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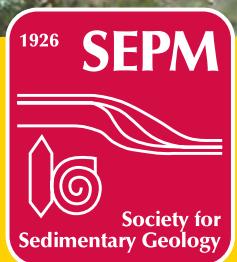
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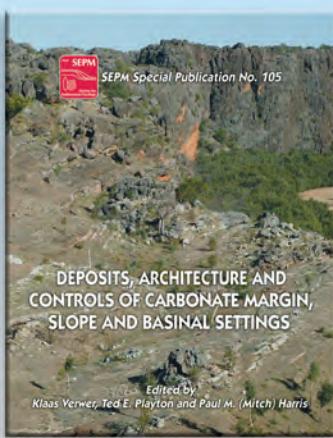
THE END OF STRATIGRAPHY

INSIDE: WHEELER'S CONFUSION AND THE SEISMIC
REVOLUTION: HOW GEOPHYSICS SAVED STRATIGRAPHY
PLUS: PRESIDENT'S COMMENTS, UPCOMING SEPM CONFERENCES,
SEPM ACTIVITIES AT ACE, CALGARY



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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.

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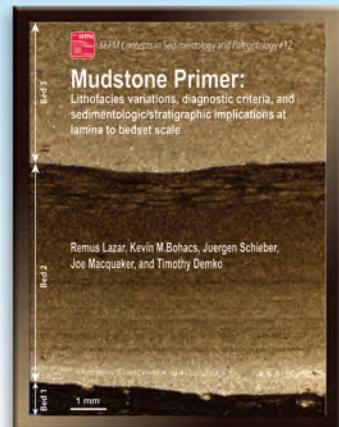
Concepts in Sedimentology and Paleontology 12

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: Spring Canyon, Utah with the lower Blackhawk stratigraphy (J. Bhattacharya).

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Wheeler's Confusion and the Seismic Revolution: How Geophysics Saved Stratigraphy

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ABSTRACT

The leading stratigrapher in his day was the late Harry Wheeler, who was one of the first stratigrapher's to use the term "sequence" to refer to unconformity-bounded rock units, although his concepts did not catch-on at the time because of an unwieldy insistence that all stratigraphic units be defined on the basis of arbitrary vertical cutoffs and diachronous facies boundaries. The net result was a nearly impenetrable proliferation of different names for the same genetic, correlative and descriptive lithofacies. Stratigraphy was largely phased out of University curricula and by the mid-1970's was replaced by an emphasis on process-based facies models and petrographic studies. The facies-oriented stratigraphic cross sections of the time bore little resemblance to real stratigraphic architecture and were not amenable to the analysis of reservoir-seal pairs, critical in delimiting flow units in subsurface reservoirs.

At around this time, Peter Vail, and other geophysical pioneers within the hydrocarbon industry, recognized that the stacking of offset seismic traces enhances the subtle, but nevertheless sharp and highly coherent lithological contrasts across beds. They also realized that seismic data was unable to image the arbitrary facies boundaries and imaginary arbitrary vertical cutoffs upon which so much lithostratigraphy was based. This led Peter Vail to make the revolutionary statement that "primary seismic reflections are generated by stratal surfaces which are chronostratigraphic, rather than by boundaries of arbitrarily defined lithostratigraphic units." Seismic data allowed geologists to observe unconformable lapout boundaries and to extend these into the areas where strata became conformable. This allowed a revolutionary reformatting and reevaluation of the stratigraphic record into sequences bounded by their unconformities and correlative conformities. This, in turn allowed for a vastly superior correlation of genetically related stratigraphic units and enabled a re-evaluation of the forcing parameters that control distribution of sediments both locally and globally. Reflection seismic data thus provided the key technological breakthrough that provided continuous cross sectional views of stratigraphic basin fills. This fresh approach has fundamentally revitalized the science of stratigraphy.

INTRODUCTION

Although there remains considerable debate as to the merits of sequence stratigraphy (Embry, 1995; Dickinson, 2003; Catuneanu et al, 2009; Bhattacharya, 2011), it is widely practiced, especially in the oil and gas industry (Miall, 2016). This paper addresses the question, what problem did sequence stratigraphy solve and why has it been so successful? We review lithostratigraphic practices prior to the advent of sequence stratigraphy, with an emphasis on fluvio-deltaic depositional systems, and show that they mostly failed to capture the complexity required to define reservoir-seal pairs in the oil and gas industry. Although it required the advent of seismic data before sequence concepts could be fully applied, , the proprietary nature of seismic data, a lack of rigorous scholarship in early publications, and an emphasis on eustasy versus tectonics, led to widespread skepticism and even derision by much of the academic community.

LITHOSTRATIGRAPHY IN CRISIS

The seeds of sequence stratigraphy, are as old as the science of stratigraphy itself (e.g. Chamberlain, 1889, 1909, Grabau, 1906, Blackwelder, 1909, and Barrell, 1912, 1917; see also review by Nystuen, 1998 and recent reviews by Miall, 2016). Sloss et al. (1949) introduced the preliminary concept of sequences as interregional rock units comprising assemblages of Formations and Groups bounded by objective recognizable horizons (commonly stratigraphic discontinuities) but without specific time significance. Harry Wheeler (1958 used the term "sequence" to formally describe unconformity-bounded stratigraphic units however his sequences were defined by **arbitrary vertical cutoffs** at the point where the unconformity passed laterally into a correlative conformity. The adherence to the use of arbitrary cutoffs resulted in a confusing proliferation of sequences. Sloss (1963) defined the now well known continent-wide, *unconformity-bounded* tectono-stratigraphic units across North America, although his ideas were not fully appreciated when first published (Sloss, 1988, Van Wagoner et al., 1990).

What is sometimes forgotten, is that many formal lithostratigraphic units, were decidedly *not* chronostratigraphic. Lateral “contacts” between many formations were routinely defined by arbitrary vertical cutoffs, especially where inter-fingering occurred (Wheeler and Mallory, 1953; 1956) (Fig. 1a). The horizontal boundaries that defined the base and top of formations and members, in measured sections were also commonly arbitrarily defined, especially where contacts were gradational. The very concept of lithofacies was also fundamentally different in Wheeler’s day (Fig. 1b), and was defined by the ratio of lithologies (e.g., sandstone, shale, limestone etc.) within gross stratigraphic units, that might include several formations, versus the environmental facies concept as practiced today.

The Blackhawk Mancos Dilemma

The problem of defining stratigraphic boundaries was a particularly acute problem in clastic wedges, such as are common in the Mesozoic successions of the Western Interior Seaway of North America (e.g. Fig. 2). One of the most important examples in sequence stratigraphy, involves the transition of the broadly fluvio-deltaic, coal-bearing Blackhawk Formation into the co-eval marine Mancos Shale Formation in the Upper Cretaceous Book Cliffs successions of Utah (Fig. 2). The nature of this pinch-out involves several sandstone tongues (Young, 1955, 1957). In lithostratigraphic terms, where the sandstone members gradually overlie a shale, the base of the sandstone member is typically arbitrarily defined by the first thick sandstone above the underlying shale (e.g. Fig. 2A). Of course with these types of gradational interbedded facies, such as where the deltaic and shoreface sandstones overly prodelta and shelf shales, a thick sandstone bed in one locale might pass laterally into a much thinner siltier bed in a more distal position, and the formation contact would thus be arbitrarily picked at a higher and younger sandstone bed in a more distal location, resulting in a diachronous lithostratigraphic

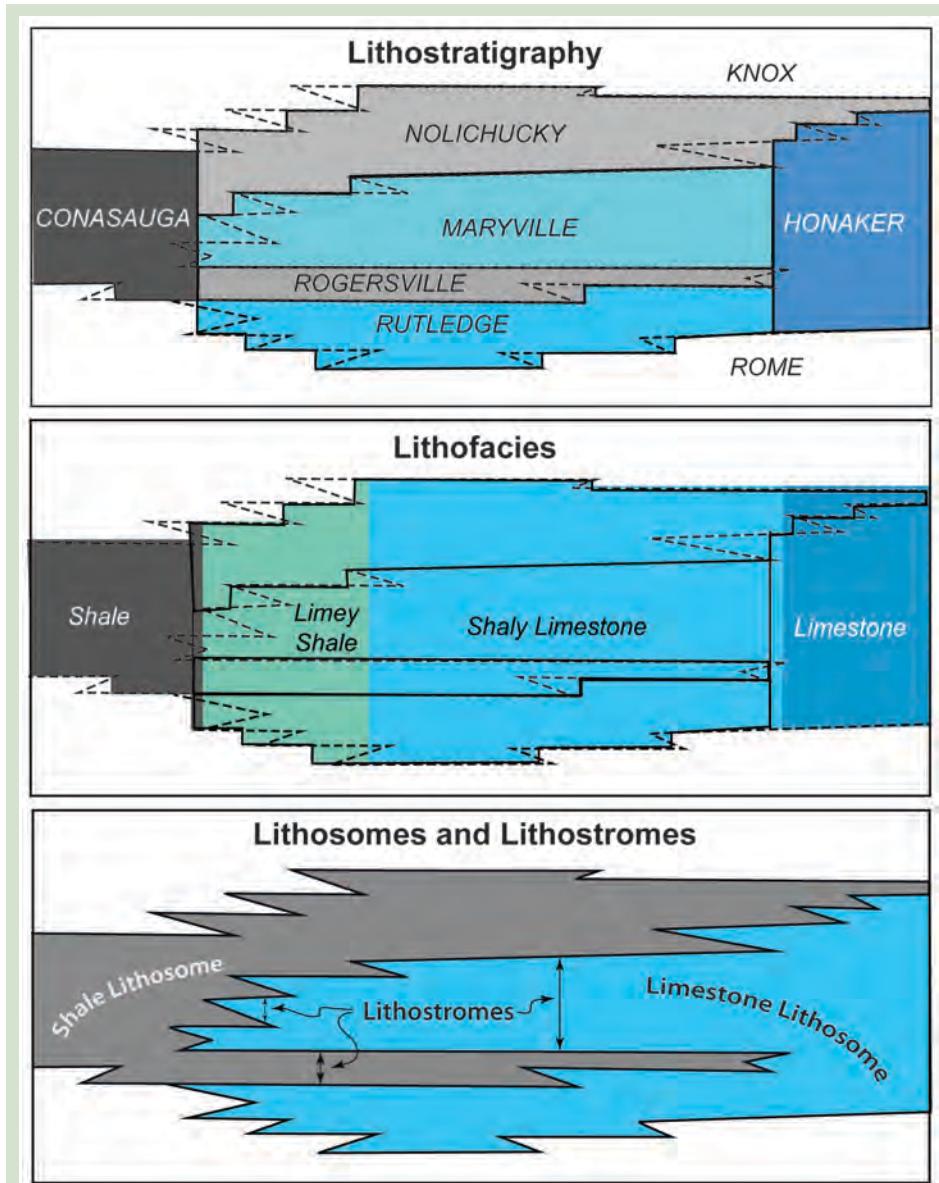


Figure 1: Lithostratigraphic and facies concepts of Wheeler and Mallory (1956). A. Arbitrary vertical cutoffs are used to define lateral “contacts” between formations. The boundary between the Honaker and Maryville formations are defined by the pinchout of the Rogersville Shale Formation. B. Lithofacies are broadly defined by the average gross lithology across several formations and are also defined by arbitrary vertical boundaries. C. Broadly conformable lithostromes and highly diachronous lithosomes roughly correspond to modern usage of the lithofacies concept.

boundary (Fig. 2). Another problem is the separation of delta front sandstones and their co-eval, genetically related prodelta mudstones, into different lithostratigraphic units.

Young (1955, 1957), influenced by Krumbein and Sloss (1951) was one of the first to recognize the cyclic nature of this transition and shows a remarkably modern understanding of the stratigraphic relationships between the Blackhawk and Mancos formations (Fig. 2B). Despite Young’s sophisticated

stratigraphy, later work emphasized generalized environmental lithofacies depictions that failed to depict the interfingering nature of the various Blackhawk tongues (e.g. Van De Graaff, 1972; Fig. 2B).

Wheeler and Mallory (1953) specifically addressed the lithostratigraphic subdivision of the Book Cliffs section but suggested a confusing nomenclatural scheme, using arbitrary vertical cutoffs (Fig. 2A). Where sandstone tongues of the

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Blackhawk extended into the Mancos Shale Formation, these sandstone tongues were assigned as members of the Blackhawk Formation. Correspondingly, the overlying shale tongue was also included as a member of the Blackhawk Formation, and was thus not treated as an extension of the Mancos Shale (Fig. 2A). The distal boundaries of these overlying “Blackhawk” shale members were defined by an arbitrary vertical line, drawn up from the tip of the pinchout of the underlying sandstone member. The net result was that the *same* rocks, with the *same* lithofacies, of the *same* biostratigraphic age were arbitrarily separated into different formations according to the pinch-out of different layers, stratigraphically above or below the particular stratigraphic unit of interest. Extended mapping of the overlying or underlying strata, or more detailed measured sections, that might have shown these strata to pinch-out farther into the basin than previously identified, could easily require the arbitrary vertical boundaries to shift, resulting in the names and positions of mapped formations or members to change. This problem instigated significant debate among stratigraphers, some of whom objected that these arbitrarily defined formations or members could not be distinguished in the field either biostratigraphically, or on the basis of lithology. Young (1955, 1957) pointed out the “cyclothem” nature of these successions and maintained that the tongues of shale be included as part of the Mancos, rather than arbitrarily assigned to the Blackhawk Formation (Fig. 2B).

The End of Stratigraphy

The net result of the Wheeler and Mallory (1953) approach was a proliferation of different names for the same rocks that was ultimately confusing to all except those geologists deeply concerned with the rules of stratigraphic nomenclature. Anecdotal evidence suggests that many stratigraphy courses in the late 50's and early 60's focused on memorizing type sections, type fossils, and local stratigraphic schemes, versus understanding stratigraphic and

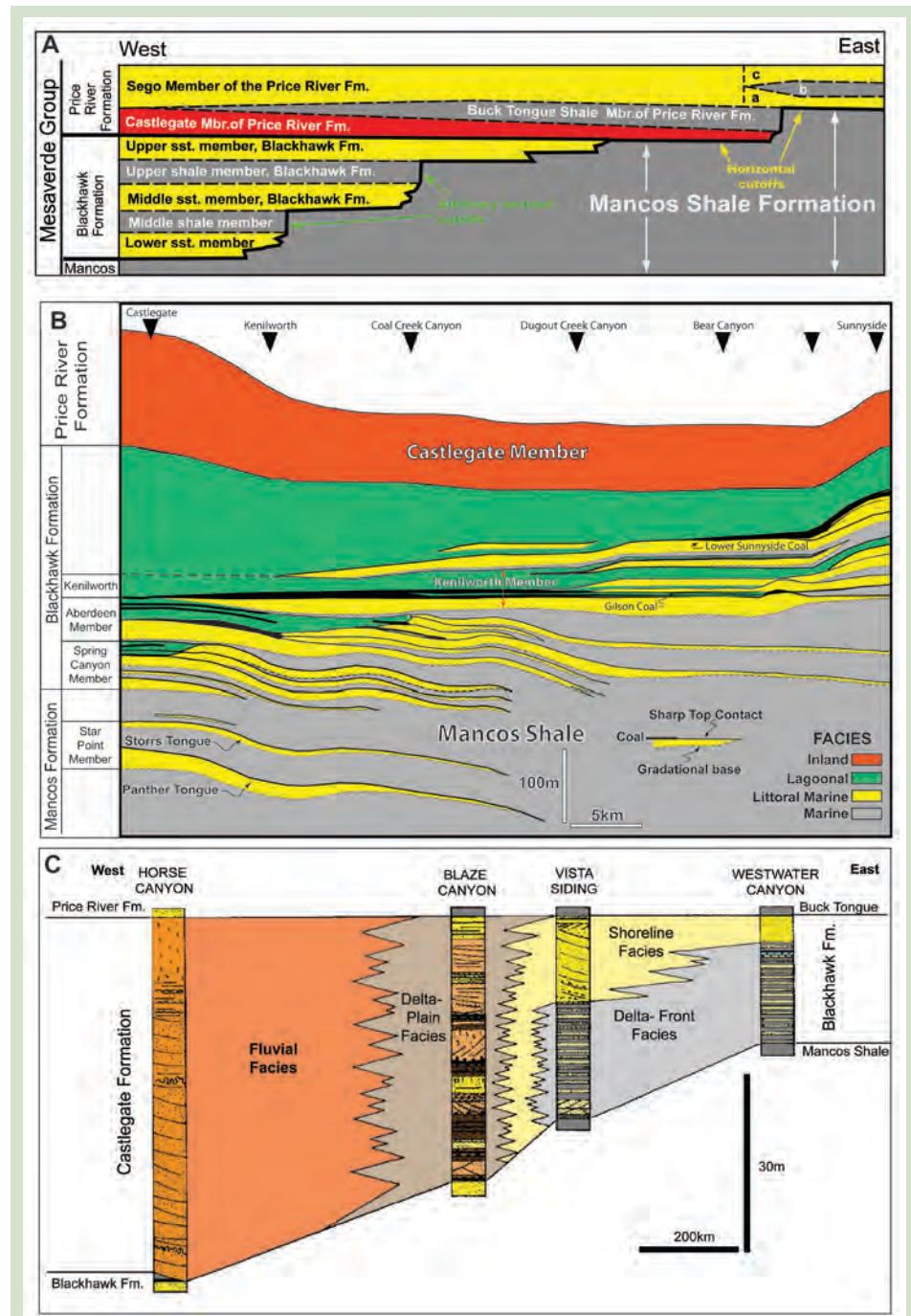


Figure 2: A. Lithostratigraphic subdivision of the Campanian Mesaverde Group strata of the Book Cliffs, Utah, using arbitrary cutoffs. Shale tongues are assigned to the Blackhawk Formation, rather than the Mancos Formation. From Wheeler and Mallory (1953). B. Dip-oriented cross section of the Campanian Book Cliffs strata showing clear interfingering of Blackhawk Formation sandstones with marine shales of the Mancos Formation. From Young (1955, 1957). C. Later depiction of the Book Cliffs from Van der Graaff (1972) de-emphasizes the cyclic nature of the Blackhawk Members. Zigzag, “shazam” lines are drawn, separating the fluvial Castlegate sandstones from the delta plain, shoreline, and delta-front lithofacies. This is a classic environmental lithofacies stratigraphic cross section, popular in the 70's and 80's. Despite the popularity of such depictions, the cross section ignores key surfaces, critical to define reservoir-seal pairs, and provides no information about stratal geometries or lateral relationships.

sedimentological processes. In contempt, famed petrologist, Paul Krynine, was alleged to have declared that “Stratigraphy is the complete triumph of

terminology over facts and common sense.” Whether or not the account of Krynine is apocryphal, the reality was that by the mid-70's, (around the time that the

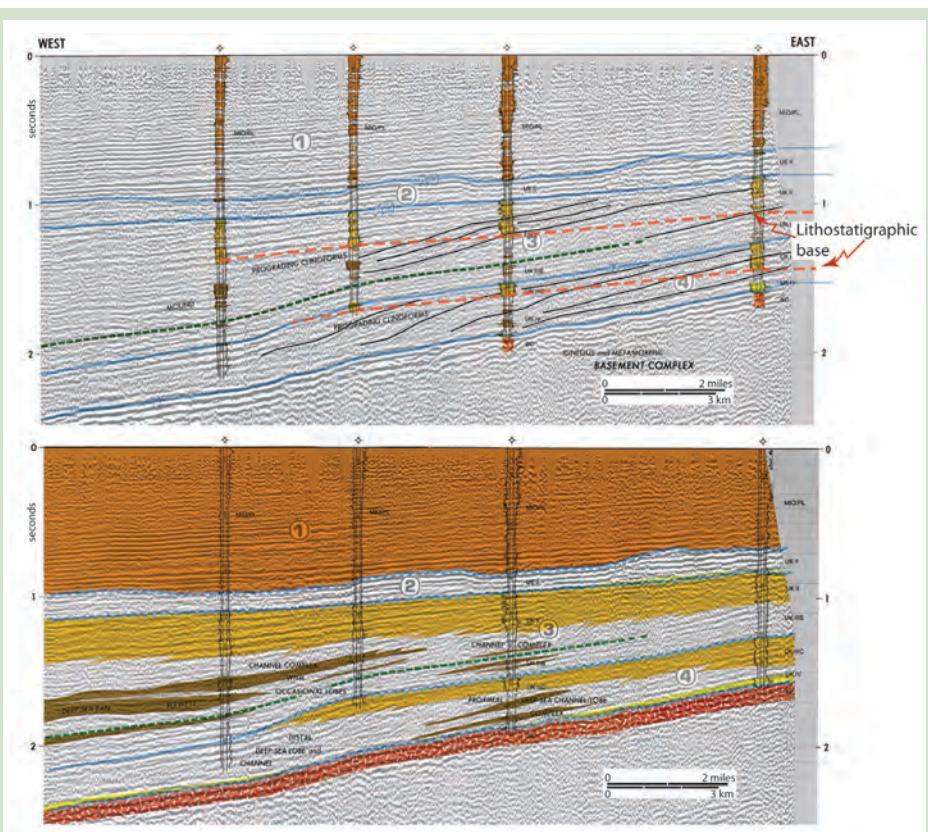


Figure 3: Seismic line and facies interpretation shows that the cliniform seismic reflections cut obliquely across the lithostratigraphic base of defined formations. However, the tops of the formations are flooding surfaces that coincide and are concordant with the seismic reflections. Vail et al. (1977) used these observations to infer that the seismic reflections more closely approximated time surfaces, rather than arbitrary lithostratigraphic boundaries.

senior author was an undergraduate) stratigraphy was moribund and the emphasis in sedimentary geology courses became focused almost exclusively on process sedimentology, facies analysis, and petrographic description, versus stratigraphy.

Stratigraphic cross sections from the 70's and 80's are astoundingly "lithostratigraphic" and fail to capture the inter-tonguing and cyclic aspect of deposition (Fig. 2C), relying, rather, on gradational and arbitrarily defined "environmental" lithofacies boundaries, depicted as zigzagging "shazam" lines, as the basis for stratigraphic correlation, more akin to the "lithosomes" of Wheeler and Mallory (1956) (Fig. 1C).

In the 70's, a group of more forward thinking stratigraphers presented early versions of stratigraphic schemes that resembled modern sequence stratigraphy, such as the genetic increments of strata (GIS) of Busch (1971, 1974), the "depositional

episodes" of Frazier (1974), and the correlations shown by Asquith (1970, 1974). These geologists ultimately influenced modern sequence stratigraphy (e.g. Galloway, 1989) as well as many in the petroleum business, but Busch was a consulting petroleum geologist in Tulsa, and Frazier worked at Exxon in Houston. Their work was largely ignored by the academic community and, in fact, Busch (1974), perhaps somewhat cynically, notes: "Very few textbook references appear in the bibliography because most of the ideas expressed here do not appear in such texts." Busch did not think that standard academic textbooks of his day reflected state-of-the art stratigraphy. In defense of the academe, lack of access to proprietary core, well log, and of course seismic data, made them naturally cynical about any science based on data that could not be published, and this same concern, is still expressed in academic criticism of the modern

formulation of sequence stratigraphy (e.g. Walker, 1990; Miall, 1991; Miall and Miall, 2001; Dickinson, 2003).

At the same time, many academic sedimentologists were focused on extremely detailed analysis of 1D vertical sections, using the newly discovered sedimentary structures that appeared to hold the key to process-based paleoenvironmental facies analysis (e.g. Middleton, 1965; Reading, 1978; Walker, 1979), which in effect served as a new paradigm. Petrographic studies provided details on composition and diagenesis that were enormously useful for provenance analysis linked to the new theory of plate tectonics (e.g. Dickinson, 1970; Folk, 1974; Dickinson and Suczek, 1979). The outdated gross lithofacies concepts of Wheeler and Mallory (1956) were abandoned in favor of much more detailed approaches. In the process, stratigraphy appeared to have been forgotten and largely disappeared in the academe as reflected in the scarce reference to stratigraphy in the undergraduate textbooks that used by the senior author at that time (e.g., Blatt, Middleton and Murray, 1972, 1980).

HOW GEOPHYSICS SAVED STRATIGRAPHY

The abandonment and then resurrection of sequence stratigraphy invites the question, what was it that seismic data imaged that so many academic petrographers, lithostratigraphers and facies analysts failed to identify?

Following graduation in 1956 from Northwestern University, and heavily influenced by Bill Krumbein and Larry Sloss, Peter Vail eventually joined Exxon corporation (Mitchum, 1985). Vail recognized that Wheeler's time-stratigraphic analytical approach and Sloss's sequence concepts, were superbly applicable to the analysis of proprietary seismic data (Vail et al., 1977). The basic concept that the stratigraphic record is built by a succession of beds, where the discontinuities are defined by lapout, as suggested by Grabau (1906), was readily applied to the interpretation of seismic data (Fig. 3). A primary assumption

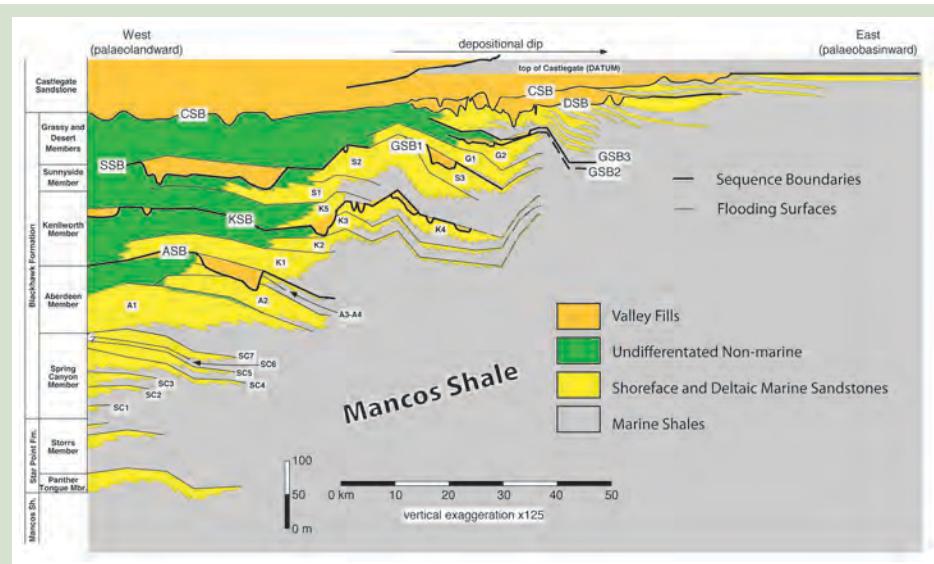


Figure 4: Sequence stratigraphic interpretation of the Campanian Mesaverde Group in the Book Cliffs, Utah (from Hampson, 2005). The strata are subdivided into sequence sets, sequences and parasequences. Parasequences include both sandstone and marine shale facies. The emphasis is on correlative key surfaces, rather than diachronous lithofacies. Compare with figure 2.

was that seismic reflections are chronostratigraphic (Vail et al., 1977), an idea that has been heavily criticized (e.g. Dickinson, 2003).

An unique aspect of seismic data is that seismic lines are constructed by stacking of separate seismic traces of the same point in space taken at different angles. This stacking creates the multi-fold data that fundamentally enhances subtle but coherent stratigraphic boundaries, such as the contacts and surfaces between beds, bedsets, and parasequences, versus the arbitrary lithostratigraphic boundaries, as clearly stated by. “*Primary seismic reflections are generated by stratal surfaces which are chronostratigraphic, rather than by boundaries of arbitrarily defined lithostratigraphic units*”, debunking much of the previous few decades of lithostratigraphic theory, Vail et al. (1977, 1987, Fig. 3)

Vail et al. (1977) originally defined lowstand and highstand sequences, which later became systems tract. The lowstand sequence was defined as a seismic package that is thickest in the basin and onlaps against the slope and lower part of the shelf. Highstand sequences are widespread on the shelf, thickest near the shelf edge, and prograde and downlap basinward.

From the beginning, these terms referred to position on the shelf (geometry) not sea level.

Concomitant with the seismic analytic approach was the development of the hypothesis that seismic sequences were largely eustatic in origin (Vail et al., 1977; Haq et al., 1987). Thus the concept that global sea level changes largely controlled sequence development also became entrenched, albeit also heavily criticized (Miall and Miall, 2001).

Despite the criticism, recognition of these cyclic patterns were of prime importance to the oil and gas industry, as these cyclic units represent the basic building blocks in the deposition of reservoir-seal pairs (i.e. sands versus shales) and were thus critical in subsurface correlation and mapping (Van Wagoner, 1995). As discussed above, lithostratigraphic approaches, especially those schemes that used arbitrary cutoffs and gradational lithofacies boundaries as the prime means of subdividing stratigraphic successions (e.g., Fig 1 and 2C), were clearly of little value in defining basic reservoir compartments, as had long been understood by Busch (1971, 1974) and others.

From Seismic to Sequence Stratigraphy: A New Paradigm

The seismic revolution caused other researcher's at Exxon to completely re-evaluate their approach to stratigraphy and correlation, especially as applied to higher resolution well log, core and outcrop data (e.g., Van Wagoner et al., 1990). They incorporated the ideas of Campbell (1967) Frazier (1974) and Busch (1971, 1974), but also incorporated process-based facies models as well as geomorphological insights (e.g. Posamentier and Vail, 1988; Posamentier et al., 1988). Jervey, 1988 explained seismically resolvable stratal patterns by new accommodation models that quickly led to the realization that the sequence could be subdivided into smaller stratal units, ultimately called “systems tracts” (after Brown and Fisher, 1977).

The new formulation of sequence stratigraphy emphasized identification and correlation of bounding discontinuities using facies analysis. by identifying surfaces across which there was an abrupt change in depositional regime or overall facies trends, such as the flooding surfaces marked by marine shales sharply capping shallow marine upward coarsening facies successions (Fig. 4), or the observation of coarse-grained fluvial deposits erosively overlying more distal marine facies that typify sequence boundaries (Wilgus et al., 1988; Van Wagoner et al., 1990, Bhattacharya, 1993).

Van Wagoner (1995b), and many others (e.g., Kamola, and Van Wagoner, 1995; Pattison, 1995; O’Byrne and Flint, 1995, Taylor and Lovell, 1995; Hampson, 2000; Hampson and Howell, 2005; Pattison, 2010; Hampson et al., 2014) eventually presented a fully revised sequence stratigraphic interpretation of the Book Cliffs section referred to above, which solved the problem of different lithofacies of the same genetic unit being separated into different lithostratigraphic units (Fig. 4). Sequence stratigraphy (and allostratigraphy) allowed different lithofacies to be grouped into the same depositional system or systems tract, and used key bounding surfaces as the means

of separating stratigraphic units, rather than gradational, arbitrarily-defined facies boundaries.

Evolution of Sequence Stratigraphy

The new version of sequence stratigraphy divide sequences into component “parasequences” and “systems tracts” on the basis of key bounding surfaces and specific facies stacking patterns. However, many of the terms used to designate systems tracts and key surfaces belied the underlying assumption that eustasy, or at least relative sea level change, was the dominant control (e.g. lowstand, forced regressive, highstand, and transgressive systems tracts; flooding surfaces and transgressive surfaces). In the early publications (Vail et al., 1977) the sequence boundary was identified by onlap and downlap surfaces. The maximum flooding surface was identified as a downlap surface and based in part on observation of biostratigraphic condensed zones (Vail et al., 1984; Van Wagoner et al. 1988).

At the same time that one set of definitions was being proposed based on geometries, another school was developing in which systems tracts were related to sea level cycles. Mitchum (1977) defined the highstand as an interval of time during a cycle of relative change in sea level when sea level is above the shelf edge. Van Wagoner et al., (1987), in contrast, defined the highstand systems tract according to its geometric characteristics as commonly widespread on the shelf and characterized by aggradational to progradation vertical stacking of shoreline systems (parasequences). Van Wagoner (1987) also defined a Transgressive Systems Tract as characterized by one or more retrogradational parasequence sets, marked at the base by the transgressive surface and at the top by the downlap surface (maximum flooding surface). Systems tracts nomenclature thus represented confusing, non-parallel terms. Highstand and lowstand systems tracts referred to position on the shelf, but could also be construed as reflecting periods of sea-level stasis, the

transgressive systems tract specifically implies a shift in position of the shoreline, but a parallel construction, such as “midstand” was never considered

Van Wagoner (1995a), recognizing this dilemma, suggested that there were two emerging sequence stratigraphic paradigms, reflected in the confusing systems tract terminology, one based on designation of stratigraphic units based on their inferred mode of origin, which he called the “sea-level paradigm”, versus an analytical approach based largely on observed facies stacking patterns and geometric relationships, which he termed the “rock paradigm”. Helland-Hansen and Gjelberg (1994) recognized that facies stacking of shallow marine systems is fundamentally controlled by sea-level changes (be they eustatic or relative), and developed the useful concept of shoreline trajectory (Helland-Hansen and Martinsen, 1996). Neal and Abreu (2009) recently introduced the concept of scale-independent accommodation successions that also emphasizes stacking patterns of clinoforms in seismic data, extending and generalizing the concept of parasequence stacking patterns to all scales, and retreating from an emphasis on the sea-level dominated terminology of systems tracts.

Facies models concepts, although novel in the early 70’s, also became less static and were re-formulated in the context of alloegenic sea-level change (e.g. Walker and James, 1992), versus the largely autogenic concepts that prevailed in the initial formulation (Reading, 1978; Walker, 1979).

Ongoing Concerns in Sequence Stratigraphy

Some of the ongoing debates in sequence stratigraphy remain focused on whether the larger-scale geometric arrangements of strata are more or less important than the vertical facies trends (Embry, 2002). Fundamentally, in seismic data, lapout relationships are directly observed and geometric considerations are paramount, although lithologies must be interpreted and vertical resolution remains a problem. However, in well log cross sections,

or in other sparse data sets, such as isolated outcrop sections (e.g. stream cuts or roadcuts), although 1D vertical resolution is greatly improved, lapout relationships are rarely observed, and must be interpolated between 1D sections or wells (Bhattacharya, 2011). As a consequence, the conceptual framework of the interpreter will be key in making the correct correlations (e.g. Gani and Bhattacharya, 2005; Catuneanu et al., 2009). Facies considerations may help drive the correlation using sparse data. For example, measured sections may show several upward-coarsening parasequences that become thinner and muddier in more distal sections. The geologist may have to make an *a priori* assumption about whether strata form clinoforms, and at what angle, or remain parallel? Assumptions must commonly be made about how units are likely to correlate (i.e. dipping or layer-cake) as opposed to seismic data, where the geometries are observed directly. Because of the level of interpolation and interpretation involved, the practice of sequence stratigraphy using well log, core, and outcrop data may require model-driven *a priori* assumptions to be made. In addition, newer concerns are being raised regarding the time-stratigraphic relationships of key sequence stratigraphic surfaces (e.g., Strong and Paola, 2009; Bhattacharya, 2011, Holbrook and Bhattacharya, 2012; Blum et al., 2013).

Despite these provisos, it is clear that the application of older stratigraphic concepts to seismic data revolutionized and revitalized stratigraphy. The proliferation of seismic data in the late 70’s demonstrated emphatically, that basin fill stratigraphic patterns could not be understood using the prevailing lithofacies concepts. The fact that lithofacies cross sections of the time (e.g. Figs. 1 and 2) failed to reproduce the kinds of stratal geometries seen in seismic data (Fig. 3) demonstrated the failure of the lithofacies approach in stratigraphic analysis. In all cases, it is key to recognize that sequence stratigraphy, at its heart, is the re-ordering, correlation, and sometimes renaming of stratigraphic units on the

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basis of bounding discontinuities and their correlative surfaces, as opposed the arbitrary lithofacies-oriented approach using broad facies “shazams” or arbitrary cutoffs, such as was used in traditional lithostratigraphy. Without using a sequence stratigraphic approach, regardless of which school of sequence stratigraphy you prefer, it will be difficult to define reservoir-seal pairs and make accurate predictions about the updip and downdip limits of strata.

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REFERENCES

- ABREU, V.S., HARDENBOL, J., HADDAD, G.A., BAUM, G.R., DROXLER, A.W. AND VAIL, P.R., 1998, Oxygen Isotope Synthesis: A Cretaceous Ice-House? *SEPM Special Publication*, 60, 54-75.
- ASQUITH, D.O., 1970, Depositional topography and major marine environments, late Cretaceous, Wyoming. *AAPG Bulletin*, 54, 1184-1224.
- ASQUITH, D.O., 1974, Sedimentary models, cycles, and deltas, Upper Cretaceous, Wyoming. *AAPG Bulletin*, 58, 2274-2283.
- BALLY, A.W., 1987, Geometric Analysis of a Depositional Sequence - Part 4. Seismic and Well Sequences In: *Atlas of Seismic Stratigraphy*, volume 1 (ed., A.W. Bally) *AAPG Studies in Geology*, 27, 11-14.
- BARRELL, J., 1912, Criteria for the recognition of ancient delta deposits. *Geological Society of America Bulletin*, 23, 377-446.
- BARRELL, J., 1917, Rhythms and the measurement of geological time. *Geological Society of America Bulletin*, 44, 745-904.
- BHATTACHARYA, J.P., 1993, The expression and interpretation of marine flooding surfaces and erosional surfaces in core; examples from the Upper Cretaceous Dunvegan Formation in the Alberta foreland basin. In: *Sequence stratigraphy and facies associations*. (eds. C.P. Summerhayes and H.W. Posamentier). *IAS special publication*, 18, 125-160.
- BHATTACHARYA, J.P., 2011, Practical problems in the application of the sequence stratigraphic method and key surfaces: integrating observations from ancient fluvial-deltaic wedges with Quaternary and modelling studies. *Sedimentology*, v. 58, p. 120-169.
- BLACKWELDER, E., 1909, The valuation of unconformities. *Journal of Geology*, 17, 289-299.
- BLATT, H., MIDDLETON, G.V. AND MURRAY, R.C., 1980. *Origin of Sedimentary Rocks*, Prentice Hall. 782p.
- BLUM, M., MARTIN, J., MILLIKEN, K., AND GARVIN, M., 2013, Paleovalley systems: Insights from Quaternary analogs and experiments. *Earth-Science Reviews* 116 (2013) 128-169
- BUSCH, D.A., 1971, Genetic units in delta prospecting: *AAPG Bulletin*, 55, 1137-1154.
- BUSCH, D.A., 1974, Stratigraphic Traps in Sandstones – Exploration Techniques. *AAPG Memoir*, 21, 174p.
- CAMPBELL, C.V., 1967, Lamina, lamina-set, bed and bedset: *Sedimentology*, 8, 7-26.
- CATUNEANU, O., V. ABREU,
J.P. BHATTACHARYA, M.D. BLUM,
R.W. DALRYMPLE, P.G. ERIKSSON,
C.R. FIELDING, W.L. FISHER,
W.E. GALLOWAY, M.R. GIBLING,
K.A. GILES, J.M. HOLBROOK, R. JORDAN,
C.G. ST.C. KENDALL, B. MACURDA,
O.J. MARTINSEN, A.D. MIALL, J.E. NEAL,
D. NUMMEDAL, L. POMAR, H.W.
POSAMENTIER, B.R. PRATT, J.F. SARG,
K.W. SHANLEY, R.J. STEEL, A. STRASSER,
M.E. TUCKER AND C. WINKER, 2009,
Toward the Standardization of Sequence
Stratigraphy. *Earth-Science Reviews*, 92, 1-33.
- CHAMBERLAIN, T.C., 1989, The ulterior basis of time divisions and the classification of geological history. *Journal of Geology*, 6, 449-462
- CHAMBERLAIN, T.C., 1909, Diastrophism as the ultimate basis of correlation. *Journal of Geology*, 17, 685-693.
- DICKINSON, W. R. (1970). Interpreting detrital modes of graywacke and arkose. *Journal of Sedimentary Research*, 40(2), 695-707.
- DICKINSON, W.R., 2003, The Place and Power of Myth in Geoscience: An Associate Editor's Perspective, *American Journal of Science*, 303, 856-864.
- DICKINSON, W. R., & SUCZEK, C. A. (1979). Plate tectonics and sandstone compositions. *AAPG Bulletin*, 63(12), 2164-2182.
- EMBRY, A.F., 1995, Sequence boundaries and sequence hierarchies: problems and proposals. In: (eds. Steel, R.J., Felt, V.L., Johannessen, E.P., Mathieu, C.), *Sequence Stratigraphy on the Northwest European Margin*. *Norwegian Petroleum Society Spec. Publ.* 5, 1-11.
- EMBRY A.F., 2002, Transgressive-Regressive (T-R) Sequence Stratigraphy. *Gulf Coast Association of Geological Societies Transactions*, 52, 151 – 172.
- FOLK, R.L., 1974, Petrology of sedimentary rocks, Hemphill Publ. Co., Austin, Texas, 182p.
- FRAZIER, D.E., 1974, Depositional episodes: their relationship to the Quaternary stratigraphic framework in the northwestern portion of the Gulf basin: Austin, TX., Bureau of Economic Geology, *Geological Circular* 74-1, 28 p.
- GALLOWAY, W.E., 1989, Genetic stratigraphic sequences in basin analysis I: architecture and genesis of flooding-surface bounded depositional units. *AAPG Bulletin*, 73, 125-142.
- GANI, M.R. AND BHATTACHARYA, J.P., 2005, Bedding correlation vs. facies correlation in deltas: Lessons for Quaternary stratigraphy, In: *River Deltas: Concepts, Models, and Examples* (eds. Giosan, L., and Bhattacharya, J.P.) *SEPM Special Publication*, 83, 31-48.
- GRABAU, A.W., 1906, Types of sedimentary overlap. *Geological Society of America Bulletin*, 17, 567-636.
- HAMPSON, G.J., 2000, Discontinuity Surfaces, Clinoforms, and Facies Architecture in a Wave-Dominated, Shoreface-Shelf Parasequence. *Journal of Sedimentary Research*, 70, 325-340.
- HAMPSON, G.J. AND HOWELL, J.A., 2005, Sedimentologic and geomorphic characterization of ancient wave-dominated deltaic shorelines: Late Cretaceous Blackhawk formation, Book Cliffs, Utah. , In: *River Deltas: Concepts, Models and Examples* (eds. Giosan, L., and Bhattacharya, J.P.) *SEPM Special Publication*, 83, 133-154.
- HAMPSON, G. J., DULLER, R. A., PETTER, A. L., ROBINSON, R. A. J., & ALLEN, P. A., 2014. Mass-Balance Constraints On Stratigraphic Interpretation of Linked Alluvial-Coastal-Shelf Deposits From Source-to-sink: Example From Cretaceous Western Interior Basin, Utah and Colorado, USA. *Journal of Sedimentary Research*, 84, 935-960.
- HAQ, B.U., HARDENBOL, J., AND VAIL, P.R., 1987, Chronology of fluctuating sea levels since the Triassic. *Science*, 235, 1156-1166.
- HELLAND-HANSEN, W. AND GJELBERG, J.G., 1994, Conceptual basis and variability in sequence stratigraphy: a different perspective: *Sedimentary Geology*, 92, 31–52.
- HELLAND-HANSEN, W. AND MARTINSEN, O.J., 1996, Shoreline trajectories and sequences: description of variable depositional-dip scenarios. *Journal of Sedimentary Research*, 66, 670-688
- JERVEY, M. T., 1988, Quantitative geological modeling of siliciclastic rock sequences and their seismic expression. In: *Sea-level changes: an integrated approach*. (eds. C.K. Wilgus, B.S. Hastings, C.G.St.C. Kendall, H.W. Posamentier, C.A. Ross, and J.C. Van Wagoner). *SEPM Special Publication*, 42, p. 47-69.
- KAMOLA, D.L., AND VAN WAGONER, J.C., 1995, Stratigraphy and Facies Architecture of Parasequences with Examples from the Spring Canyon Member, Blackhawk Formation, Utah. In: *Sequence stratigraphy of foreland basin deposits: outcrop and subsurface examples from the Cretaceous of North America* (eds. J.C. Van Wagoner and G.T. Bertram), *AAPG Memoir* 64, 27-54.
- KRUMBEIN, W.C., AND SLOSS, L.L., 1951, *Stratigraphy and Sedimentation*, W. H. Freeman & Company, New York, 497p.
- MIALL, A.D., 1991, Stratigraphic sequences and their chronostratigraphic correlation. *Journal of Sedimentary Petrology*, 61, 497–505
- MIALL, A.D., 2016 Stratigraphy: A Modern Synthesis (pp. 161-214). Springer International Publishing.
- MIALL, A.D., AND MIALL, C.E., 2001, Sequence stratigraphy as a scientific enterprise: the evolution and persistence of conflicting paradigms. *Earth Science Reviews*, 54, 321-348.
- MIDDLETON, G.V. (ED.), 1965, Primary sedimentary structures and their hydrodynamic interpretation, *SEPM Special Publication*, 12.
- MITCHUM, R.M., 1985, Peter R. Vail, biographic sketch for SEG Honorary membership, http://www.mssu.edu/SEG-VM/bio_peter_r_vail.html
- NEAL, J AND ABREU, V., 2009, Sequence stratigraphy hierarchy and the accommodation succession method. *Geology*, 37, 779-782.
- NYSTUEN, J.P. (1998) History and development of sequence stratigraphy. In: *Sequence stratigraphy – concepts and Application* (Eds F.M. Gradstein, K.O. Sandvik and N.J. Milton), *Norwegian Petrol. Soc. Spec. Publ.*, 8, 31-116.,

- O'BYRNE, C.J., AND FLINT, S., 1995, Sequence, Parasequence, and Intraparasequence Architecture of the Grassy Member, Blackhawk Formation, Book Cliffs, Utah, U.S.A., In: Sequence stratigraphy of foreland basin deposits: outcrop and subsurface examples from the Cretaceous of North America (eds. J.C. Van Wagoner and G.T. Bertram), *AAPG Memoir 64*, 225-255.
- PATTISON, S.A.J., 1995, Sequence Stratigraphic Significance of Sharp-Based Lowstand Shoreface Deposits, Kenilworth Member, Book Cliffs, Utah. *AAPG Bull.*, 79, 444 – 462.
- PATTISON, S. A.J., 2010. Alternative sequence stratigraphic model for the Desert Member to Castlegate Sandstone interval, Book Cliffs, eastern Utah: Implications for the high-resolution correlation of falling stage nonmarine, marginal-marine, and marine strata. *Geological Association of America Field Guides*, 18, 163-192.
- POSAMENTIER, H.W. AND VAIL, P.R., 1988, Eustatic controls on clastic deposition II - sequence and systems tract models. In: Sea-level changes: an integrated approach. (eds. C.K. Wilgus, B.S. Hastings, C.G.St.C. Kendall, H.W. Posamentier, C.A. Ross, and J.C. Van Wagoner). *SEPM Special Publication*, 42, 125-154.
- POSAMENTIER, H.W., JERVEY, M.T. AND VAIL, P.R., 1988, Eustatic controls on clastic deposition I - conceptual framework. In: Sea-level changes: an integrated approach. (eds. C.K. Wilgus, B.S. Hastings, C.G.St.C. Kendall, H.W. Posamentier, C.A. Ross, and J.C. Van Wagoner). *SEPM Special Publication*, 42, 109 - 124.
- POSAMENTIER, H. W. AND ALLEN, G. P., 1999, Siliciclastic Sequence Stratigraphy - Concepts and Applications, *SEPM Concepts in Sedimentology and Paleontology*, 7, 216p.
- POSAMENTIER, H. W., & KOLLA, V., 2003, Seismic geomorphology and stratigraphy of depositional elements in deep-water settings. *Journal of Sedimentary Research*, 73(3), 367-388.
- READING, H.G., 1978, Sedimentary Environments and Facies, Blackwell Scientific Publications Oxford, 557p.
- SLOSS, L. L., KRUMBEIN, W. C., AND DAPPLES, E.C., 1949, Integrated Facies Analysis. In: Longwell, C. R. Ed., Sedimentary Facies in Geologic History. *Geological Society of America, Memoir*, 39: 91-124.
- SLOSS, L.L., 1963, Sequences in the cratonic interior of North America. *Geological Society of America Bulletin*, 74, 93-113.
- SLOSS, L. L., 1988. Forty years of sequence stratigraphy. *Geological Society of America Bulletin*, 100(11), 1661-1665.
- STRONG, N., AND PAOLA, C. (2008) Valleys That Never Were: Time Surfaces Versus Stratigraphic Surfaces. *J. Sed. Res.*, 78, 579-593.
- TAYLOR, D.R. AND LOVELL, R.W., 1995, High-frequency sequence stratigraphy and paleogeography of the Kenilworth member, Blackhawk Formation, Book Cliffs, Utah, U.S.A In: Sequence stratigraphy of foreland basin deposits: outcrop and subsurface examples from the Cretaceous of North America (eds. J.C. Van Wagoner and G.T. Bertram), *AAPG Memoir 64*, 137-223
- VAIL, P.R., MITCHUM, R.M., JR., AND THOMPSON, S., III, 1977, Seismic stratigraphy and global changes of sea level, part 4: Global cycles of relative changes of sea level. In: *Seismic Stratigraphy - Applications to Hydrocarbon Exploration*. (ed., C.E. Payton). *AAPG Memoir*, 26, 83-97
- VAIL, P.R., TODD, R.G., AND SANGREE, J.B., 1977, Seismic stratigraphy and global changes of sea level, part 5: Chronostratigraphic Significance of Seismic Reflections. In: *Seismic Stratigraphy - Applications to Hydrocarbon Exploration*. (ed., C.E. Payton). *AAPG Memoir*, 26, 99-116
- VAIL, P.R., 1987, Seismic Stratigraphy Interpretation Using Sequence Stratigraphy: Part 1: Seismic Stratigraphy Interpretation Procedure, In: *Atlas of Seismic Stratigraphy*, volume 1 (ed., A.W. Bally) *AAPG Studies in Geology*, 27, 1-10.
- VAN DE GRAAFF, F.R., 1972, Fluvial-Deltaic Facies of the Castlegate Sandstone (Cretaceous), East-Central Utah, *Journal of Sedimentary Petrology*, 42, 558-571.
- VAN WAGONER, J.C., MITCHUM, R.M., POSAMENTIER, H.W. AND VAIL, P.R., 1987, An overview of sequence stratigraphy and key definitions. In: *Atlas of Seismic Stratigraphy*, volume 1 (ed., A.W. Bally) *AAPG Studies in Geology*, 27, 11-14.
- VAN WAGONER, J.C., POSAMENTIER, H.W., MITCHUM, R.M., VAIL, P.R., SARG, J.F., LOUTIT, T.S. AND HARDENBOL, J., 1988, An overview of sequence stratigraphy and key definitions, . In: Sea-level changes: an integrated approach. (eds. C.K. Wilgus, B.S. Hastings, C.G.St.C. Kendall, H.W. Posamentier, C.A. Ross, and J.C. Van Wagoner). *SEPM, Special Publication*, 42, 39-45.
- VAN WAGONER, J.C., 1995a, Overview of Sequence Stratigraphy of Foreland Basin Deposits: Terminology, Summary of Papers, and Glossary of Sequence Stratigraphy, In: *Sequence stratigraphy of foreland basin deposits: outcrop and subsurface examples from the Cretaceous of North America* (eds. J.C. Van Wagoner and G.T. Bertram), *AAPG Memoir 64*, 137-223
- VAN WAGONER, J.C., 1995b, Sequence stratigraphy and marine to nonmarine facies architecture of foreland basin strata, Book Cliffs, Utah, U.S.A, In: *Sequence stratigraphy of foreland basin deposits: outcrop and subsurface examples from the Cretaceous of North America* (eds. J.C. Van Wagoner and G.T. Bertram), *AAPG Memoir 64*, 137-223
- VAN WAGONER, J.C., MITCHUM, R.M., CAMPION, K.M., AND RAHMANIAN, V.D., 1990, Siliciclastic sequence stratigraphy in well logs, cores, and outcrops: concepts for high-resolution correlation of time and facies. *AAPG methods in exploration series*, 7, 55p.
- WALKER, R.G. (ED.), 1979, Facies Models, 1st Edition: Geoscience Canada, Reprint Series 1, 211p.
- WALKER, R. G. (1990). Facies modeling and sequence stratigraphy. *Journal of Sedimentary Research*, 60(5), 777-786.
- WALKER, R.G., AND JAMES, N.P., (EDS.) 1992, Facies models: response to sea level change: Geological Association of Canada, St. Johns, 409p.
- WILGUS, C.K., HASTINGS, B.S., KENDALL, C.G. ST.C., POSAMENTIER, H.W., ROSS, C.A., AND VAN WAGONER, J.C. (EDS.) 1988, Sea-level changes: an integrated approach. *Society of Economic Paleontologists and Mineralogists, Special Publication* 42, Tulsa, Oklahoma, 407 p.
- WHEELER, H.E., 1958. Time Stratigraphy. *AAPG Bulletin*, 42, 1047-1063.
- WHEELER, H.E., AND MALLORY, V.S., 1953, Designation of stratigraphic units, *AAPG Bulletin*, 37, 2407-2421.
- WHEELER, H.E., AND MALLORY, V.S., 1956, Factors in lithostratigraphy, *AAPG Bulletin*, 40, 2711-2723.
- YOUNG, R.G., 1955, Sedimentary facies and intertonguing in the Upper Cretaceous of the Book Cliffs, eastern Utah. *Geological Society of America, Bulletin*, 66, 177–202.
- YOUNG, R.G., 1957, Late Cretaceous Cyclic Deposits, Book Cliffs, Eastern Utah. *AAPG Bulletin*, 41, 1760-1774.

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STEPPE NEWS

STEPPE welcomes 2016 Fellow, Rachel Salter, from North Dakota State University. She is currently pursuing a dual doctoral degree at North Dakota State University in Evolutionary Biology and STEM Education. She will work to further develop education and outreach programs and materials focused on early career professionals, K-16 students and teachers. Keep your eyes open for her blog posts, etc. The STEPPE Fellowship program is generously supported by SEPM, The Paleontological Society, and the Geological Society of America.

PRESIDENT'S COMMENTS

Dear colleagues,

There is no greater honor than to be recognized by your peers and I thank you for electing me to serve as President of SEPM. Thanks to Janok Battacharya for all his hard work as outgoing President and for his efforts in revitalizing the SEPM STRATA webpage. Janok took the leadership on revising this great SEPM resource through his Presidential Project. The SEPM Presidential Project is designed to address key issues or important developments for the society, with strong impact in the future of SEPM and in the community. Janok's project objective is to keep STRATA vital with a strong editorial board that will ensure continuity. The STRATA editorial board will be analogous to our journal editorial boards, with a chief editor (we may use the model of having this position shared among two or several discipline-specific co-editors) and a larger group of associate editors. Several other efforts from Past Presidents had similar impact. As examples, Mitch Harris

convened a conference that focused on getting SEPM into the "digital" world - redoing the website, new apps, better email updates and new membership ideas. Chris Fielding worked with GSA to increase our collaboration and presence in their annual meeting.

My proposed Presidential Project is to enhance and deepen our collaboration with IAS and plan for our first major SEPM international meeting, perhaps to be called a Sedimentary Geology Congress. Recently, SEPM signed an MOU with the International Association of Sedimentologists (IAS), who are keen to partner more closely with SEPM. We plan to build on that and start planning several activities in collaboration in the next few years, which hopefully will culminate with our first international meeting in 2020. We would like to have this meeting in partnership with IAS – a 2020 SEPM/IAS international meeting. After our first meeting together, we are proposing to have meetings every 2 years, intercalating the leading organization

of the meeting (e.g., 2022 IAS International Sedimentological Congress with SEPM participating). Negotiations have already started with IAS leadership and we feel strong support for the proposal. As part of this effort, we strongly encourage our community to propose ideas for research conferences. We understand that times are tough for sponsorship, but we see research conferences as a part of the important learning process as we prepare to organize a larger meeting. Our outgoing Research Councilor Andrea Fildani did an outstanding job in preparing an exciting list of new conferences to occur in the next few years (see Research Conference Ad) and please keep the ideas coming. I am sure the incoming Research Councilor Elizabeth Hajek would appreciate the help! We will keep you informed about our progress on these initiatives.

**Vitor Abreu,
SEPM President**



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

SEPM STUDENT PARTICIPATION TRAVEL GRANT PROGRAM

SEPM's new program is entitled SEPM Student Participation Grants. These grants provide travel funds for students that have abstracts accepted to SEPM 'approved' meetings and conferences. Check out the rules for this program at <http://www.sepm.org/Apply-for-a-Student-Travel--Grant>

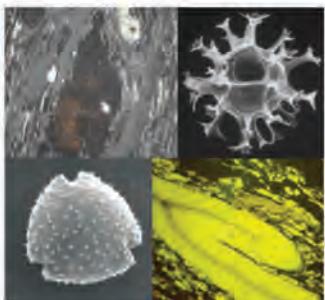
Over \$5,000 in travel awards to SEPM Student Members so far.



HOUSTON 2016

Joint Meeting of TSOP-AASP-ICCP

The Society for Organic Petrology - AASP The Palynological Society – International Committee for Coal and Organic Petrology
September 18-23, 2016 The Magnolia Hotel, Downtown Houston



*Organic Petrology and Microscopy – Palynology and Biostratigraphy
Organic Geochemistry – Source Rock and Source Rock Reservoir Characterization*

Pre-MEETING SHORT COURSE: Saturday, September 17th 9am-5pm
Integration of Microscopy and Geochemistry in Petroleum Source Rock Evaluation
Instructor: Richard Tyson (Getech, UK) Cost: US\$250 (Prof.) US\$200 (Students)

ALL-DAY JOINT SPONSORED SYMPOSIUM: Wednesday, September 21st
Multi-Modal Characterization of Source Rocks, Including Source-Rock Reservoirs
Keynote Speakers: Hamed Sanei (GSC-Calgary), Cortland Eble (KGS-Lexington),
Richard Tyson (Getech, UK)

ADDITIONAL SYMPOSIA AND THEME SESSIONS:

"Microscope Methodologies in Recognizing and Characterizing Organic Matter"

"Palynofacies and Kerogen"

"Palynofloral Contributions to Source Rocks"

TSOP Theme Session Honoring the Scientific Contributions of Jack Burgess

AASP Symposium Honoring the Scientific Contributions of Alfred Traverse

PRE-MEETING FIELDTRIP: Eagle Ford Formation Outcrops of West Texas

POST-MEETING FIELDTRIP: Paleocene-Eocene Wilcox Outcrops of South-Central Texas

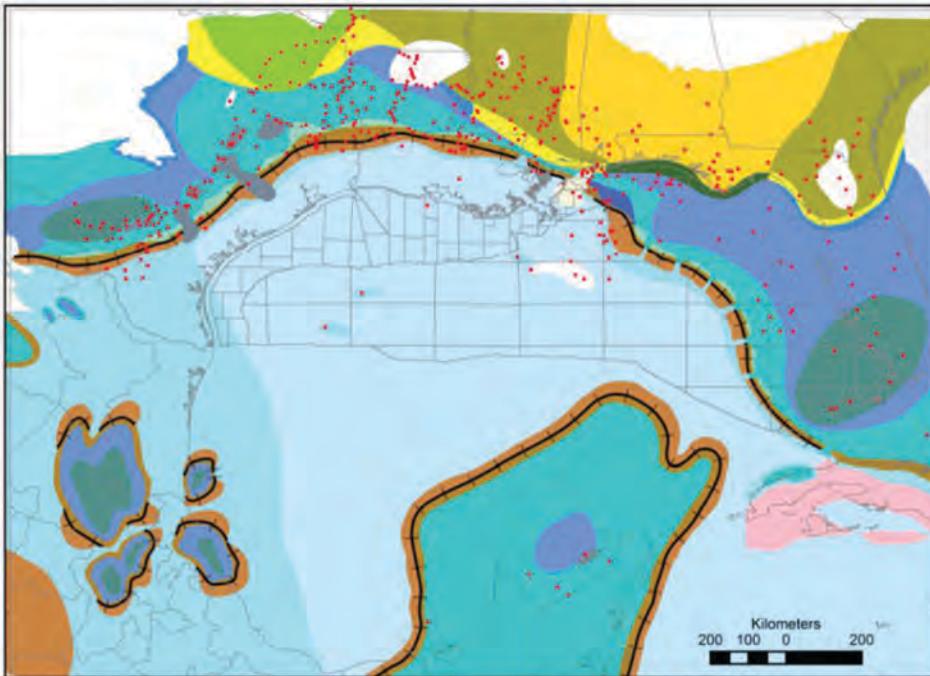
CONFERENCE DINNER: Wednesday, September 21st, 6:30-10pm Sambuca Cafe

For additional information regarding this meeting, please visit the website:

<http://palynology.org/home-page-2016-joint-meeting-tsop-aasp-iccp/>

Houston 2016 Organizing Cttee.: Thomas Demchuk, Thomas Gentzis, Joe Curiale, Jen O'Keefe

Please send all meeting inquiries to tdemchuk@swbell.net



Mesozoic of the Gulf Rim and Beyond: New Progress in the Science and Exploration of the Gulf of Mexico Basin

35th Annual GCSSEPM FNDTN Perkins-Rosen Research Conference

December 8-9, 2016 Marathon Auditorium Houston, TX

Go to www.gcssep.org for latest information

UPCOMING SEPM RESEARCH CONFERENCES

2016

SEPM-AAPG Mudstone Diagenesis Research Conference

Conference webpage: <http://www.sepm.org/MudstoneConference>

Dates: 16-19 October, 2016

Venue: Sante Fe, New Mexico

This conference will promote the exchange of new ideas among the leading experts from industry, academia, and government on the controls and impacts of inorganic and organic diagenesis on mudstone hydrocarbon generation, reservoir properties and seal quality.

Conveners: Wayne Camp (Andarko), Neil Fishman (Hess), Paul Hackley (USGS), Kitty Milliken (BEG—UT Austin) & Kevin Taylor (Manchester Metro. Univ.)

- Abstracts are closed and the program is being organized.
- Registration opens June, 2016

Oceanic Anoxic Events

Conference webpage: www.sepm.org/OAE-Conference

Dates: 2-7 November, 2016

Venue: Austin, Texas, USA

Oceanic anoxic events (OAE) are described as relatively short geological time intervals (< 1 Myr) where large parts of the world oceans became depleted in oxygen. Contemporaneous mass marine extinctions, perturbation to the global carbon cycle, and widespread black shale deposition are thought to be related to these events.

Conveners: Rob Forkner (Statoil) <RFork@statoil.com>, Charles Kerans (UT Austin), Benjamin Gill (Virginia Tech), Gianluca Frijia (Univ. Potsdam) & Ute Mann (Statoil)

- Abstract Submission – Closed
- Program being organized

Mesozoic of the Gulf Rim and Beyond: New Progress in Science and Exploration of the Gulf of Mexico Basin

Conference webpage: <http://www.sepm.org/2016PerkinsRosen>

Dates: 3-4 December – Field Trip; 7 Dec.–Workshop; 8-9 Dec.–Technical Sessions

Venue: Houston, Texas, USA

The 35th GCSSEPM 2016 Perkins-Rosen Research Conference will focus upon the Mesozoic of the Gulf Basin, from mountain source terrain to deep-water abyssal plain. A significant portion of the program will be devoted to the Mesozoic of Mexico and its potential for international exploration. A highlight will be a special SEPM-sponsored research symposium on Mesozoic source to sink: provenance and process led by Mike Blum (U. Kansas).

Technical Conveners: John W. Snedden, UT-Austin; Mike Blum, U. Kansas; Chris Lowery, UT-Austin

- Abstract Submission – Closed
- Program being organized

UPCOMING SEPM RESEARCH CONFERENCES

2017

Propagation of Environmental Signals within Source-to-Sink Stratigraphy

Conference webpage: tba

Dates: 5-9 June, 2017

Venue: Tremp & Ainsa, Spanish Pyrenees

The focus of this research conference is on controls on clastic sedimentation at different geologic time-scales and the propagation of sediment-flux signals in the stratigraphic record of correlative segments of source-to-sink sedimentary systems. The conference will aim to bring together scientists from Academia and Industry interested in the stratigraphic responses to tectonic, climatic and sea-level controls on sedimentation, and how these signals propagate or attenuate along the depositional profile.

- Main Conveners: Sébastien Castelltort (Univ. Geneva); Julian Clark (Statoil); Andrea Fildani (Statoil); and Cai Puigdefabregas (Univ. Barcelona)
- General structure and Key Note Speakers being organized

Mountjoy II – Joint SEPM/CSPG Research Conference: Characterization and Modeling of Carbonate Pore Systems

Conference webpage: tba

Dates: 26-29 June, 2017

Venue: Austin, Texas, USA

The 2017 Mountjoy Conference, sponsored by SEPM and CSPG, will be held at the University of Texas Learning Commons and the Texas Bureau of Economic Geology core facilities. The Conference will showcase new approaches and results through oral and poster sessions as well as core workshops and selected fieldtrips. The theme is broad, encompassing the stratigraphic, facies and diagenetic influences on varied pore systems, petrographic, geochemical and visualization tools applied to enhanced characterization of pore systems, from nano- and micro-scale, to fractures and cavernous pores, and new approaches for modeling the origin and distribution of pore systems. Integrated case studies from academia and industry are of particular interest. One of the highlights of the 1st Mountjoy meeting in 2015 was the opportunity for individual discussion and interaction between the attendees and the presenters. The 2017 Mountjoy Conference will continue to stress the importance of dedicated time for discussion and one-on-one networking throughout the program.

Main Conveners: Mitch Harris; Gene Rankey; Don McNeill; Astrid Arts; and Jean Hsieh

- General structure being organized

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.



SEPM Activities at ACE, Calgary

Thursday

- Short Course #2: Applied Ichnology: The Use of Trace Fossils in Sequence Stratigraphy, Exploration and Production Geology, Day 1 of 2 (Calgary Core Research Centre)

Friday

- Short Course #2: Applied Ichnology: The Use of Trace Fossils in Sequence Stratigraphy, Exploration and Production Geology, Day 2 of 2 (Calgary Core Research Centre)

Saturday

- SEPM Council Meeting (TELUS Convention Centre)
- Short Course #7: Sequence-Stratigraphic Analysis of Shales: Key to Paleoclimate Archives, Subsurface Fluid Flow and Hydrocarbon Source, Reservoir and Seal, Day 1 of 1 (TELUS CC)
- Short Course # 11: Basin Analysis Methods for Exploration, Day 1 of 2 (TELUS CC)
- Short Course #12: Sequence Stratigraphy for Graduate Students, Day 1 of 2 (TELUS CC)-SOLD OUT

Sunday

- Short Course # 11: Basin Analysis Methods for Exploration, Day 2 of 2 (TELUS Convention Centre)
- Short Course #12: Sequence Stratigraphy for Graduate Students, Day 2 of 2 (TELUS Convention Centre)- SOLD OUT
- SEPM NAMS Council Meeting (TELUS Convention Centre)
- SEPM Booth – Exhibit Hall Ice Breaker – 5:00-7:30 pm

Monday

- SEPM Booth Exhibit Hall: 8:30 am – 5:30 pm
- AAPG/SEPM Student Reception: 6:30 pm – 8:30 pm (Open Event) Hyatt Regency
- SEPM Research Group Meetings & Reception: 7:00 pm – 10:00 pm (Open Event) (TELUS CC)

Tuesday

- SEPM Booth Exhibit Hall – 8:30 am – 5:30 pm
- SEPM Research Symposium: *Not all Foreland Basins are Created Equal* (Morning and Afternoon Oral Sessions)
- SEPM Luncheon: *Carbonates in a Cold Ocean*, Noel James – 12:00 pm – 1:15 pm (Ticket required) Hyatt Regency Calgary – Imperial Ballroom 4/6
- SEPM Foundation Reception (Invitation Only) Calgary Marriott Downtown
- SEPM President's Reception and Awards Ceremony – President Janok Bhattacharya – 7:30 pm – 9:30 pm (Open Event) Calgary Marriott Downtown – Acadia A/B

Wednesday

- SEPM Booth Exhibit Hall – 8:30 am – 12:00 pm

Thursday

- Short Course #16: Rock & Seismic Sequence Expression of Carbonate Systems (Day 1 of 2) (TELUS CC)

Friday

- Short Course #16: Rock & Seismic Sequence Expression of Carbonate Systems (Day 2 of 2) (TELUS CC)

