to urge AAPG to reconsider their revenue sharing agreements with us.

I am delighted to report that AAPG Leadership has taken our request very seriously. We have just been informed that as a first step, AAPG will now offer $20 per SEPM registrant with no cap and furthermore that this will be instituted retroactively to include the past Denver meeting. This should immediately double our registration revenue for Denver and should result in a significant increase in revenue at future meetings. This is an important indication that AAPG understands our value to them and I can assure you that we will be engaging in further negotiations for equitable revenue sharing as we plan future meetings.

Howard Harper has played an important role in this regard with his interactions with AAPG Executive Director David Curtiss, including making sure that the SEPM logo is prominent on the AAPG convention website. In order to maximize SEPM revenues at future AAPG meetings, it will be important to urge registrants to tick the SEPM box. I am sure you can all do the math, but a 1000 ticks would net us an additional $20,000; a significant improvement over the $5000 that we have historically received.

The deadline for abstract submittal for the next AAPG ACE with SEPM (June 19-22, 2016, Calgary, Canada) is September 24th. SEPM is co-ordinating two major themes and 16 sub-themes from deep-water to carbonate geomicrobiology as well as the SEPM Research Symposium and SEPM Student Posters. Please consider submitting an abstract and convincing a colleague or student to attend. I am in the process of soliciting our luncheon speaker and have helped assemble a great team to run the SEPM component and I think it will be a great meeting.

Janok Bhattacharya,
SEPM President

SEPM Society for Sedimentary Geology
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WANT TO CONTRIBUTE TO SEPM?

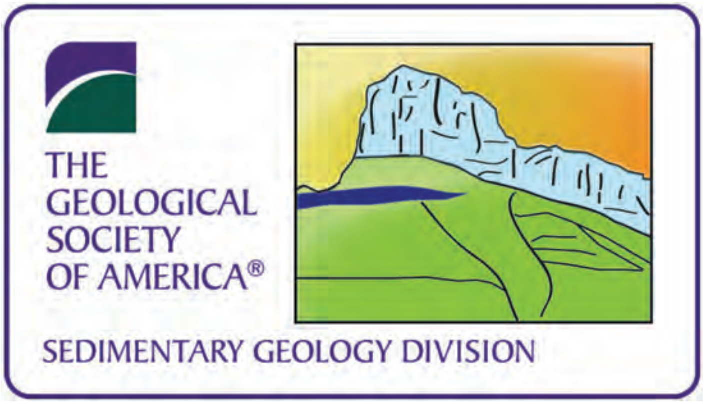
SEPM needs two new volunteer positions filled for 2016

SEPM Web & Technology Councilor –

SEPM is accepting applications from individuals that may want to become the next SEPM Web & Technology Councilor. This position is chosen by the Nominating Committee from among the applicants based on a letter indicating interest, a web-use background and a desire to see SEPM continue to expand and exploit the web for its mission. The next Web & Technology Councilor's term will run from Spring, 2016 to Spring, 2018 (two years).
Details at https://www.sepm.org/webcouncilor

SEPM Editor(s) for *The Sedimentary Record* –

Science Editor(s) of SEPM's quarterly magazine, *The Sedimentary Record*, are responsible for solicitation, review, and editing of scientific articles for the magazine. All other content in the magazine (columns, advertisements, news) is handled by the SEPM Headquarters Staff. Editor terms are three years. Details are at https://www.sepm.org/Callforeditors

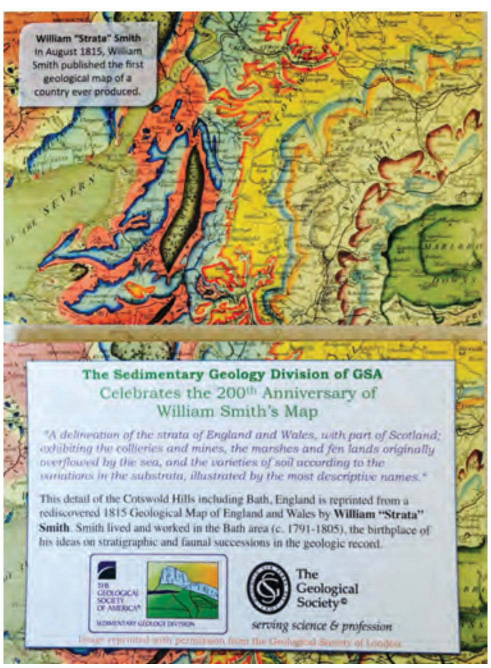


Join Us for the Annual 2015 GSA Meeting in Baltimore MD

Greetings to all the GSA Sedimentary Geology Division (SGD) members! As many of you know, many of our interests, activities, and events are shared with SEPM (Society for Sedimentary Geology), which is why you are seeing our newsletter here in SEPM's Sedimentary Record. Please consider yourselves invited to any of our SGD events.

This year's Annual GSA 2015 meeting in Baltimore, Maryland (Nov. 1-4) will celebrate the 200th anniversary of William "Strata" Smith's map of England and Wales. There will be a number of special events for this including a special Pardee session (co-sponsored by SGD and several other divisions and groups): P1. Celebrating the Genius of William 'Strata' Smith: Bicentennial Anniversary of Smith's Revolutionary Map.

To commemorate this event, SGD will give out a FREE postcard at GSA (both sides shown above) made especially for this celebration.



The technical program for the Baltimore meeting will include many sessions relevant to sedimentary geology (see the sessions SGD has endorsed at the end of this newsletter, particularly the student poster session T193. Sedimentary Environment and Process Studies: The Emerging Generation of Scientists (Posters).

Mark your calendars for our SGD Annual special events that are all condensed into one reception this year: Seds and Suds (with SEPM and STEPPE) and the Joint Sedimentary Geology and Limnogeology Divisions Annual Business Meeting & Awards Reception with SEPM, on Tuesday evening Nov. 3! At that time we will be honoring all award recipients including the special one below.

2015 Laurence L. Sloss Award


Dr. Joanne (Jody) Bourgeois - Sloss Awardee.

The Sedimentary Geology Division is pleased to announce Dr. Jody Bourgeois (University of Washington) as the 2015 Laurence L. Sloss Award recipient.

Dr. Bourgeois is a well-known international expert in marine and tsunami sedimentation as well as in the history of geology. Over the last three decades, her research has spanned: investigations of marine and non-marine deposits with her students and U.S.G.S. colleagues in the Pacific Northwest; Cretaceous shelf mudstones exposed on the Texas coastal plain interrupted by large-wave or tsunami deposits associated with the Chicxulub asteroid impact; as well as neotectonics and paleoseismology of the Russian Far East, an area frequented by volcanic eruptions, subduction-zone earthquakes, and tsunamis. She is one of the founders of the field of tsunami geology and sedimentology.

Prof. Bourgeois' interest in sedimentary geology started with her undergraduate work at Barnard College in New York City with sedimentologist and mentor John Sanders. She then was an instructor at Barnard while co-editing the Encyclopedia of Sedimentology with Rhodes Fairbridge at Columbia University. In her Ph.D. research at University of Wisconsin under Prof. Robert H. Dott, Jr., she developed a project on Late Cretaceous sandstone and shale on southern coast of Oregon. Here she recognized hummocky stratification, a then newly identified sedimentary structure formed by storm waves.

Jody has always been very active in professional service in addition to her research and education efforts. She has served as a Program Officer at the National Science Foundation, a Councilor of the Geological Society of America, and Chair of the GSA History and Philosophy of Geology Division. She has been active in several GSA committees, the Advisory Board of the American Chemical Society's Petroleum Research Fund, and the Association for Women Geoscientists.

We are proud to award Dr. Bourgeois with the 2015 Laurence L. Sloss Award.

Do you know a colleague who is particularly deserving of the Laurence L. Sloss Award for Sedimentary Geology?

Please forward nominations to Linda Kah, lckah@utk.edu

2015 SGD Student Research Award Recipients

Each year the Sedimentary Geology Division presents a student award for the sedimentary geology research grant proposal. The $500 award (plus $500 travel expenses to the upcoming annual meeting in Baltimore) is in addition to the GSA research grant. The 2015 GSA SGD Student Research Grant Award recipient is John Chesley from the University of South Carolina for his Master's thesis project entitled "Modeling fluvial planform architecture from the Salt Wash Member of the Morrison Formation, central Utah: New applications for understanding ancient fluvial systems". Congratulations John! We look forward to seeing the results of your research project at a future GSA meeting.

At our Division Business Meeting and Awards Reception we will recognize John Chesley, as well as new winners (to be announced) who will receive the 2015 SGD/SEPM sponsored student poster awards.

SGD Student Representative

GSA has set up a new Student Advisory Council and each GSA division and section has a student representative. Our SGD representative is **Kelsi Ustipak**. Students are encouraged to reach out to Kelsi (ustipak@utexas.edu) to share questions, concerns or ideas regarding membership with GSA or SGD. http://www.geosociety.org/aboutus/SAC.htm

This is a great opportunity for our young scientists to help guide GSA's future.

Any SGD Student Members who might be interested in being considered as our SGD representative starting in 2016 should talk to the SGD officers at GSA in Baltimore or drop us a line.

Looking Forward

Don't forget: FREE FOOD at this year's 2015 SGD meeting in Baltimore, featuring a NEW and DIFFERENT format! We will combine the Seds and Suds and the awards reception into a single event on Tuesday night of the GSA meeting so it won't conflict with your alumni events on Monday evening. We will feature a special activity called "BYE" (Bring Your Example), where you are invited to bring a small, single puzzling, engaging sedimentary-related or geo-art picture (e.g., max 18x18" or min 8 x 10" size) for us to informally walk around, look at, discuss, and hypothesize about. BYE should have twitter-style captions -nothing extensive. This is a great opportunity to get feedback on a baffling problem or something you want input on. We hope to foster fun student-professional input through this BYE activity, so don't miss it!

Let's talk about this "BYE" – What is this??
Is it a weird silica cementation pattern?

SGD is continuing its yearly postcard tradition, with the first one of the Jurassic Navajo Sandstone "the Wave" of Northern Arizona shown below. The second one of course features the William "Strata" Smith map to celebrate the 200th anniversary of the map. Make YOUR suggestions of future postcards for the SGD division!

SGD also looks forward to:

1. More international partnerships as GSA recently signed a commitment agreement with the European Geosciences Union.
2. SGD participation in funding opportunities (e.g., SEPM accepts proposals to foster cooperation).

Stay connected by making sure you're a current SGD Division member and encourage others you know to join (cost is very modest and you can be a member of multiple divisions). Also, remember GSA's new online networking and collaboration site for members: community.geosociety.org

THANK YOU to those who serve on our committees, help with the web page (Kelly Dilliard), and joint technical program coordination (Ed Simpson and Ryan Morgan). We couldn't accomplish the many goals without you!

FINALLY… Get involved! We could use your help and ideas in shaping SGD. You can be a judge, serve on a committee, help with our annual GSA events, or serve as an SGD officer.

SGD Officers

Marjorie Chan (Chair)
Katherine Giles (Vice Chair)
Linda Kah (Secretary-Treasurer)

Chan (left) will hand over chair reins to Giles (right) after the 2015 Baltimore meeting.

2015 GSA Annual Meeting SGD-Endorsed Sessions

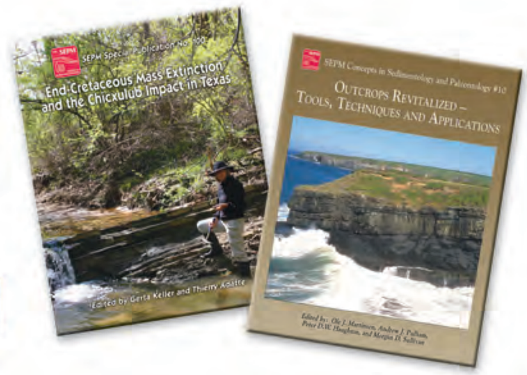
Sedimentary Geology continues to serve as a point of integration with many other scientific fields, which is a hallmark of our specialization at this year's at GSA Annual Meeting. The variety and importance of these sessions, on both scientific and societal levels highlights the importance of our discipline.

T25. *An Early Involvement of Undergraduates and K–12 Students in Geological Research Brings a Strong Sense of Ownership and Achievement for Young Researchers (Posters)*
Nazrul I. Khandaker
T45. *Transforming the Life of the Geoscientist from Planning to Post-Submission: Cyberinfrastructure as an Agent of Change*
Simon Goring, Noah McLean
T64. *Rotations, Oroclinal Bending; Variscan-Alleghenian Nondipoles; Diagenetic Enigmatic Remagnetizations; Vignettes of Orogenies and Oceans: A Celebration of Rob Van der Voo's Career*
John W. Geissman, Joseph G. Meert
T70. *Digital Technology in Real and Virtual Geoscience Experiences (Posters)*
Declan De Paor, Steven J. Whitmeyer, Callan Bentley
T137. *Fresh Perspectives on Critical Transitions in Earth History: Insights from Novel Tools or New Successions*
Victoria A. Petryshyn, Aradhna Tripati
T142. *The Middle Paleozoic World*
Adam David Sproson, David Selby, James R. Ebert
T171. *Exploring the Sedimentary Rock Record of Mars*
Kathryn M. Stack, Kenneth Edgett, Kevin Lewis
T184. *African Environments across Space and through Time: Integrating Modern and Ancient Climate Data for Insights into Terrestrial Ecosystem Dynamics*
David Patterson, Sophie B. Lehmann, Naomi E. Levin
T193. *Sedimentary Environment and Process Studies: The Emerging Generation of Scientists (Posters)*
Katherine Giles, Marjorie Chan

The GSA SGD-SEPM student poster session T193 will be on Monday, Nov. 1, 2015. We hope you'll be sure to stop in and talk with the students about their exciting research!

T195. *Paleoenvironmental Reconstruction of Hominin Sites: New Methods, New Data, and New Insights*
Cynthia M. Liutkus-Pierce, Gail M. Ashley, Andrew S. Cohen
T198. *Shale Gas Basins: Their Stratigraphy, Sedimentary Environments, Tectonics, and Structural Evolution*
Ibrahim Çemen, Jack C. Pashin, James O. Puckette, Denise J. Hills
T212. *Deconstructing Rodinia: Neoproterozoic-Cambrian Geologic Evolution of Laurentia's Margins*
Chris Holm-Denoma, Arthur J. Merschat
T217. *Rift-Drift, Seafloor Spreading, and Subduction Zone Tectonics of Collisional Orogens: Comparative Analysis of the Circum-Mediterranean and Appalachian-Caledonian Orogenic Belts*
Andrea Festa, Yildirim Dilek
P1. *Celebrating the Genius of William 'Strata' Smith: Bicentennial Anniversary of Smith's Revolutionary Map*
George H. Davis, Renee Clary, Suzanne O'Connell

Thrombolites of Lake Clifton, W. Australia



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High impact journals

- ***Journal of Sedimentary Research*** – First published in 1931, JSR is the oldest earth science journal dedicated to the field of sedimentology. The journal is broad and international in scope and welcomes contributions that further the fundamental understanding of sedimentary processes, the origin of sedimentary deposits, the workings of sedimentary systems, and the records of earth history contained within sedimentary rocks.
- ***PALAIOS* -** Founded in 1986, PALAIOS is dedicated to emphasizing the impact of life on Earth's history as recorded in the paleontological, sedimentologic and stratigraphic records. PALAIOS is the journal of choice in which to publish innovative research on all aspects of past and present life from which geological, biological, chemical, and atmospheric processes can be deciphered and applied to finding solutions to past and future geological and paleontological problems.

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UPCOMING SEPM RESEARCH CONFERENCES

2015

"Petroleum Systems in "Rift" Basins - Bob F. Perkins Conference - Gulf Coast Section of SEPM–December 13-16. OMNI Houston Westside, Houston, Texas. http://www.gcssepm.org/

2016

"Mudstone Diagenesis" Conference (with AAPG) set for October 16-19, 2016 in Santa Fe, NM. This conference is focusing on fine grained rocks and their properties. Abstract Submission will be open soon. Conveners: Wayne Camp, Neil Fishman, Paul Hackley, Kitty Milliken and Joe Macquaker.

"Oceanic Anoxic Events" Conference is being planned for November 2-7, 2016 in Austin, TX. Examining the features and resources of OAE's. Conveners: Rob Forkner, Charles Kerans, Benjamin Gill and Gianluca Frijia.

2017

"Multi-scale analysis of deep-water depositional systems; insights from bathymetric, shallow seismic and outcrop data" to be held in the Karoo Basin area of South Africa in Spring, 2017, in Cape Town area, South Africa. Conveners: David Hodgson, Stephen Flint, Christopher Aiden-Lee Jackson, Bradford Prather, and Emmanuelle Ducassou.

"Propagation of Environmental Signals within Source-to-Sink Stratigraphy" to be held in Ainsa, Spain. Looking at the propagation of sediment-flux signals in the stratigraphic record of correlative segments of source-to-sink sedimentary systems. Conveners: Sébastien Castelltort (University of Geneva), Cai Puigdefabregas (University of Barcelona), Julian Clark (Statoil) and Andrea Fildani (Statoil).

If you are considering a research conference within the realm of sedimentary geology be sure to consider working or partnering with SEPM Society for Sedimentary Geology.

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