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The rise and fall of stromatolites in shallow marine environments

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ABSTRACT

Stromatolites are abundant in shallow marine sediments deposited before the evolution of animals, but in the modern ocean they are restricted to locations where the activity of animals is limited. Overall decline in the abundance of stromatolites has, therefore, been attributed to the evolution of substrate-modifying metazoans, with Phanerozoic stromatolite resurgences attributed to the aftermaths of mass extinctions. Here we use a comprehensive stratigraphic database, the published literature, and a machine reading system to show that the rock record–normalized occurrence of stromatolites in marine environments in North America exhibits three phases: an initial Paleoproterozoic (ca. 2500 Ma) increase, a sustained interval of dominance during the Proterozoic (2500–800 Ma), and a late Neoproterozoic (700–541 Ma) decline to lower mean prevalence during the Phanerozoic (541–0 Ma). Stromatolites continued to exhibit large changes in prevalence after the evolution of metazoans, and they transiently achieved Proterozoic-like prevalence during the Paleozoic. The aftermaths of major mass extinctions are not well correlated with stromatolite resurgence. Instead, stromatolite occurrence is well predicted by the prevalence of dolomite, a shift in carbonate mineralogy that is sensitive to changes in water-column and pore-water chemistry occurring during continent-scale marine transgressive-regressive cycles.

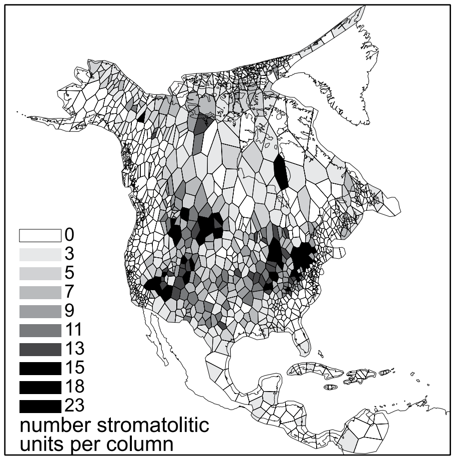

Figure 1. Spatial distribution and number of stromatolite-bearing sedimentary units in Macrostrat (https://macrostrat.org) for North America–Caribbean region. Polygons show approximate spatial boundaries of 1013 geologic columns used here. Shading indicates the total number of stratigraphic units identified as containing stromatolites in each column.

INTRODUCTION

Stromatolites, attached accretionary sedimentary structures that are formed either inorganically (Lowe, 1994; Grotzinger and Rothman, 1996) or by microbial interactions between carbonate sediment and the overlying water (Grotzinger and Knoll, 1999; Bosak et al., 2013), are one of the most distinctive of all sedimentary structures. The stratigraphic distribution and abundance of stromatolites has been viewed as a proxy record that can integrate information about the physical, chemical, and biological environment (Hofmann, 1973; Grotzinger, 1990; Grotzinger and Knoll, 1999). For example, stromatolite growth and morphology are responsive to the presence and abundance of grazing metazoans (Garrett, 1970; Walter and Heys, 1985) and possibly to the input of skeletal debris (Pratt, 1982). The evolution and diversification of metazoans has, therefore, been identified as a cause for the decline of stromatolites and other microbially formed structures, with disruptions of animal communities in the aftermaths of major mass extinctions promoting their transient reestablishment (Schubert and Bottjer, 1992; Sheehan and Harris, 2004; Baud et al., 2007; Mata and Bottjer, 2012; but see Riding, 2000, 2005, 2006). Increases in the carbonate saturation state of the ocean have also been invoked to explain increases in microbialite abundance (Riding, 2005) and inorganic seafloor carbonate precipitates (Grotzinger and Knoll, 1995).

Several attempts have been made to compile stromatolite occurrences and quantify large-scale temporal trends in their morphology and abundance (Awramik, 1971, 1991; Awramik and Sprinkle, 1999; Walter and Heys, 1985; Semikhatov and Raaben, 1996; Riding, 2000). However, most previous compilations have focused on specific time intervals, and none has taken into consideration temporal changes in stromatolite numbers that might be attributable to variation in the quantity of sedimentary rock.

Here we use a comprehensive stratigraphic database covering North America and the circum-Caribbean region (Fig. 1) to measure the total quantity and age of shallow marine sediment and the rock record–normalized frequency of occurrence of stromatolites. Our approach is agnostic with respect to the genetic interpretation of stromatolitic structures, their morphology, or their local abundance within individual stratigraphic units. Instead, our goal is to measure the relative frequency of occurrence of sedimentary features described as stromatolites in the literature in a way that explicitly accounts for variation in the total amount of sedimentary rock. We then use the same stratigraphic framework to evaluate stromatolite occurrence in relation to carbonate mineralogy and marine animal diversity.

DATA SETS AND METHODS

Stratigraphic data derive from 1013 regionally composited Macrostrat database (https://macrostrat.org) geological columns (Fig. 1) covering 26 × 10^6 km^2 in North America and the Caribbean (Peters, 2006, 2008; Husson and Peters, 2017). Within these columns there are 22,282 lithologically and chronostratigraphically defined units, 83% of which are inferred based on their contained biota and/or geographic and stratigraphic position to have been deposited in marine and/or marginal marine environments. It is often difficult to determine whether Precambrian sedimentary units are marine or lacustrine in origin. However, most Phanerozoic sedimentary rock is shallow marine (Peters and Husson, 2017), so our default assumption is that Precambrian sedimentary rocks are also shallow marine, unless explicitly identified otherwise. Each Macrostrat unit is assigned at least one lithology, and most units are associated with multiple lithologies. More than 97% of all sedimentary units older than the Quaternary are assigned a lithostratigraphic name (e.g., formation) that is linked to a nomenclatural hierarchy, if applicable. Here, we also employ a simple age model that linearly distributes time between superposed stratigraphic units using basic geological principles. Constraining the age model is difficult in the Precambrian, but average rates of Precambrian sedimentation derived from it are comparable to Phanerozoic rates (Husson and Peters, 2017). The effects of correlation errors are also minimized in this analysis because we focus on count-based metrics and relative proportions in aggregate data (Adrain and Westrop, 2000).

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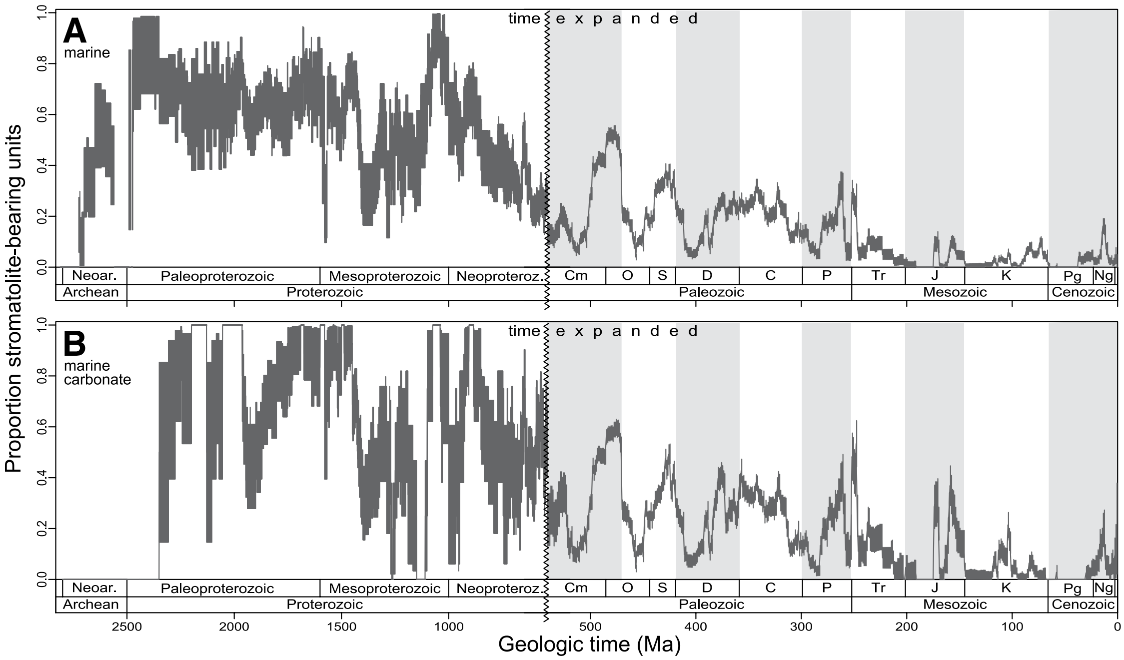

Figure 2. Occurrence of stromatolites over geological time normalized by total number of sedimentary rock units in study area (Fig. 1). A: Number of stromatolite-bearing marine units normalized by all marine sedimentary rock units. B: Number of stromatolite-bearing units normalized by number of marine carbonate-bearing rock units. Estimated proportion ± one standard error of estimate in each 1 m.y. increment is shown. Abbreviations correspond to international chronostratigraphic time intervals: Neoar.—Neoarchean; Neoproteroz.—Neoproterozoic; Cm—Cambrian; O—Ordovician; S—Silurian; D—Devonian; C—Carboniferous; P—Permian; Tr—Triassic; J—Jurassic; K—Cretaceous; Pg—Paleogene; Ng—Neogene. Vertical light gray bars identify Phanerozoic marine transgressive-regressive cycles (Meyers and Peters, 2011).

Stromatolite prevalence is defined here as the proportion of all North American–Caribbean named marine sedimentary rock units (20,484 total) or carbonate-bearing marine rock units (9,643 total) that are described as preserving stromatolites. The GeoDeepDive (https://geodeepdive.org) digital library and machine reading system (*sensu* Peters et al., 2014) was used to locate mentions of the term "stromatolite" (and variations thereof) within the full text of published documents. At the time of this analysis, GeoDeepDive contained most geoscience-relevant titles from Elsevier, Wiley, Canada Science Publishing, and PLoS One, and content from the U.S. Geological Survey, the Society for Sedimentary Geology, and the Geological Society of America. This library is not exhaustive; it does not contain all published papers that mention stromatolites. However, we sample a large set of literature that is unlikely to be strongly biased with respect to stromatolite occurrence versus age in the study region. A total of 10,683 documents in the GeoDeepDive library contain the term "stromatolite(s)" or "stromatolitic". Of these, 941 contain mentions of stromatolites that are linked to a total of 612 unique stratigraphic names in the focal area (see Table DR2 and the supplemental reference list in the GSA Data Repository[1]).

The algorithm we developed to link stromatolites to named stratigraphic units utilizes Stanford natural language processing (NLP), which decomposes sentences into parts of speech and linguistic dependencies (Manning et al., 2014). Manual assessment of a random sample of 3.8% of the machine-extracted stromatolite–rock unit pairs indicates an accuracy of 86%–89% at the individual level (Table DR1). Incorrect pairs identified during assessment were removed from the analysis and the sources of error assessed. In most cases, errors are limited to situations involving multiple sentences that express comparative or complex relationships between superposed stratigraphic units. Approximately 30% of the incorrect pairs found during manual assessment were identified as correct in another manually assessed instance. Thus, our effective accuracy is at least 90% (Table DR1).

Animal genus-level diversity of Phanerozoic marine carbonates was estimated using 25,221 Paleobiology Database (PBDB, https://paleobiodb.org) collections (303,158 occurrences) that have been matched to Macrostrat units (Peters and Heim, 2010). The PBDB taxonomy for each occurrence is accessible from the database's programmatic interface (Peters and McClennen, 2016). The Macrostrat age model was used to determine the age of PBDB collections. Genus-level diversity in each time increment was divided by the total number of carbonate units to account for variation in rock quantity. The proportion of carbonate units that contain dolomite was estimated using information already present in the Macrostrat database.

RESULTS

Stromatolites are reported from sedimentary rocks assigned an Archean age in Macrostrat. Whether some of these Archean structures formed because of biological activity remains an open question (Lowe, 1994), but by the Paleoproterozoic, stromatolites occur in ~75% of all named sedimentary units (Fig. 2A). There is a decline in stromatolite occurrence during the middle Mesoproterozoic to ~40%, but it increases again to ~80% by the end of the Mesoproterozoic. After achieving a peak at ca. 1000 Ma, stromatolites decline until reaching a Proterozoic minimum at end of the eon. Stromatolite occurrence remains low during the early Cambrian, but by the Early Ordovician stromatolites achieve Neoproterozoic- to Mesoproterozoic-like prevalence (Fig. 2). For the remainder of the Paleozoic, stromatolites exhibit large oscillations in occurrence, with peaks in the late Silurian, Carboniferous, and Permian. Stromatolite occurrence declines after the Early Triassic and remains low, with few oscillations, for the remainder of the Mesozoic and Cenozoic. Normalizing stromatolite prevalence by the number of named carbonate-bearing marine sedimentary units (Fig. 2B) yields broadly similar patterns, but at many times in the Proterozoic, 100% of all named carbonate-bearing lithostratigraphic rock units contain stromatolites.

Oscillations in stromatolite prevalence within the Phanerozoic (Fig. 2) coincide with inflections in continent-scale marine transgressive-regressive cycles known as Sloss sequences (Sloss, 1963; Meyers and Peters, 2011). For example, the peak in stromatolite prevalence achieved during the late Cambrian–Early Ordovician occurs near the end of the first large-scale marine transgression of the Phanerozoic, which

[1]GSA Data Repository item 2017155, containing an expanded description of the text mining tools and software, and full reference list used to compile stromatolites, is available online at http://www.geosociety.org/datarepository/2017/ or on request from editing@geosociety.org.

resulted in the deposition of the Cambrian–Early Ordovician Sauk sequence over much of North America. Similarly, the late Silurian peak in stromatolite prevalence occurs near the end of the Ordovician–Silurian Tippecanoe sequence (Sloss, 1963). The following two Sloss-type sequences are less quantitatively distinct (Meyers and Peters, 2011), and stromatolite prevalence in this interval exhibits only one peak near the base of the Carboniferous. A peak in stromatolite prevalence occurs near the end of the Permian, which culminated in a withdrawal of epicontinental seaways and a Phanerozoic minimum in continental flooding (Miller et al., 2005). Stromatolite prevalence remains near Paleozoic average values for the Early to Middle Triassic and then declines to low values in the Early Jurassic. The Late Jurassic peak coincides in time with the end of the Jurassic Sloss-scale sequence. The mid- to Late Cretaceous peak in stromatolite occurrence coincides in time with maximum continental flooding during the Mesozoic–Cenozoic.

The fraction of all marine carbonate units that are dolomitic in each time increment is positively correlated with the fraction of marine units that contain stromatolites (Fig. 3A). This is true overall (Spearman's $\rho = 0.72$) and separately within the Phanerozoic ($\rho = 0.72$) and Proterozoic ($\rho = 0.58$). All correlations are significant ($P < 0.0002$) when the data are detrended by taking first differences.

There is a weak negative correlation ($\rho = -0.12$) between average metazoan genus-level diversity in Phanerozoic carbonate-bearing rock units and stromatolite prevalence (Fig. 3B). In the Paleozoic, the negative correlation between metazoan diversity and stromatolite prevalence is comparable when the data are detrended by taking first differences ($\rho = -0.12$, $P = 0.04$). There is no correlation between dolomite prevalence and average genus diversity in Paleozoic carbonate units ($\rho = 0.00$, $P = 0.94$).

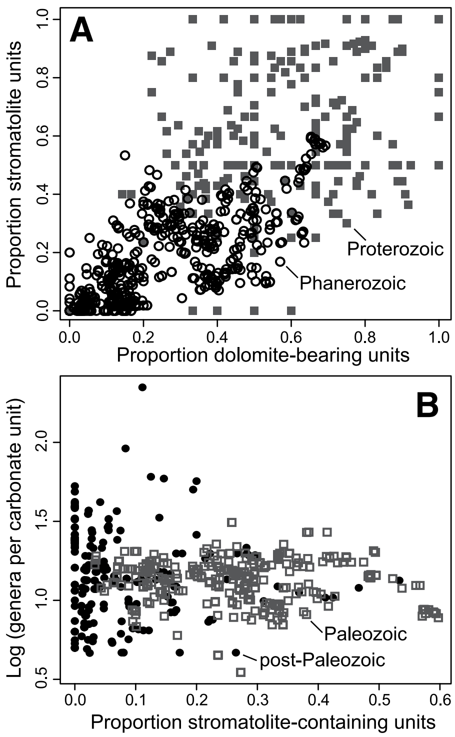

Figure 3. Proportion of dolomite-bearing carbonate units and marine genus diversity in relation to stromatolite prevalence for North America–Caribbean region. A: Stromatolite prevalence (from Fig. 2B) versus proportion of dolomitic carbonates in shallow marine carbonates. Open circles are Phanerozoic (541–0 Ma) data; solid boxes are Precambrian (3000–541 Ma) data. B: Log of average genus diversity versus stromatolite prevalence in shallow marine carbonates. Solid circles show post-Paleozoic; open boxes show Paleozoic. See text for correlation coefficients.

DISCUSSION

Stromatolites exhibit large changes in rock quantity–normalized occurrence within North American marine environments over the past 3 b.y. (Fig. 2), and many of the general patterns found here are consistent with previous descriptions of stromatolite form and abundance (e.g., Awramik and Sprinkle, 1999). The increase of stromatolites to near omnipresence at the start of the Paleoproterozoic likely reflects the environmental spread of cyanobacteria-bearing, stromatolite-forming microbial communities, but it is also possible that the increase is accentuated by a tendency to assign stromatolite-bearing Precambrian rock units an age no older than the early Proterozoic. The evolution of metazoans and their diversification during the late Neoproterozoic–Paleozoic likely contributed to the decline of stromatolites, but the decline starts before the appearance of metazoans, and stromatolites reach high prevalence during the Paleozoic. Normalization of stromatolite occurrence by the total number of marine carbonate units suggests that some component of the Mesozoic–Cenozoic decline in stromatolites (Fig. 2B) may reflect a post-Paleozoic decline in the ratio of carbonate to clastic sediments deposited in shallow marine settings (Walker et al., 2002; Peters, 2008).

Previous work has suggested that there is an inverse relationship between animal diversity and the abundance of stromatolites and other microbialites in the Phanerozoic (Riding, 2005, 2006). Within the Paleozoic, we find that shallow marine animal diversity is negatively correlated with stromatolite prevalence, but the correlation is weak (Fig. 3B). There is also a peak in stromatolite prevalence during the Early Triassic, as previously suggested (Schubert and Bottjer, 1992), but the Late Permian peak is comparable (Grotzinger and Knoll, 1995). The coarse stratigraphic scale of our analysis, however, prevents detection of facies-level environmental partitioning of marine metazoans and stromatolite-forming microbial communities that can occur in the aftermath of mass extinctions (Sheehan and Harris, 2004; Mata and Bottjer, 2012). This analysis is also restricted to sedimentary features described as stromatolites, which does not include all microbially formed sediments. Nevertheless, like Riding (2000, 2006), we find little evidence to suggest that metazoan diversity or mass extinctions exert a dominant influence on stromatolite occurrence. The co-occurrence of stromatolites and abundant, diverse metazoans in some lakes (Cohen et al., 1997) may provide further evidence for a reduced role for animals in limiting stromatolite formation.

Marine animal diversity is not a good predictor of stromatolite occurrence, but we do find a consistent positive correlation between the proportion of carbonate units that are dolomitic and those that are stromatolite-bearing (Fig. 3A). Dolomite can form as a primary and early diagenetic feature in some depositional environments, but many carbonate units have experienced late-stage diagenetic dolomitization. The fact that dolomite has at least two modes of origin is likely to have weakened the correlation documented here. A correlation between dolomite frequency and stromatolite occurrence is also expected under some scenarios. For example, carbonate oversaturation can positively influence the accretion and preservation of microbial carbonates (Riding, 2000) and help to overcome the kinetic inhibitors that slow or inhibit the dolomite formation process (Morse, 2003). It is also possible that the presence of extracellular polysaccharides in the microbial mats that form stromatolites promoted early dolomite formation (Zhang et al., 2012). Intervals of Earth history with lower O_2 levels, such as the Proterozoic and times of transient hypoxia in the Phanerozoic, could have also allowed for more widespread bottom-water carbonate oversaturation and direct carbonate precipitation on the seafloor (Grotzinger and Knoll, 1995; Higgins et al., 2009). Fluctuation in the geographic extent of tidal environments during continent-scale marine transgressive-regressive cycles is another possible explanation for dolomite-stromatolite covariation, at least within the Phanerozoic.

Regardless of the specific mechanism for the observed correlation between dolomite- and stromatolite-bearing marine rock units, our results provide quantitative evidence for the hypothesis (Riding, 2000, 2005, 2006) that changes in average water column chemistry in shallow marine environments, possibly promoted by fluctuations in sea level and changes in the carbonate saturation state of seawater, have played a primary role in determining the prevalence of stromatolites throughout Earth history.

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REFERENCES CITED

Adrain, J.M., and Westrop, S.R., 2000, An empirical assessment of taxic paleobiology: Science, v. 289, p. 110–112, doi:10.1126/science.289.5476.110.

Awramik, S.M., 1971, Precambrian columnar stromatolite diversity: Reflection of metazoan appearance: Science, v. 174, p. 825–827, doi:10.1126/science.174.4011.825.

Awramik, S.M., 1991, Archean and Proterozoic stromatolites, *in* Riding, R., ed., Fossil Algae and Stromatolites: New York, Springer-Verlag, p. 289–304, doi:10.1007/978-3-642-52335-9_15.

Awramik, S.M., and Sprinkle, J., 1999, Proterozoic stromatolites: The first marine evolutionary biota: Historical Biology, v. 13, p. 241–253, doi:10.1080/08912969909386584.

Baud, A., Richoz, S., and Pruss, S., 2007, The lower Triassic anachronistic carbonate facies in space and time: Global and Planetary Change, v. 55, p. 81–89, doi:10.1016/j.gloplacha.2006.06.008.

Bosak, T., Knoll, A.H., and Petroff, A.P., 2013, The meaning of stromatolites: Annual Review of Earth and Planetary Sciences, v. 41, p. 21–44, doi:10.1146/annurev-earth-042711-105327.

Cohen, A.S., Talbot, M.R., Awramik, S.M., Dettman, D.L., and Abell, P., 1997, Lake level and paleoenvironmental history of Lake Tanganyika, Africa, as inferred from late Holocene and modern stromatolites: Geological Society of America Bulletin, v. 109, p. 444–460, doi:10.1130/0016-7606(1997)109<0444:LLAPHO>2.3.CO;2.

Garrett, P., 1970, Phanerozoic stromatolites: Noncompetitive ecologic restriction by grazing and burrowing animals: Science, v. 169, p. 171–173, doi:10.1126/science.169.3941.171.

Grotzinger, J.P., 1990, Geochemical model for Proterozoic stromatolite decline: American Journal of Science, v. 290A, p. 80–103.

Grotzinger, J.P., and Knoll, A.H., 1995, Anomalous carbonate precipitates: Is the Precambrian the key to the Permian?: Palaios, v. 10, p. 578–596, doi:10.2307/3515096.

Grotzinger, J.P., and Knoll, A.H., 1999, Stromatolites in Precambrian carbonates: Evolutionary mileposts or environmental dipsticks?: Annual Review of Earth and Planetary Sciences, v. 27, p. 313–358, doi:10.1146/annurev.earth.27.1.313.

Grotzinger, J.P., and Rothman, D.H., 1996, An abiotic model from stromatolite morphogenesis: Nature, v. 383, p. 423–425, doi:10.1038/383423a0.

Higgins, J., Fischer, W., and Schrag, D., 2009, Oxygenation of the ocean and sediments: Consequences for the seafloor carbonate factory: Earth and Planetary Science Letters, v. 284, p. 25–33, doi:10.1016/j.epsl.2009.03.039.

Hofmann, H.J., 1973, Stromatolites: Characteristics and utility: Earth-Science Reviews, v. 9, p. 339–373, doi:10.1016/0012-8252(73)90002-0.

Husson, J.M., and Peters, S.E., 2017, Atmospheric oxygenation driven by unsteady growth of the continental sedimentary reservoir: Earth and Planetary Science Letters, v. 460, p. 68–75, doi:10.1016/j.epsl.2016.12.012.

Lowe, D.R., 1994, Abiological origin of described stromatolites older than 3.2 Ga: Geology, v. 22, p. 387–390, doi:10.1130/0091-7613(1994)022<0387:AOODSO>2.3.CO;2.

Manning, C.D., Surdeanu, M., Bauer, J., Finkel, J., Bethard, S.J., and McClosky, D., 2014, The Stanford CoreNLP natural language processing toolkit, *in* Proceedings of the 52nd Annual Meeting of the Association for Computational Linguistics: System Demonstrations, Baltimore, Maryland, p. 55–60.

Mata, S.A., and Bottjer, D.J., 2012, Microbes and mass extinctions: Paleoenvironmental distribution of microbialites during times of biotic crisis: Geobiology, v. 10, p. 3–24, doi:10.1111/j.1472-4669.2011.00305.x.

Meyers, S.R., and Peters, S.E., 2011, A 56 million year rhythm in North American sedimentation during the Phanerozoic: Earth and Planetary Science Letters, v. 303, p. 174–180, doi:10.1016/j.epsl.2010.12.044.

Miller, K.G., Kominz, M.A., Browning, J.V., Wright, J.D., Mountain, G.S., Katz, M.E., Sugarman, P.J., Cramer, B.S., Christie-Blick, N., and Pekar, S.F., 2005, The Phanerozoic record of global sea-level change: Science, v. 310, p. 1293–1298, doi:10.1126/science.1116412.

Morse, J., 2003, Formation and diagenesis of carbonate sediments; *in* Holland, H.D., and Turekian, K.K., eds., Treatise on Geochemistry: Pergamon Press, p. 67–85.

Peters, S.E., 2006, Macrostratigraphy of North America: The Journal of Geology, v. 114, p. 391–412, doi:10.1086/504176.

Peters, S.E., 2008, Environmental determinants of extinction selectivity in the fossil record: Nature, v. 454, p. 626–629, doi:10.1038/nature07032.

Peters, S.E., and Heim, N.A., 2010, The geological completeness of paleontological sampling in North America: Paleobiology, v. 36, p. 61–79, doi:10.1666/0094-8373-36.1.61.

Peters, S.E., and Husson, J.M., 2017, Sediment cycling on continental and oceanic crust: Geology, v. 45, p. 323–326, doi:10.1130/G38861.1.

Peters, S.E., and McClennen, M., 2016, The Paleobiology Database application programming interface: Paleobiology, v. 42, p. 1–7, doi:10.1017/pab.2015.39.

Peters, S.E., Zhang, C., Livny, M., and Ré, C., 2014, A machine reading system for assembling synthetic paleontological databases: PLoS One, v. 9, e113523, doi:10.1371/journal.pone.0113523.

Pratt, B.R., 1982, Stromatolite decline: A reconsideration: Geology, v. 10, p. 512–515, doi:10.1130/0091-7613(1982)10<512:SDR>2.0.CO;2.

Riding, R., 2000, Microbial carbonates: The geological record of calcified bacterial–algal mats and biofilms: Sedimentology, v. 47, p. 179–214, doi:10.1046/j.1365-3091.2000.00003.x.

Riding, R., 2005, Phanerozoic reefal microbial carbonate abundance: Comparisons with metazoan diversity, mass extinction events, and seawater saturation state: Revista Española de Micropaleontología, v. 37, p. 23–39.

Riding, R., 2006, Microbial carbonate abundance compared with fluctuations in metazoan diversity over geological time: Sedimentary Geology, v. 185, p. 229–238, doi:10.1016/j.sedgeo.2005.12.015.

Schubert, J.K., and Bottjer, D.J., 1992, Early Triassic stromatolites as post–mass extinction disaster forms: Geology, v. 20, p. 883–886, doi:10.1130/0091-7613(1992)020<0883:ETSAPM>2.3.CO;2.

Semikhatov, M.A., and Raaben, M.E., 1996, Dynamics of the global diversity of Proterozoic stromatolites. Article II: Africa, Australia, North America, and general synthesis: Stratigraphy and Geological Correlation, v. 4, p. 24–50.

Sheehan, P.M., and Harris, M.T., 2004, Microbialite resurgence after the Late Ordovician extinction: Nature, v. 430, p. 75–78, doi:10.1038/nature02654.

Sloss, L., 1963, Sequences in the cratonic interior of North America: Geological Society of America Bulletin, v. 74, p. 93–114, doi:10.1130/0016-7606(1963)74[93:SITCIO]2.0.CO;2.

Walker, L.J., Wilkinson, B.H., and Ivany, L.C., 2002, Continental drift and Phanerozoic carbonate accumulation in shallow-shelf and deep-marine settings: The Journal of Geology, v. 110, p. 75–87, doi:10.1086/324318.

Walter, M.R., and Heys, G.R., 1985, Links between the rise of the metazoan and the decline of stromatolites: Precambrian Research, v. 29, p. 149–174, doi:10.1016/0301-9268(85)90066-X.

Zhang, F., Xu, H., Konishi, H., Shelobolina, E.S., and Roden, E., 2012, Polysaccharide-catalyzed nucleation and growth of disordered dolomite: A potential precursor of sedimentary dolomite: The American Mineralogist, v. 97, p. 556–567, doi:10.2138/am.2012.3979.

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Rise and Fall of Stromatolites in Shallow Marine Environments

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Supplementary Discussion

S1 Text mining application

The objective of the stromatolite text mining application is to create a list of stratigraphic names that are identified as stromatolite-bearing. A total of 10,683 documents from the GeoDeepDive library, parsed by the Stanford NLP tookit (Manning et al., 2014) into 7,087,939 sentences, constituted the input for the application run used to generate the results presented here. This set of documents was determined to be potentially relevant to this study because each of them contained at least one instance of the term ‘stromatolite(s)’ and/or ‘stromatolitic’. The first part of the application consists of defining two, initially independent datasets: (*i*) mentions of stromatolite fossils and (*ii*) mentions of likely stratigraphic names.

For (*i*), simple word variants were included, such as ‘stromatolite’ (i.e., ‘stromatolites’, ‘stromatolitic,’ and ‘microstromatolites’) as well as compound words, such as ‘thrombolite-stromatolite,’ ‘microbial-stromatolitic’ and ‘stromatolite-bearing.’

For (*ii*), the application relies upon the conventions used for expression of formally named stratigraphic entities in the literature. Namely, a stratigraphic name is a proper noun, or a series of proper nouns, that ends with a defined set of capitalized words (i.e., ‘Group,’ ‘Formation,’ ‘Member,’ ‘Supergroup,’ ‘Bed,’ ‘Subgroup’) or abbreviations (i.e., ‘Gp,’ ‘Fm,’ ‘Mbr,’ ‘SGp’). Capitalized lithologies also are used to indicate a stratigraphic names (e.g., Nolichucky Shale, Virgin Limestone, Copper Harbor Conglomerate). Within a document, once a stratigraphic name is formally described (e.g., ‘Guelph Formation’), the rules for recognizing this stratigraphic entity elsewhere in the document are relaxed. This step allows for more informal use of names, such as:

> The basal stromatolite beds are distinctive and traceable into the more typical

> Guelph facies of Ontario.

assuming that the 'Guelph Formation' was used elsewhere in this same paper (Brett et al., 1995).

Defining the intersection of these two datasets uses three types of logic. The simplest extraction is based upon finding a mention of a stromatolite fossil in the same sentence as a single, unique stratigraphic name. For example, from Dehler et al. (2001):

> The Chuar Group contains numerous stromatolites, the acritarch, *Chuaria circularis*, and the vase-shaped microfossil *Melanocyrillium*, all of which are found in other Mid-Neoproterozoic deposits (Fig. 9).

For cases where a stratigraphic name is not collocated with a stromaolite mention, the 'in sentence' requirement is relaxed, and stratigraphic names are searched for in immediately preceding sentences. Consider this example from Johnson (1984):

> The **Cow Ridge Member** is a heterogeneous mixture of gray, clay-rich low-grade oil shale, brown carbonaceous shale with thin coal beds, and gray to tan siltstone, sandstone, and limestone. Siltstone and sandstone beds are commonly ripple-laminated, fairly persistent laterally, and commonly fossiliferous. The limestones contain abundant ostracods and mollusks and only rarely contain **stromatolite** structures.

These 'out of sentence' extractions were restricted to stromatolite-stratigraphic name tuples that are within 3 sentences of one another (emphasis added).

Both of these extraction types are quite simple, but they are powerful when applied to a large enough dataset. That is, these logical conditions are not sophisticated enough to capture all possible tuples, but when there are a large number of documents available, it is likely that the occurrence of stromatolites in a given stratigraphic unit will be described at least once in these simple ways.

In order to make more complex extractions, we rely upon the part-of-speech component of Stanford's natural language processing (NLP) tools, which decomposes sentences and the words in them into both parts of speech and linguistic dependencies (Manning et al., 2014). These NLP products can help deconvolve the grammatical relationship between stromatolite fossils and named stratigraphic units within more complex sentences. For example (emphasis added):

> In the eastern Pilbara, the **Jeerinah Formation** is overlain by the shallow-water **stromatolitic** ~2.63 Ga **Carawine Dolomite**.

In this sentence from Barley et al. (2005), multiple named stratigraphic entities occur in proximity to a mention of stromatolites within a single sentence. Linguistic context distinguishes the fact that the Carawine Dolomite is identified as having stromatolites, whereas the Jeerinah Formation is not.

The method the application uses to derive the correct inference from a sentence is shown in Fig. S1. The example sentence, as it appears in the original paper, is shown in Fig. S1a, while Fig. S1b shows how this sentence is represented in the GeoDeepDive library. Individual words from the sentence have been parsed into a text array (column 'words'), and the grammatical function that each word plays has been defined by NLP and stored in the column 'dep_paths'. In this case, 'stromatolitic' is an adjectival modifier, 'Carawine' is a part of a compound noun, and 'Dolomite' is a noun modified by a past participle verb. In the column 'dep_parents,' the parent of each of these words ('dependents') is described. Thus, 'stromatolitic' depends upon 'Dolomite,' as does 'Carawine' (note that the other parents in this text array have been expressed as the word number

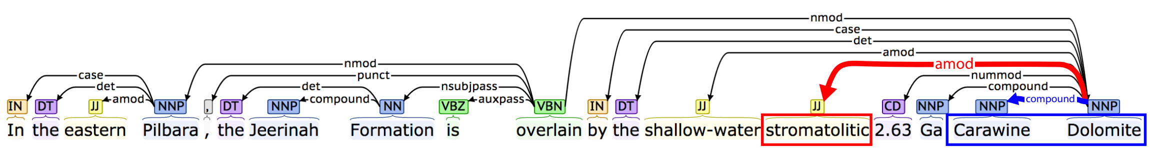
example sentence: **a**

In the eastern Pilbara, the Jeerinah Formation is overlain by the shallow-water stromatolitic ~2.63 Ga Carawine Dolomite [41].

sentence representation in GeoDeepDive database: **b**

docid	sentid	words	dep_paths	dep_parents
54e432ffe138237cc914fbfb	88	{In,the,eastern,Pilbara,",",the,Jeerinah,Formation,is,overlain,by,the,shallow-water,stromatolitic,~,2.63,Ga,Carawine,Dolomite,[,41,],.}	{case,det,amod,nmod:in,"",det,compound,nsubjpass,auxpass,"",case,det,amod,amod,compound,nummod,compound,compound,nmod:agent,"",nmod:tmod,"","",""}	{4,4,4,10,0,8,8,10,10,0,19,19,Dolomite,19,19,19,19,Dolomite,overlain,0,19,0,0}

Natural Language Processing visualization: **c**



extracted result: **d**

result_id	docid	sentid	target_word	strat_phrase_root	strat_flag	strat_name_id	in_ref	source
7266	54e432ffe138237cc914fbfb	88	stromatolitic	Carawine	Dolomite	88283	no	in_sent

Figure S1: An annotated example of a stromatolite-stratigraphic name tuple extraction that utilizes natural language processing (NLP).

index for simplicity).

Fig. S1c is a visualization of these parent-dependent relationships, created by the Stanford CoreNLP webservice API. This parsing shows a clear grammatical relationship between the compound noun 'Carawine Dolomite' and 'stromatolitic.' It is this parsing that allows this tuple to be recognized and written to the result table (Fig. S1d). It is, at this point a potential (but incorrect) tuple between 'stromatolitic' and 'Jeerinah Formation' to be ignored. Also, by querying the Macrostrat API with the discovered stratigraphic name:

https://macrostrat.org/api/defs/strat_names?strat_name_like=Carawine

the Macrostrat database strat_name_id for 'Carawine Dolomite' is also recorded in the

manual tuple assessment		
	N	**N (culled)**
correct	166	166
incorrect	21	15
uncertain	6	5
percent correct	**86% / 89%**	**89% / 91%**

Table S1: For each of the percent correct values, the left value assumes that all uncertain tuples are incorrect, and the right assumes that all uncertain tuples are correct. The 'culled' column removes incorrect or uncertain tuples that were found to be correct in other instances.

results table. Not every stratigraphic name is in the Macrostrat database, nor is every strat_name_id in Macrostrat linked to a lithostratigraphic rock unit:

`https://macrostrat.org/api/units?strat_name_id=88283`

Accuracy of these extractions, discussed in detail in the Methods section of the main text, was assessed to be at least 90% (Table S1). All documents from which at least one North American stromatolitic stratigraphic name with a linked strat_name_id was extracted (941 in total) are included in section S4, with hyperlinks to the original publication. A table of the extracted stratigraphic names, linked to the references where they were found, is included as a supplementary Excel spreadsheet.

The application used to operate on the GeoDeepDive library was written in Python and the results were written to a PostgreSQL database. The code, accompanied by an example dataset consisting of USGS publications, is available on GitHub at `https://github.com/UW-Macrostrat/stromatolites`.

S2 Paleobiology Database Genus Diversity

The complete list of PBDB collection numbers matched to Macrostrat units is available via the Macrostrat API (`https://macrostrat.org/api/v2/fossils?lith_type=carbonate&project_id=1,7`). This returns the PBDB collection number, the Macrostrat unit identifier to which that collection is assigned, and a list of distinct genus numbers from the PBDB (specific taxaonomic names and their classification are available via the PBDB API(Peters and McClennen, 2016), e.g., `https://paleobiodb.org/data1.2/taxa/list.txt?id=21387`). To estimate genus-level diversity in each one million year increment, the total number of unique genus numbers assigned to Macrostrat marine carbonate-bearing units was tabulated and then divided by the total number of Macrostrat carbonate-bearing units contributing to that estimate. The number of distinct genera in each time increment and the number of fossil-bearing units is reported in the supplemental data table and are reproducible using the Macrostrat API.

References

Barley, M. E., Bekker, A., and Krapez, B., 2005, Late Archean to Early Paleoproterozoic global tectonics, environmental change and the rise of atmospheric oxygen: Earth and Planetary Science Letters, vol. 1-2, pp. 156–171.

Brett, C. E., Tepper, D. H., Goodman, W. M., LoDuca, S. T., and Eckert, B.-Y., 1995, Revised stratigraphy and correlations of the Niagaran provincial series (Medina, Clinton, and Lockport groups) in the type area of western New York: Tech. rep., USGS.

Dehler, C. M., Elrick, M., Karlstrom, K. E., Smith, G. A., Crossey, L. J., and Timmons, J., 2001, Neoproterozoic Chuar Group (∼800 – 742 Ma), Grand Canyon: a record of cyclic marine deposition during global cooling and supercontinent rifting: Sedimentary Geology, pp. 465–499.

Johnson, R. C., 1984, New names for units in the lower part of the Green River Formation, Piceance Creek basin, Colorado: Tech. rep., USGS.

Manning, C. D., Surdeanu, M., Bauer, J., Finkel, J. R., Bethard, S., and McClosky, D., 2014, The Stanford CoreNLP natural language processing toolkit.: *In* Proceedings of the 52nd Annual Meeting of the Association for Computational Linguistics: System Demonstrations, pp. 55–60.

Peters, S. E. and McClennen, M., 2016, The Paleobiology Database application programming interface: Paleobiology, vol. 42, pp. 1–7.

S3 Publishers and journals used in stromatolite extractions

Publisher Totals	
name	number references
Elsevier	334
USGS	144
GSA	134
SEPM	119
Wiley	105
Canadian Science Publishing	105

Journal Totals	
name	number references
Precambrian Research	108
Canadian Journal of Earth Sciences	105
SEPM Journal of Sedimentary Research	65
Geol Soc America Bull	54
Palaeogeography, Palaeoclimatology, Palaeoecology	51
Sedimentary Geology	49
Open-File Report	48
Sedimentology	47
Professional Paper	43
Bulletin	43
Geological Society of America Bulletin	38
Geol	34
Journal of Sedimentary Research	28
PALAIOS	26
Earth-Science Reviews	19
Geobiology	16
Lethaia	12
Geochimica et Cosmochimica Acta	12
Organic Geochemistry	9
Chemical Geology	9
Marine and Petroleum Geology	8
Earth and Planetary Science Letters	8
Tectonophysics	6
Journal of African Earth Sciences	6

Geological Journal	6
Circular	6
Gondwana Research	5
Ore Geology Reviews	4
Geosphere	4
Geobios	4
Lithos	3
Journal of South American Earth Sciences	3
Journal of Geophysical Research	3
Journal of Geochemical Exploration	3
Geology Today	3
Geology	3
Terra Nova	2
Russian Geology and Geophysics	2
Proceedings of the Geologists' Association	2
Marine Geology	2
Journal of Geodynamics	2
Journal of Asian Earth Sciences	2
Global and Planetary Change	2
Geofluids	2
Cretaceous Research	2
Basin Research	2
Trends in Ecology & Evolution	1
The Island Arc	1
Scientific Investigations Report	1
Physics of the Earth and Planetary Interiors	1
Physics and Chemistry of the Earth	1
Palaeoworld	1
Palaeontology	1
Miscellaneous Field Studies Map	1
Journal of Structural Geology	1
Journal of Research of the U.S. Geological Survey	1
Journal of Petroleum Geology	1
Journal of Metamorphic Geology	1
Journal of Hydrology	1
Journal of Geophysical Research: Solid Earth	1

Journal of Geophysical Research: Planets	1
Journal of Applied Geophysics	1
Gsa Today	1
Geophysical Prospecting	1
Geologic Quadrangle	1
Geochemistry, Geophysics, Geosystems	1
Deep Sea Research Part II: Topical Studies in Oceanography	1
Comptes Rendus de l'Académie des Sciences - Series IIA - Earth and Planetary Science	1
Comptes Rendus Palevol	1
Botanical Journal of the Linnean Society	1
Boreas	1
Biological Reviews	1
Applied Geochemistry	1
Annales de Paléontologie	1
Advances in Space Research	1
Acta Geologica Sinica - English Edition	1

S4 References used in stromatolite extractions

Dunn, W. & Elmore, R. Paleomagnetic and petrographic investigation of the Taum Sauk Limestone, southeast Missouri. *Journal of Geophysical Research* **90**, 11469 (1985)

Miller, R. On the inorganic character of Halichondrites graphitiferus Matthew, a supposed sponge from the Precambrian of Saint John, New Brunswick. *Canadian Journal of Earth Sciences* **24**, 1913–1915 (1987)

Twitchett, R. The palaeoclimatology, palaeoecology and palaeoenvironmental analysis of mass extinction events. *Palaeogeography, Palaeoclimatology, Palaeoecology* **232**, 190–213 (2006)

Ritts, B. & Grotzinger, J. Depositional facies and detrital composition of the Paleoproterozoic Et-Then Group, N.W.T., Canada: sedimentary response to intracratonic indentation. *Canadian Journal of Earth Sciences* **31**, 1763–1778 (1994)

Lane, L. & Gehrels, G. Detrital zircon lineages of late Neoproterozoic and Cambrian strata, NW Laurentia. *Geological Society of America Bulletin* **126**, 398–414 (2014)

Bartley, J., Kah, L., Frank, T. & Lyons, T. Deep-water microbialites of the Mesoproterozoic Dismal Lakes Group: microbial growth, lithification, and implications for coniform stromatolites. *Geobiology* **13**, 15–32 (2015)

Hersi, O., Lavoie, D. & Nowlan, G. Reappraisal of the Beekmantown Group sedimentology and stratigraphy, Montréal area, southwestern Quebec: implications for understanding the depositional evolution of the Lower-Middle Ordovician Laurentian passive margin of eastern Canada. *Canadian Journal of Earth Sciences* **40**, 149–176 (2003)

Harrison, J. & Cressman, E. Geology of the Libby thrust belt of northwestern Montana and its implications to regional tectonics. Tech. Rep., USGS (1993)

Zhang, Y. & Hoffmann, L. Blue-green algal mats of the salinas in San-ya, Hai-nan Island (China): structure, taxonomic composition, and implications for the interpretation of Precambrian stromatolites. *Precambrian Research* **56**, 275–290 (1992)

Gebelein, C. & Hoffman, P. Algal Origin of Dolomite Laminations in Stromatolitic Limestone. *SEPM Journal of Sedimentary Research* **Vol. 43** (1973)

Cecile, M. & Campbell, F. Large-scale stratiform and intrusive sedimentary breccias of the lower Proterozoic Goulburn Group, Bathurst Inlet, N.W.T. *Canadian Journal of Earth Sciences* **14**, 2364–2387 (1977)

Pratt, L., Vuletich, A. & Shaw, C. Preliminary results of organic geochemical and stable isotope analyses of Newark supergroup rocks in the Hartford and Newark basins, Eastern U.S. Tech. Rep., USGS (1986)

Sears, S. & Lucia, F. Reef-growth model for Silurian pinnacle reefs, northern Michigan reef trend. *Geol* **7**, 299 (1979)

Olivier, N., Brayard, A., Vennin, E., Escarguel, G., Fara, E., Bylund, K., Jenks, J., Caravaca, G. & Stephen, D. Evolution of depositional settings in the Torrey area during the Smithian (Early Triassic, Utah, USA) and their significance for the biotic recovery. *Geological Journal* **51**, 600–626 (2016)

edited by Weber, F., McCammon, R., Rinehart, C., Light, T. & Wheeler, K. Geology and mineral resources of the White Mountains National Recreation Area, east-central Alaska. Tech. Rep., USGS (1988)

Wilson, J., Fischer, W., Johnston, D., Knoll, A., Grotzinger, J., Walter, M., McNaughton, N., Simon, M., Abelson, J., Schrag, D., Summons, R., Allwood, A., Andres, M., Gammon, C., Garvin, J., Rashby, S., Schweizer, M. & Watters, W. Geobiology of the late Paleoproterozoic Duck Creek Formation, Western Australia. *Precambrian Research* **179**, 135–149 (2010)

Schenk, P. Southeastern Atlantic Canada, Northwestern Africa, and Continental Drift. *Canadian Journal of Earth Sciences* **8**, 1218–1251 (1971)

Peckmann, J. & Thiel, V. Carbon cycling at ancient methane–seeps. *Chemical Geology* **205**, 443–467 (2004)

Hill, C., Corcoran, P., Aranha, R. & Longstaffe, F. Microbially induced sedimentary structures in the Paleoproterozoic, upper Huronian Supergroup, Canada. *Precambrian Research,* 155–165 (2016)

Dodd, J. & Nelson, C. Diagenetic comparisons between non-tropical Cenozoic limestones of New Zealand and tropical Mississippian limestones from Indiana, USA: Is the non-tropical model better than the tropical model? *Sedimentary Geology* **121**, 1–21 (1998)

Macke, D. Cambrian through Mississippian rocks of the Powder River basin, Wyoming, Montana, and adjacent areas. Tech. Rep., USGS (1993)

Elston, D. Late Precambrian Sixtymile Formation and orogeny at top of the Grand Canyon Supergroup, northern Arizona. Tech. Rep., USGS (1979)

Weil, A., Yonkee, A. & Kendall, J. Towards a better understanding of the influence of basement heterogeneities and lithospheric coupling on foreland deformation: A structural and paleomagnetic study of Laramide deformation in the southern Bighorn Arch, Wyoming. *Geological Society of America Bulletin* **126**, 415–437 (2014)

James, N., Narbonne, G., Dalrymple, R. & Kyser, T. Glendonites in Neoproterozoic low-latitude, interglacial, sedimentary rocks, northwest Canada: Insights into the Cryogenian ocean and Precambrian cold-water carbonates. *Geol* **33**, 9 (2005)

Church, S., Cox, D., Wooden, J., Tingley, J. & Vaughn, R. Base- and precious-metal deposits in the Basin and Range of Southern California and Southern Nevada—Metallogenic implications of lead isotope studies. *Earth-Science Reviews* **73**, 323–346 (2005)

Cloud, J. Bauxite deposits of the Anniston, Fort Payne, and Ashville areas, northeast Alabama. Tech. Rep., USGS (1966)

Chakrabarti, G., Shome, D., Kumar, S., Stephens, G. & Kah, L. Carbonate platform development in a Paleoproterozoic extensional basin, Vempalle Formation, Cuddapah Basin, India. *Journal of Asian Earth Sciences,* 263–279 (2014)

Yochelson, E. & Stanley, G. An early Ordovician patelliform gastropod, Palaelophacmaea, reinterpreted as a coelenterate. *Lethaia* **14**, 323–330 (1981)

Mingxiang, M. Sedimentary Features and Implications for the Precambrian Non-stromatolitic Carbonate Succession: A Case Study of the Mesoproterozoic Gaoyuzhuang Formation at the Qiangou Section in Yanqing County of Beijing. *Acta Geologica Sinica - English Edition* **82**, 295–309 (2008)

Summerson, C. Crystal molds in dolomite; their origin and environmental interpretation. *Journal of Sedimentary Research* **36**, 221–224 (1966)

edited by Schumann, R. Geologic radon potential of EPA Region 4; Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee. Tech. Rep., USGS (1993)

Wallace, P. The geology of the Palaeozoic rocks of the South-Western part of the Cantabrian Cordillera, North Spain. *Proceedings of the Geologists' Association* **83**, 57–IN4 (1972)

Nash, J. Geology, petrology, and chemistry of the Leadville Dolomite: host for uranium at the Pitch Mine, Saguache County, Colorado. Tech. Rep., USGS (1979)

Tang, D., Shi, X., Wang, X. & Jiang, G. Extremely low oxygen concentration in mid-Proterozoic shallow seawaters. *Precambrian Research,* 145–157 (2016)

Gall, Q. & Hyde, R. Analcime in lake and lake-margin sediments of the Carboniferous Rocky Brook Formation, Western Newfoundland, Canada. *Sedimentology* **36**, 875–887 (1989)

Young, G. & Long, D. Stromatolites and basin analysis: an example from the upper proterozoic of northwestern Canada. *Palaeogeography, Palaeoclimatology, Palaeoecology* **19**, 303–318 (1976)

Drake, J. Carbonate rocks of Cambrian and Ordovician age, Northampton and Bucks Counties, eastern Pennsylvania, and Warren and Hunterdon Counties, western New Jersey. Tech. Rep., USGS (1965)

Pratt, B. & James, N. Cryptalgal-metazoan bioherms of early Ordovician age in the St George Group, western Newfoundland. *Sedimentology* **29**, 543–569 (1982)

Webb, G. Earliest known Carboniferous shallow-water reefs, Gudman Formation (Tn1b), Queensland, Australia: Implications for Late Devonian reef collapse and recovery. *Geol* **26**, 951 (1998)

Rast, N. & Skehan, J. The evolution of the avalonian plate. *Tectonophysics* **1-3**, 257–286 (1983)

Currie, K. Repeated basement reactivation in the northeastern Appalachians. *Geological Journal* **18**, 223–239 (1983)

Abbott, P. On the hydrology of the Edwards Limestone, south-central Texas. *Journal of Hydrology* **24**, 251–269 (1975)

Simonson, B. & Carney, K. Roll-up Structures: Evidence of In situ Microbial Mats in Late Archean Deep Shelf Environments. *Palaios* **14**, 13 (1999)

Horodyski, R. Impressions of algal mats from the Middle Proterozoic Belt Supergroup, northwestern Montana, U.S.A. *Sedimentology* **29**, 285–289 (1982)

Myrow, P. & Landing, E. Mixed Siliciclastic-Carbonate Deposition in an Early Cambrian Oxygen-Stratified Basin, Chapel Island Formation, Southeastern Newfoundland. *SEPM Journal of Sedimentary Research* **Vol. 62** (1992)

Lipman, P. Explosive volcanism. Developments in volcanology, 3 edited by M.F. Sheridan and F. Barberi, Elsevier, Amsterdam, 1983, viii + 482 pp. Price: U.S. $84.75 (U.S.A. and Canada)/Dfl. 220.00 (rest of world). Hardback. *Lithos,* 66 (1985)

Kah, L. & Riding, R. Mesoproterozoic carbon dioxide levels inferred from calcified cyanobacteria. *Geol* **35**, 799 (2007)

Garzanti, E., Nicora, A. & Rettori, R. Permo-Triassic boundary and Lower to Middle Triassic in South Tibet. *Journal of Asian Earth Sciences* **16**, 143–157 (1998)

Miller, D., Reynolds, R., Bright, J. & Starratt, S. Bouse Formation in the Bristol basin near Amboy, California, USA. *Geosphere* **10**, 462–475 (2014)

Fagerstrom, J. Cryptalgal structures in the Detroit River Group (Devonian), Southwestern Ontario. *Canadian Journal of Earth Sciences* **7**, 548–550 (1970)

Thorpe, R., Guha, J. & Cimon, J. Evidence from lead isotopes regarding the genesis of ore deposits in the Chibougamau region, Quebec. *Canadian Journal of Earth Sciences* **18**, 708–723 (1981)

Mudge, M., Erickson, R., Kleinkopf, D., Curtin, G., Marranzino, A. & Zartman, R. Reconnaissance geology, geophysics, and geochemistry of the southeastern part of the Lewis and Clark Range, Montana. Tech. Rep., USGS (1968)

Ford, T. & Breed, W. Late Precambrian Chuar Group, Grand Canyon, Arizona. *Geol Soc America Bull* **84**, 1243 (1973)

Turner, E. & Bekker, A. Thick sulfate evaporite accumulations marking a mid-Neoproterozoic oxygenation event (Ten Stone Formation, Northwest Territories, Canada). *Geological Society of America Bulletin,* B31268.1 (2015)

DeWitt, E., Thorson, J., Smith, R., Whipple, J. & Saunders, J. Epithermal gold deposits; Part II. Tech. Rep., USGS (1991)

Zentmyer, R., Pufahl, P., James, N. & Hiatt, E. Dolomitization on an evaporitic Paleoproterozoic ramp: Widespread synsedimentary dolomite in the Denault Formation, Labrador Trough, Canada. *Sedimentary Geology* **238**, 116–131 (2011)

Armstrong, A. Carbonate facies and the lithostrotionid corals of the Mississippian Kogruk Formation, Delong Mountains, northwestern Alaska. Tech. Rep., USGS (1970)

Bazhenova, O. & Arefiev, O. Immature oils as the products of early catagenetic transformation of bacterial-algal organic matter. *Organic Geochemistry* **16**, 307–311 (1990)

Swett, K. & Smit, D. Paleogeography and Depositional Environments of the Cambro-Ordovician Shallow-Marine Facies of the North Atlantic. *Geol Soc America Bull* **83**, 3223 (1972)

Parnell, J. & Janaway, T. Sulphide-mineralised algal breccias in a Devonian evaporitic lake system, Orkney, Scotland. *Ore Geology Reviews* **5**, 445–460 (1990)

Rainbird, R., Jefferson, C. & Young, G. The early Neoproterozoic sedimentary Succession B of northwestern Laurentia: Correlations and paleogeographic significance. *Geological Society of America Bulletin* **108**, 454–470 (1996)

Awramik, S., Schopf, J. & Walter, M. Filamentous fossil bacteria from the Archean of Western Australia. *Precambrian Research* **2-4**, 357–374 (1983)

Logan, G., Calver, C., Gorjan, P., Summons, R., Hayes, J. & Walter, M. Terminal Proterozoic mid-shelf benthic microbial mats in the Centralian Superbasin and their environmental significance. *Geochimica et Cosmochimica Acta* **63**, 1345–1358 (1999)

(2), R. & Dougla, R. Paleosols Capping Regressive Carbonate Cycles in the Pennsylvanian Black Prince Limestone, Arizona. *SEPM Journal of Sedimentary Research* **Vol. 54** (1984)

Stasiuk, L. Oil-prone alginite macerals from organic-rich Mesozoic and Palaeozoic strata, Saskatchewan, Canada. *Marine and Petroleum Geology* **11**, 208–217 (1994)

Seilacher, A. & Hagadorn, J. Early Molluscan Evolution: Evidence From The Trace Fossil Record. *Palaios* **25**, 565–575 (2010)

Calzia, J., Frisken, J., Jachens, R., McMahon, A. & Rumsey, C. Mineral resources of the Kingston Range Wilderness Study Area, San Bernardino County, California. Tech. Rep., USGS (1987)

Barnes, H. & Christiansen, R. Cambrian and Precambrian rocks of the Groom district, Nevada, southern Great Basin. Tech. Rep., USGS (1967)

Copper, P. Reef development at the Frasnian/Famennian mass extinction boundary. *Palaeogeography, Palaeoclimatology, Palaeoecology* **181**, 27–65 (2002)

Sami, T. & James, N. Peritidal Carbonate Platform Growth and Cyclicity in an Early Proterozoic Foreland Basin, Upper Pethei Group, Northwest Canada. *SEPM Journal of Sedimentary Research* **Vol. 64B** (1994)

Bernstein, L. & Young, G. Depositional environments of the Early Proterozoic Espanola Formation, Ontario, Canada. *Canadian Journal of Earth Sciences* **27**, 539–551 (1990)

Stauffer, K. Quantitative Petrographic Study of Paleozoic Carbonate Rocks, Caballo Mountains, New Mexico. *SEPM Journal of Sedimentary Research* **Vol. 32** (1962)

Laporte, L. Paleoecology of the Cottonwood Limestone (Permian), Northern Mid-Continent. *Geol Soc America Bull* **73**, 521 (1962)

Olszewski Jr., W. & Gaudette, H. Age of the Brookville Gneiss and associated rocks, southeastern New Brunswick. *Canadian Journal of Earth Sciences* **19**, 2158–2166 (1982)

Fairchild, I. & Hambrey, M. The Vendian succession of northeastern Spitsbergen: Petrogenesis of a dolomite-tillite association. *Precambrian Research* **26**, 111–167 (1984)

(2), S. & Jam, N. Dolomitized Middle Proterozoic Calcretes, Bathurst Inlet, Northwest Territories, Canada. *SEPM Journal of Sedimentary Research* **Vol. 61** (1991)

Pope, M. & Grotzinger, J. Paleoproterozoic Stark Formation, Athapuscow Basin, Northwest Canada: Record of Cratonic-Scale Salinity Crisis. *Journal of Sedimentary Research* **73**, 280–295 (2003)

(2), D. & Southgat, P. Ultrastructure of a Middle Cambrian Primary Nonpelletal Phosphorite and its Early Transformation into Phosphate Vadoids: Georgina Basin, Australia. *SEPM Journal of Sedimentary Research* **Vol. 59** (1989)

Sheldon, N. Causes and consequences of low atmospheric pCO2 in the Late Mesoproterozoic. *Chemical Geology,* 224–231 (2013)

Muir, M. Proterozoic microfossils from the Mara Dolomite Member, Emmerugga Dolomite, McArthur Group, from the Northern Territory, Australia. *Botanical Journal of the Linnean Society* **86**, 1–18 (1983)

Singh, S. Sedimentation patterns of the Proterozoic Delhi Supergroup, northeastern Rajasthan, India, and their tectonic implications. *Sedimentary Geology* **58**, 79–94 (1988)

Van Kranendonk, M., Mazumder, R., Yamaguchi, K., Yamada, K. & Ikehara, M. Sedimentology of the Paleoproterozoic Kungarra Formation, Turee Creek Group, Western Australia: A conformable record of the transition from early to modern Earth. *Precambrian Research,* 314–343 (2015)

Mahon, R., Dehler, C., Link, P., Karlstrom, K. & Gehrels, G. Detrital zircon provenance and paleogeography of the Pahrump Group and overlying strata, Death Valley, California. *Precambrian Research,* 102–117 (2014)

Donaldson, J. & Delaney, G. Microfossils from the Dismal Lakes Group (Neohelikian), District of Mackenzie. *Canadian Journal of Earth Sciences* **12**, 371–377 (1975)

Azomani, E., Azmy, K., Blamey, N., Brand, U. & Al-Aasm, I. Origin of Lower Ordovician dolomites in eastern Laurentia: Controls on porosity and implications from geochemistry. *Marine and Petroleum Geology,* 99–114 (2013)

Lelubre, M. Developments and Interactions of the Precambrian Atmosphere, Lithosphere and Biosphere B. Nagy, R. Weber, J.C. Guevrero and M. Schidlowski (Editors), 1983. Developments in Precambrian Geology, 7. Elsevier, Amsterdam, xii + 476 pp. (repr. from Precambrian Research, 20; 2–4), U.S.$89,25 (U.S.A. and Canada), Dfl.210,00 (rest of world) (hardback). *Earth-Science Reviews* **22**, 167–168 (1985)

Dostal, J. & McCutcheon, S. Geochemistry of Late Proterozoic basaltic rocks from southeastern New Brunswick, Canada. *Precambrian Research* **47**, 83–98 (1990)

Allison, C. & Awramik, S. Organic-walled microfossils from earliest Cambrian or latest proterozoic Tindir Group rocks, Northwest Canada. *Precambrian Research* **43**, 253–294 (1989)

Macneil, A. "Microbial mounds prior to the Frasnian-Famennian mass extinctions, Hantang, Guilin, South China" by Shen et al., Sedimentology, 57, 1615-1639: Discussion. *Sedimentology* **58**, 2061–2065 (2011)

Thurston, P. & Chivers, K. Secular variation in greenstone sequence development emphasizing Superior Province, Canada. *Precambrian Research* **46**, 21–58 (1990)

Pruss, S., Corsetti, F. & Bottjer, D. The unusual sedimentary rock record of the Early Triassic: A case study from the southwestern United States. *Palaeogeography, Palaeoclimatology, Palaeoecology* **222**, 33–52 (2005)

Barbieri, R. & Cavalazzi, B. Microbial fabrics from Neogene cold seep carbonates, Northern Apennine, Italy. *Palaeogeography, Palaeoclimatology, Palaeoecology* **227**, 143–155 (2005)

Khomentovsky, V., Nagovitsin, K. & Postnikov, A. Mayanian (1100–850 Ma) – Prebaikalian Upper Riphean of Siberia. *Russian Geology and Geophysics* **49**, 1–22 (2008)

Edited by Blean, K. The United States Geological Survey in Alaska; accomplishments during 1976. Tech. Rep., USGS (1977)

Algouti, A., Algouti, A., Beauchamp, J., Chbani, B. & Taj-Eddine, K. Paléogéographie d'une plateforme infracambrienne en dislocation : série de base adoudounienne de la région Waoufengha–Igherm, Anti-Atlas occidental, Maroc. *Comptes Rendus de l'Académie des Sciences - Series IIA - Earth and Planetary Science* **330**, 155–160 (2000)

Foster, C., Wicander, R. & Reed, J. Gloeocapsomorpha prisca Zalessky, 1917: A new study part II: Origin of Kukersite, a new interpretation. *Geobios* **23**, 133–140 (1990)

Guido, A., Rosso, A., Sanfilippo, R., Russo, F. & Mastandrea, A. Frutexites from microbial/metazoan bioconstructions of recent and Pleistocene marine caves (Sicily, Italy). *Palaeogeography, Palaeoclimatology, Palaeoecology,* 127–138 (2016)

Rice, R. Recent developments in Precambrian sedimentary geology. *Canadian Journal of Earth Sciences* **29**, 2521–2522 (1992)

(2), A. Devonian Alluvial Fans, Prince of Wales Island, Arctic Canada. *SEPM Journal of Sedimentary Research* **Vol. 40** (1970)

Verdel, C., Wernicke, B. & Bowring, S. The Shuram and subsequent Ediacaran carbon isotope excursions from southwest Laurentia, and implications for environmental stability during the metazoan radiation. *Geological Society of America Bulletin* **123**, 1539–1559 (2011)

Furlanetto, F., Thorkelson, D., Rainbird, R., Davis, W., Gibson, H. & Marshall, D. The Paleoproterozoic Wernecke Supergroup of Yukon, Canada: Relationships to orogeny in northwestern Laurentia and basins in North America, East Australia, and China. *Gondwana Research,* 14–40 (2016)

Schieber, J. Possible indicators of microbial mat deposits in shales and sandstones: examples from the Mid-Proterozoic Belt Supergroup, Montana, U.S.A. *Sedimentary Geology* **120**, 105–124 (1998)

Johnson, M., Jia-yu, R. & Xue-chang, Y. Intercontinental correlation by sea-level events in the Early Silurian of North America and China (Yangtze Platform). *Geol Soc America Bull* **96**, 1384 (1985)

Fedorchuk, N., Dornbos, S., Corsetti, F., Isbell, J., Petryshyn, V., Bowles, J. & Wilmeth, D. Early non-marine life: Evaluating the biogenicity of Mesoproterozoic fluvial-lacustrine stromatolites. *Precambrian Research,* 105–118 (2016)

Schieber, J. Significance of styles of epicontinental shale sedimentation in the Belt basin, Mid-Proterozoic of Montana, U.S.A. *Sedimentary Geology* **69**, 297–312 (1990)

Binda, P. Microfossils from the Lower Kundelungu (Late Precambrian) of Zambia. *Precambrian Research* **4**, 285–306 (1977)

Butler, W. The rationale for assessment of undiscovered, economically recoverable oil and gas in south-central New Mexico; a geologic overview and play analysis of two favorable areas. Tech. Rep., USGS (1988)

Edited by Yount, M. United States Geological Survey Alaska Program, 1975. Tech. Rep., USGS (1975)

Hofmann, H. New stromatolites from the Aphebian Mistassini Group, Quebec. *Canadian Journal of Earth Sciences* **15**, 571–585 (1978)

Brett, C., Goodman, W. & LoDuca, S. Sequences, cycles, and basin dynamics in the Silurian of the Appalachian Foreland Basin. *Sedimentary Geology* **69**, 191–244 (1990)

Des Marais, D. Microbial mats and the early evolution of life. *Trends in Ecology & Evolution* **5**, 140–144 (1990)

Adrain, J. & Westrop, S. Lower Ordovician trilobites from the Baumann Fiord Formation, Ellesmere Island, Arctic Canada. *Canadian Journal of Earth Sciences* **42**, 1523–1546 (2005)

Maliva, R., Knoll, A. & Simonson, B. Secular change in the Precambrian silica cycle: Insights from chert petrology. *Geol Soc America Bull* **117**, 835 (2005)

Grey, K. & Thorne, A. Biostratigraphic significance of stromatolites in upward shallowing sequences of the early proterozoic duck creek dolomite, Western Australia. *Precambrian Research* **29**, 183–206 (1985)

Loyd, S. & Corsetti, F. The Origin of the Millimeter-Scale Lamination in the Neoproterozoic Lower Beck Spring Dolomite: Implications for Widespread, Fine-Scale, Layer-Parallel Diagenesis in Precambrian Carbonates. *Journal of Sedimentary Research* **80**, 678–687 (2010)

Davies, G. & Nassichuk, W. Subaqueous evaporites of the Carboniferous Otto Fiord Formation, Canadian Arctic Archipelago: A summary. *Geol* **3**, 273 (1975)

Reitsema, R. Dolomite and nahcolite formation in organic rich sediments: isotopically heavy carbonates. *Geochimica et Cosmochimica Acta* **44**, 2045–2049 (1980)

Boucot, A. & Janis, C. Environment of the Early Paleozoic vertebrates. *Palaeogeography, Palaeoclimatology, Palaeoecology* **41**, 251–287 (1983)

Jiang, G., Christie-Blick, N., Kaufman, A., Banerjee, D. & Rai, V. Carbonate platform growth and cyclicity at a terminal Proterozoic passive margin, Infra Krol Formation and Krol Group, Lesser Himalaya, India. *Sedimentology* **50**, 921–952 (2003)

Myrow, P., Hanson, A., Phelps, A., Creveling, J., Strauss, J., Fike, D. & Ripperdan, R. Latest Devonian (Famennian) global events in western Laurentia: Variations in the carbon isotopic record linked to diagenetic alteration below regionally extensive unconformities. *Palaeogeography, Palaeoclimatology, Palaeoecology,* 194–209 (2013)

Dallmeyer, R. & Nance, R. 40 Ar/ 39 Ar ages of detrital muscovite within early Paleozoic overstep sequences, Avalon composite terrane, southern New Brunswick: implications for extent of late Paleozoic tectonothermal overprint. *Canadian Journal of Earth Sciences* **27**, 1209–1214 (1990)

Dixon, O., Williams, S. & Dixon, J. The Aston Formation (? Proterozoic) on Prince of Wales Island, Arctic Canada. *Canadian Journal of Earth Sciences* **8**, 732–742 (1971)

Kidder, D. Stratigraphy, micropaleontology, petrography, carbonate geochemistry, and depositional history of the Proterozoic Libby Formation, Belt Supergroup, northwestern Montana and northeastern Idaho. Tech. Rep., USGS (1987)

Hofmann, H. & Snyder, G. Archean stromatolites from the Hartville Uplift, eastern Wyoming. *Geol Soc America Bull* **96**, 842 (1985)

Timmons, J., Karlstrom, K., Heizler, M., Bowring, S., Gehrels, G. & Crossey, L. Tectonic inferences from the ca. 1255–1100 Ma Unkar Group and Nankoweap Formation, Grand Canyon: Intracratonic deformation and basin formation during protracted Grenville orogenesis. *Geol Soc America Bull* **117**, 1573 (2005)

Ueda, A., Cameron, E. & Roy Krouse, H. 34S-enriched sulphate in the Belcher Group, N.W.T., Canada: evidence for dissimilatory sulphate reduction in the early Proterozoic ocean. *Precambrian Research* **49**, 229–233 (1991)

Shapiro, R. & Konhauser, K. Hematite-coated microfossils: primary ecological fingerprint or taphonomic oddity of the Paleoproterozoic? *Geobiology* **13**, 209–224 (2015)

Jiang, G., Kennedy, M., Christie-Blick, N., Wu, H. & Zhang, S. Stratigraphy, Sedimentary Structures, and Textures of the Late Neoproterozoic Doushantuo Cap Carbonate in South China. *Journal of Sedimentary Research* **76**, 978–995 (2006)

Dehler, C., Elrick, M., Bloch, J., Crossey, L., Karlstrom, K. & Des Marais, D. High-resolution δ13C stratigraphy of the Chuar Group (ca. 770–742 Ma), Grand Canyon: Implications for mid-Neoproterozoic climate change. *Geol Soc America Bull* **117**, 32 (2005)

Abell, P., McClory, J., Hendry, H. & Wheatley, K. Stratigraphic variations in carbon and oxygen isotopes in the dolostone of the Carswell Formation (Proterozoic) of northern Saskatchewan. *Canadian Journal of Earth Sciences* **26**, 2318–2326 (1989)

Churnet, H., Misra, K. & Walker, K. Deposition and dolomitization of Upper Knox carbonate sediments, Copper Ridge district, East Tennessee. *Geol Soc America Bull* **93**, 76 (1982)

Whisonant, R. Paleocurrent and Petrographic Analysis of Imbricate Intraclasts in Shallow-Marine Carbonates, Upper Cambrian, Southwestern Virginia. *SEPM Journal of Sedimentary Research* **Vol. 57** (1987)

Corsetti, F., Kidder, D. & Marenco, P. Trends in oolite dolomitization across the Neoproterozoic–Cambrian boundary: A case study from Death Valley, California. *Sedimentary Geology* **191**, 135–150 (2006)

Nabelek, P., Bédard, J., Hryciuk, M. & Hayes, B. Short-duration contact metamorphism of calcareous sedimentary rocks by Neoproterozoic Franklin gabbro sills and dykes on Victoria Island, Canada. *Journal of Metamorphic Geology* **31**, 205–220 (2013)

Mudge, M., Yochelson, E., Douglass, R., Duncan, H., Strimple, H., Gordon, J. & Dunkle, D. Stratigraphy and paleontology of the uppermost Pennsylvanian and lowermost Permian rocks in Kansas, with sections on paleontology. Tech. Rep., USGS (1962)

Eriksson, K. Tidal flat and subtidal sedimentation in the 2250 M.Y. Malmani Dolomite, Transvaal, South Africa. *Sedimentary Geology* **18**, 223–244 (1977)

Walter, M. & Awramik, S. Frutexites from stromatolites of the Gunflint Iron Formation of Canada, and its biological affinities. *Precambrian Research* **9**, 23–33 (1979)

Liu, L., Wu, Y., Hongxia, J. & Riding, R. Calcified rivulariaceans from the Ordovician of the Tarim Basin, Northwest China, Phanerozoic lagoonal examples, and possible controlling factors. *Palaeogeography, Palaeoclimatology, Palaeoecology* (2015)

Hintze, L., Taylor, M. & Miller, J. Upper Cambrian-Lower Ordovician Notch Peak Formation in western Utah. Tech. Rep., USGS (1988)

Behrens, E. Environment Reconstruction For A Part Of The Glen Rose Limestone, Central Texas. *Sedimentology* **4**, 65–111 (1965)

Bertrand-Sarfati, J. & Potin, B. Microfossiliferous cherty stromatolites in the 2000 Ma Franceville Group, Gabon. *Precambrian Research* **65**, 341–356 (1994)

(2), W. & H., B. Diagenesis of Late Proterozoic Carbonates: The Beck Spring Dolomite of Eastern California. *SEPM Journal of Sedimentary Research* **Vol. 58** (1988)

White, B. Stromatolites and associated facies in shallowing-upward cycles from the Middle Proterozoic Altyn Formation of Glacier National Park, Montana. *Precambrian Research* **24**, 1–26 (1984)

Mukhopadhyay, M. & Gibb, R. Gravity anomalies and deep structure of eastern Hudson bay. *Tectonophysics* **72**, 43–60 (1981)

Nichols, K. Coextensive Supratidal Dolomite and Underlying Secondary Dolomite in the Triassic of North-Central Nevada. *SEPM Journal of Sedimentary Research* **Vol. 44** (1974)

Trower, E. & Grotzinger, J. Sedimentology, diagenesis, and stratigraphic occurrence of giant ooids in the Ediacaran Rainstorm Member, Johnnie Formation, Death Valley region, California. *Precambrian Research* **180**, 113–124 (2010)

Clark, S., Spanksi, G., Hadley, D. & Hofstra, A. Geology and mineral resource potential of the Chattanooga 1 degree x 2 degrees Quadrangle, Tennessee and North Carolina; a preliminary assessment. Tech. Rep., USGS (1993)

Sami, T. & James, N. Evolution of an early Proterozoic foreland basin carbonate platform, lower Pethei Group, Great Slave Lake, north-west Canada. *Sedimentology* **40**, 403–430 (1993)

Speed, R. Evaporite-Carbonate Rocks of the Jurassic Lovelock Formation, West Humboldt Range, Nevada. *Geol Soc America Bull* **85**, 105 (1974)

Narbonne, G. & James, N. Mesoproterozoic deep-water reefs from Borden Peninsula, Arctic Canada. *Sedimentology* **43**, 827–848 (1996)

Burchette, T. & Wright, V. Carbonate ramp depositional systems. *Sedimentary Geology* **79**, 3–57 (1992)

Pratt, B. Limestone response to stress; pressure solution and dolomitization; discussion and examples of compaction in carbonate sediments. *Journal of Sedimentary Research* **52**, 323–328 (1982)

Neuweiler, F., Turner, E. & Burdige, D. Early Neoproterozoic origin of the metazoan clade recorded in carbonate rock texture. *Geology* **37**, 475–478 (2009)

Earhart, R., Grimes, D., Leinz, R., Marks, L. & Peterson, D. Mineral resources of the proposed additions to the Scapegoat Wilderness, Powell and Lewis and Clark counties, Montana, with a section on geophysical surveys. Tech. Rep., USGS (1977)

Edited by Dyman, T., Rice, D. & Westcott, P. Geologic controls of deep natural gas resources in the United States. Tech. Rep., USGS (1997)

Tazaki, K., Ferris, F., Wiese, R. & Fyfe, W. Iron and graphite associated with fossil bacteria in chert. *Chemical Geology* **95**, 313–325 (1992)

Soto, D., Mann, P. & Escalona, A. Miocene-to-recent structure and basinal architecture along the Central Range strike-slip fault zone, eastern offshore Trinidad. *Marine and Petroleum Geology* **28**, 212–234 (2011)

Lavoie, D., Bourque, P. & Héroux, Y. Early Silurian carbonate platforms in the Appalachian orogenic belt: the Sayabec – La Vieille formations of the Gaspé–Matapédia basin, Quebec. *Canadian Journal of Earth Sciences* **29**, 704–719 (1992)

Ashton, M. Carbonate tidal rhythmites from the Middle Jurassic of Britain. *Sedimentology* **28**, 689–698 (1981)

Kennedy, M. Southeastern margin of the northeastern Appalachians: Late Precambrian orogeny on a continental margin. *Geol Soc America Bull* **87**, 1317 (1976)

Cook, D. & MacLean, B. Proterozoic thick-skinned intracratonic deformation, Colville Hills region, Northwest Territories, Canada. *Geol* **20**, 67 (1992)

Kalliokoski, J. Calcium carbonate cement (caliche) in Keweenawan sedimentary rocks ($\sim$ 1.1 Ga), upper Peninsula of Michigan. *Precambrian Research* **32**, 243–259 (1986)

Oversby, B. Thrust Sequences in the Windermere Hills, Northeastern Elko County, Nevada. *Geol Soc America Bull* **83**, 2677 (1972)

Pecoits, E., Gingras, M., Aubet, N. & Konhauser, K. Ediacaran in Uruguay: palaeoclimatic and palaeobiological implications. *Sedimentology* **55**, 689–719 (2008)

Macdonald, F., Cohen, P., Dudas, F. & Schrag, D. Early Neoproterozoic scale microfossils in the Lower Tindir Group of Alaska and the Yukon Territory. *Geology* **38**, 143–146 (2010)

Gammon, P. An organodiagenetic model for Marinoan-age cap carbonates. *Sedimentary Geology,* 17–32 (2012)

Bekker, A., Kaufman, A., Karhu, J. & Eriksson, K. Evidence for Paleoproterozoic cap carbonates in North America. *Precambrian Research* **137**, 167–206 (2005)

Lee, J., Chen, J. & Chough, S. The middle–late Cambrian reef transition and related geological events: A review and new view. *Earth-Science Reviews,* 66–84 (2015)

Wilson, J. Upper Cambrian Stratigraphy In The Central Appalachians. *Geol Soc America Bull* **63**, 275 (1952)

Unrug, R. & Unrug, S. Paleontological evidence of Paleozoic age for the Walden Creek Group, Ocoee Supergroup, Tennessee. *Geol* **18**, 1041 (1990)

Edited by Taylor, M. Short papers for the Second International Symposium on the Cambrian System, 1981. Tech. Rep., USGS (1981)

Elston, D. & Bressler, S. Paleomagnetic poles and polarity zonation from the Middle Proterozoic Belt Supergroup, Montana and Idaho. *Journal of Geophysical Research* **85**, 339 (1980)

Horodyski, R. Stromatolites of the lower Missoula Group (Middle Proterozoic), Belt Supergroup, Glacier National Park, Montana. *Precambrian Research* **2**, 215–254 (1975)

Fairchild, I. & Herrington, P. A tempestite-stromatolite-evaporite association (late Vendian, East Greenland): a shoreface-lagoon model. *Precambrian Research* **43**, 101–127 (1989)

Neuweiler, F., Gautret, P., Thiel, V., Lange, R., Michaelis, W. & Reitner, J. Petrology of Lower Cretaceous carbonate mud mounds (Albian, N. Spain): insights into organomineralic deposits of the geological record. *Sedimentology* **46**, 837–859 (1999)

Elston, D. & McKEE, E. Age and correlation of the late Proterozoic Grand Canyon disturbance, northern Arizona. *Geol Soc America Bull* **93**, 681 (1982)

Riding, R. & Voronova, L. Recent freshwater oscillatoriacean analogue of the Lower Palaeozoic calcareous alga Angulocellularia. *Lethaia* **15**, 105–114 (1982)

Park, J. & Aitken, J. Paleomagnetism of the Katherine Group in the Mackenzie Mountains: implications for post-Grenville (Hadrynian) apparent polar wander. *Canadian Journal of Earth Sciences* **23**, 308–323 (1986)

Mudge, M., Earhart, R., Watts, J., Tuchek, E. & Rice, W. Mineral resources of the Scapegoat Wilderness, Powell and Lewis and Clark counties, Montana. Tech. Rep., USGS (1974)

Shapiro, R. & West, R. Late Paleozoic stromatolites: new insights from the Lower Permian of Kansas. *Lethaia* **32**, 131–139 (1999)

Ineson, J., Peel, J. & Bentley, S. Geological and depositional setting of the Sirius Passet Lagerstätte (Early Cambrian), North Greenland. *Canadian Journal of Earth Sciences* **48**, 1259–1281 (2011)

Peterson, J. Stratigraphy and sedimentary facies of the Madison Limestone and associated rocks in parts of Montana, Nebraska, North Dakota, South Dakota, and Wyoming. Tech. Rep., USGS (1984)

Frank, T., Lyons, T. & Lohmann, K. Isotopic evidence for the paleoenvironmental evolution of the Mesoproterozoic Helena Formation, Belt Supergroup, Montana, USA. *Geochimica et Cosmochimica Acta* **61**, 5023–5041 (1997)

Hoffman, P. & Schrag, D. The snowball Earth hypothesis: testing the limits of global change. *Terra Nova* **14**, 129–155 (2002)

Rubin, D. & Friedman, G. Intermittently emergent shelf carbonates: an example from the Cambro-Ordovician of eastern New York State. *Sedimentary Geology,* 81–106 (1977)

Schoell, M., McCaffrey, M., Fago, F. & Moldowan, J. Carbon isotopic compositions of 28,30-bisnorhopanes and other biological markers in a Monterey crude oil. *Geochimica et Cosmochimica Acta* **56**, 1391–1399 (1992)

Johnson, R., Birdwell, J., Mercier, T. & Brownfield, M. Geology of tight oil and potential tight oil reservoirs in the lower part of the Green River Formation, Uinta, Piceance, and Greater Green River Basins, Utah, Colorado, and Wyoming. Tech. Rep., USGS (2016)

Speed, R. & Jones, R. Synorogenic Quartz Sandstone in the Jurassic Mobile Belt of Western Nevada: Boyer Ranch Formation. *Geol Soc America Bull* **80**, 2551 (1969)

Lovelace, D. & Doebbert, A. A new age constraint for the Early Triassic Alcova Limestone (Chugwater Group), Wyoming. *Palaeogeography, Palaeoclimatology, Palaeoecology,* 1–5 (2015)

Riding, R. The term stromatolite: towards an essential definition. *Lethaia* **32**, 321–330 (1999)

(U.S.), G. Mineral resources of the Bob Marshall Wilderness and study areas, Lewis and Clark, Teton, Pondera, Flathead, Lake, Missoula, and Powell counties, Montana. Tech. Rep., USGS (1978)

Mata, S. & Bottjer, D. Origin of Lower Triassic microbialites in mixed carbonate-siliciclastic successions: Ichnology, applied stratigraphy, and the end-Permian mass extinction. *Palaeogeography, Palaeoclimatology, Palaeoecology* **300**, 158–178 (2011)

Lindsay, M., Anderson, C., Fox, N., Scofield, G., Allen, J., Anderson, E., Bueter, L., Poudel, S., Sutherland, K., Munson-McGee, J., Van Nostrand, J., Zhou, J., Spear, J., Baxter, B., Lageson, D. & Boyd, E. Microbialite response to an anthropogenic salinity gradient in Great Salt Lake, Utah. *Geobiology* (2016)

Kimura, H., Azmy, K., Yamamuro, M., Zhi-Wen, J. & Cizdziel, J. Integrated stratigraphy of the upper Neoproterozoic succession in Yunnan Province of South China: Re-evaluation of global correlation and carbon cycle. *Precambrian Research* **138**, 1–36 (2005)

Bingham, D. & Evans, M. Paleomagnetism of the Great Slave Supergroup, Northwest Territories, Canada: the Stark Formation. *Canadian Journal of Earth Sciences* **13**, 563–578 (1976)

King, V., Block, L., Yeck, W., Wood, C. & Derouin, S. Geological structure of the Paradox Valley Region, Colorado, and relationship to seismicity induced by deep well injection. *Journal of Geophysical Research: Solid Earth* **119**, 4955–4978 (2014)

Thomson, D., Rainbird, R. & Krapez, B. Sequence and tectonostratigraphy of the Neoproterozoic (Tonian-Cryogenian) Amundsen Basin prior to supercontinent (Rodinia) breakup. *Precambrian Research,* 246–259 (2015)

Wilmeth, D., Corsetti, F., Bisenic, N., Dornbos, S., Oji, T. & Gonchigdorj, S. Punctuated Growth Of Microbial Cones Within Early Cambrian Oncoids, Bayan Gol Formation, Western Mongolia. *Palaios* **30**, 836–845 (2015)

Föllmi, K. Sedimentary condensation. *Earth-Science Reviews* (2015)

Smosna, R. & Warshauer, S. Rank exposure index on a Silurian carbonate tidal flat. *Sedimentology* **28**, 723–731 (1981)

Hasiotis, S. Reconnaissance of Upper Jurassic Morrison Formation ichnofossils, Rocky Mountain Region, USA: paleoenvironmental, stratigraphic, and paleoclimatic significance of terrestrial and freshwater ichnocoenoses. *Sedimentary Geology* **167**, 177–268 (2004)

Narbonne, G. & Aitken, J. Neoproterozoic of the Mackenzie Mountains, northwestern Canada. *Precambrian Research* **73**, 101–121 (1995)

Nance, R., Murphy, J., Strachan, R., D'Lemos, R. & Taylor, G. Late Proterozoic tectonostratigraphic evolution of the Avalonian and Cadomian terranes. *Precambrian Research* **53**, 41–78 (1991)

Kottlowski, F., LeMone, D. & Foster, R. Remnant Mountains in Early Ordovician Seas of the El Paso Region, Texas and New Mexico. *Geol* **1**, 137 (1973)

Sprechmann, P., Gaucher, C., Blanco, G. & Montaña, J. Stromatolitic and Trace Fossils Community of the Cerro Victoria Formation, Arroyo del Soldado Group (Lowermost Cambrian, Uruguay). *Gondwana Research* **7**, 753–766 (2004)

Preiss, W. The biostratigraphic potential of Precambrian stromatolites. *Precambrian Research* **5**, 207–219 (1977)

Crittenden, M. & Sorensen, M. The Facer Formation, a new early Proterozoic unit in northern Utah. Tech. Rep., USGS (1980)

Johnson, M., Cocks, L. & Copper, P. Late Ordovician-Early Silurian fluctuations in sea level from eastern Anticosti Island, Quebec. *Lethaia* **14**, 73–82 (1981)

Jerzykiewicz, T. & Sweet, A. Sedimentological and palynological evidence of regional climatic changes in the Campanian to Paleocene sediments of the Rocky Mountain Foothills, Canada. *Sedimentary Geology* **59**, 29–76 (1988)

Horodyski, R. Stromatolites of the upper Siyeh Limestone (Middle Proterozoic), Belt Supergroup, Glacier National Park, Montana. *Precambrian Research* **3**, 517–536 (1976)

Hunt, C. & Mabey, D. Stratigraphy and structure, Death Valley, California. Tech. Rep., USGS (1966)

Sims, P. & Carter, L. Archean and Proterozoic geology of the Lake Superior region, U.S.A., 1993. Tech. Rep., USGS (1996)

Murphy, M. & Sumner, D. Tube structures of probable microbial origin in the Neoarchean Carawine Dolomite, Hamersley Basin, Western Australia. *Geobiology* **0**, 070627140740001–??? (2007)

Cros, P., Michaud, F., Fourcade, E. & Fleury, J. Sedimentological evolution of the Cretaceous carbonate platform of Chiapas (Mexico). *Journal of South American Earth Sciences* **11**, 311–332 (1998)

Edited by Galloway, J. & Hamilton, T. Geologic studies in Alaska by the U.S. Geological Survey during 1987. Tech. Rep., USGS (1988)

Kah, L., Lyons, T. & Chesley, J. Geochemistry of a 1.2 Ga carbonate-evaporite succession, northern Baffin and Bylot Islands: implications for Mesoproterozoic marine evolution. *Precambrian Research* **111**, 203–234 (2001)

Corsetti, F. & J. Kaufman, A. Stratigraphic investigations of carbon isotope anomalies and Neoproterozoic ice ages in Death Valley, California. *Geological Society of America Bulletin* **115**, 916–932 (2003)

Kindler, P. Coastal response to the Holocene transgression in the Bahamas: episodic sedimentation versus continuous sea-level rise. *Sedimentary Geology* **80**, 319–329 (1992)

Pacton, M. & Gorin, G. Role of microorganisms in oceanic anoxic events (OAEs). *Geology Today* **30**, 215–221 (2014)

Rubin, D. & Friedman, G. Origin of Chert Grains and a Halite-silcrete Bed in the Cambrian and Ordovician Whitehall Formation of Eastern New York State. *SEPM Journal of Sedimentary Research* **Vol. 51** (1981)

Austin, G. Multiple Overgrowths on Detrital Quartz Sand Grains in the Shakopee Formation (Lower Ordovician) of Minnesota. *SEPM Journal of Sedimentary Research* **Vol. 44** (1974)

Maliva, R. Quartz Geodes: Early Diagenetic Silicified Anhydrite Nodules Related to Dolomitization. *SEPM Journal of Sedimentary Research* **Vol. 57** (1987)

Ruppel, E., Watts, K. & Peterson, D. Geologic, geochemical, and geophysical investigations in the northern part of the Gilmore mining district, Lemhi County, Idaho. Tech. Rep., USGS (1970)

Dyman, T. A review of the geology and petroleum resource potential of north central Montana. Tech. Rep., USGS (1987)

Young, G. Possible Organic Structures In Early Proterozoic (huronian) Rocks Of Ontario. *Canadian Journal of Earth Sciences* **4**, 565–568 (1967)

(U.S.), G. Geological Survey research 1969, Chapter D. Tech. Rep., USGS (1969)

Ng, K. & Jones, B. Sedimentology and diagenesis of Upper Mississippian to Lower Permian strata, Talbot Lake area, Jasper National Park, Alberta. *Canadian Journal of Earth Sciences* **26**, 275–295 (1989)

Fürsich, F. & Hurst, J. Euryhalinity of Palaeozoic articulate brachiopods. *Lethaia* **13**, 303–312 (1980)

Bengtson, S., Ivarsson, M., Astolfo, A., Belivanova, V., Broman, C., Marone, F. & Stampanoni, M. Deep-biosphere consortium of fungi and prokaryotes in Eocene subseafloor basalts. *Geobiology* **12**, 489–496 (2014)

Lockley, M., Houck, K. & Prince, N. North America's largest dinosaur trackway site: Implications for Morrison Formation paleoecology. *Geol Soc America Bull* **97**, 1163 (1986)

Jones, B., Renaut, R., Rosen, M. & Ansdell, K. Coniform Stromatolites from Geothermal Systems, North Island, New Zealand. *Palaios* **17**, 84–103 (2002)

Melezhik, V., Fallick, A. & Clark, T. Two billion year old isotopically heavy carbon: evidence from the Labrador Trough, Canada. *Canadian Journal of Earth Sciences* **34**, 271–285 (1997)

Doig, R., Murphy, J. & Nance, R. Tectonic significance of the Late Proterozoic Economy River gneiss, Cobequid Highlands, Avalon Composite Terrane, Nova Scotia. *Canadian Journal of Earth Sciences* **30**, 474–479 (1993)

Batten, K., Narbonne, G. & James, N. Paleoenvironments and growth of early Neoproterozoic calcimicrobial reefs: platformal Little Dal Group, northwestern Canada. *Precambrian Research* **133**, 249–269 (2004)

Pratt, W. The Conterminous United States Mineral-Resource Assessment Program; background information to accompany folio of geologic and mineral-resources maps of the Rolla 1 degree x 2 degrees quadrangle, Missouri. Tech. Rep., USGS (1991)

Cloud, P., Wright, L., Williams, E., Diehl, P. & Walter, M. Giant Stromatolites and Associated Vertical Tubes from the Upper Proterozoic Noonday Dolomite, Death Valley Region, Eastern California. *Geol Soc America Bull* **85**, 1869 (1974)

Schultze, H. Terrestrial biota in coastal marine deposits: fossil-Lagerstätten in the Pennsylvanian of Kansas, USA. *Palaeogeography, Palaeoclimatology, Palaeoecology* **119**, 255–273 (1996)

Floran, R. & Papike, J. Petrology of the Low-Grade Rocks of the Gunflint Iron-Formation, Ontario-Minnesota. *Geol Soc America Bull* **86**, 1169 (1975)

Knight, I. & James, N. The stratigraphy of the Lower Ordovician St. George Group, western Newfoundland: the interaction between eustasy and tectonics. *Canadian Journal of Earth Sciences* **24**, 1927–1951 (1987)

Ettensohn, F., Rice, C., Dever, J. & Chesnut, D. Slade and Paragon formations; new stratigraphic nomenclature for Mississippian rocks along the Cumberland Escarpment in Kentucky. Tech. Rep., USGS (1984)

Macdonald, F., McClelland, W., Schrag, D. & Macdonald, W. Neoproterozoic glaciation on a carbonate platform margin in Arctic Alaska and the origin of the North Slope subterrane. *Geological Society of America Bulletin* **121**, 448–473 (2009)

Halverson, G., Hoffman, P., Schrag, D., Maloof, A. & Rice, A. Toward a Neoproterozoic composite carbon-isotope record. *Geol Soc America Bull* **117**, 1181 (2005)

Fralick, P., Davis, D. & Kissin, S. The age of the Gunflint Formation, Ontario, Canada: single zircon U-Pb age determinations from reworked volcanic ash. *Canadian Journal of Earth Sciences* **39**, 1085–1091 (2002)

Schopf, J. & Prasad, K. Microfossils in Collenia-like stromatolites from the proterozoic Vempalle formation of the Cuddapah Basin, India. *Precambrian Research* **6**, 347–366 (1978)

Mudge, M. Pre-Quaternary rocks in the Sun River Canyon area, northwestern Montana. Tech. Rep., USGS (1972)

Fairchild, I., Knoll, A. & Swett, K. Coastal lithofacies and biofacies associated with syndepositional dolomitization and silicification (Draken Formation, Upper Riphean, Svalbard). *Precambrian Research* **53**, 165–197 (1991)

Kahle, C. & Floyd, J. Stratigraphic and Environmental Significance of Sedimentary Structures in Cayugan (Silurian) Tidal Flat Carbonates, Northwestern Ohio. *Geol Soc America Bull* **82**, 2071 (1971)

Strong, D. Proterozoic tectonics of northwestern gondwanaland: New evidence from eastern newfoundland. *Tectonophysics* **54**, 81–101 (1979)

Schwarz, E. & Arnott, R. Anatomy and Evolution of a Slope Channel-Complex Set (Neoproterozoic Isaac Formation, Windermere Supergroup, Southern Canadian Cordillera): Implications for Reservoir Characterization. *Journal of Sedimentary Research* **77**, 89–109 (2007)

Chafetz, H. Morphological Evolution of Cambrian Algal Mounds in Response to a Change in Depositional Environment. *SEPM Journal of Sedimentary Research* **Vol. 43** (1973)

Paik, I. & Kim, H. Palustrine calcretes of the Cretaceous Gyeongsang Supergroup, Korea: Variation and paleoenvironmental implications. *The Island Arc* **12**, 110–124 (2003)

Pietsch, C., Mata, S. & Bottjer, D. High temperature and low oxygen perturbations drive contrasting benthic recovery dynamics following the end-Permian mass extinction. *Palaeogeography, Palaeoclimatology, Palaeoecology,* 98–113 (2014)

Creveling, J., Bergmann, K. & Grotzinger, J. Cap carbonate platform facies model, Noonday Formation, SE California. *Geological Society of America Bulletin,* B31442.1 (2016)

Keppie, J., Davis, D. & Krogh, T. U-Pb geochronological constraints on Precambrian stratified units in the Avalon Composite Terrane of Nova Scotia, Canada: tectonic implications. *Canadian Journal of Earth Sciences* **35**, 222–236 (1998)

González-Álvarez, I. & Kerrich, R. Trace element mobility in dolomitic argillites of the Mesoproterozoic Belt-Purcell Supergroup, Western North America. *Geochimica et Cosmochimica Acta* **75**, 1733–1756 (2011)

Barth, J., Chafetz, H. & Pufahl, P. Cool water geyser travertine: Crystal Geyser, Utah, USA. *Sedimentology* **62**, 607–620 (2015)

Gregg, J. & Shelton, K. Dolomitization and Dolomite Neomorphism in the Back Reef Facies of the Bonneterre and Davis Formations (Cambrian), Southeastern Missouri. *SEPM Journal of Sedimentary Research* **Vol. 60** (1990)

Anderson, R., Tarhan, L., Cummings, K., Planavsky, N. & Bjørnerud, M. MACROSCOPIC STRUCTURES IN THE 1.1 Ga CONTINENTAL COPPER HARBOR FORMATION: CONCRETIONS OR FOSSILS? *Palaios* **31**, 327–338 (2016)

Sims, P., K isvarsanyi, E. & Morey, G. Geology and metallogeny of Archean and Proterozoic basement terranes in the northern midcontinent, U.S.A.; an overview. Tech. Rep., USGS (1987)

Kusky, T. & Hudleston, P. Growth and demise of an Archean carbonate platform, Steep Rock Lake, Ontario, Canada. *Canadian Journal of Earth Sciences* **36**, 565–584 (1999)

Aaron, J. Geology of the Nazareth Quadrangle, Northampton County, Pennsylvania. Tech. Rep., USGS (1975)

Horodyski, R. & Von, S. Recent Calcareous Stromatolites from Laguna Mormona (Baja California) Mexico. *SEPM Journal of Sedimentary Research* **Vol. 45** (1975)

Turner, E., James, N. & Narbonne, G. Taphonomic Control on Microstructure in Early Neoproterozoic Reefal Stromatolites and Thrombolites. *Palaios* **15**, 87–111 (2000)

Joeckel, R. Tectonic and paleoclimatic significance of a prominent upper Pennsylvanian (Virgilian/Stephanian) weathering profile, Iowa and Nebraska, USA. *Palaeogeography, Palaeoclimatology, Palaeoecology* **118**, 159–179 (1995)

Osborne, R., Licari, G. & Link, M. Modern lacustrine stromatolites, Walker Lake, Nevada. *Sedimentary Geology* **32**, 39–61 (1982)

Beranek, L., Pease, V., Scott, R., Thomsen, T. & Mahoney, J. Detrital zircon geochronology of Ediacaran to Cambrian deep-water strata of the Franklinian basin, northern Ellesmere Island, Nunavut: implications for regional stratigraphic correlations. *Canadian Journal of Earth Sciences* **50**, 1007–1018 (2013)

Edited by Dusel-Bacon, C. & Till, A. Geologic studies in Alaska by the U.S. Geological Survey, 1992. Tech. Rep., USGS (1993)

Leach, D., Rowan, E. & Clendenin, C. Comment and Reply on Focused fluid flow and Ozark Mississippi Valley-type deposits. *Geol* **19**, 190 (1991)

Young, H. & Siegel, D. Hydrogeology of the Cambrian-Ordovician aquifer system in the northern Midwest, United States, with a section on ground-water quality. Tech. Rep., USGS (1992)

Sun, X., Zhang, T., Sun, Y., Milliken, K. & Sun, D. Geochemical evidence of organic matter source input and depositional environments in the lower and upper Eagle Ford Formation, south Texas. *Organic Geochemistry* (2016)

Lenz, A. Ordovician to Devonian sea-level changes in western and northern Canada. *Canadian Journal of Earth Sciences* **19**, 1919–1932 (1982)

Westrop, S. Facies anatomy of an Upper Cambrian grand cycle: Bison Creek and Mistaya formations, southern Alberta. *Canadian Journal of Earth Sciences* **26**, 2292–2304 (1989)

Nutt, C. A model of uranium mineralization in the Dripping Spring Quartzite, Gila County, Arizona. Tech. Rep., USGS (1981)

Guo, H., Du, Y., Kah, L., Hu, C., Huang, J., Huang, H., Yu, W. & Song, H. Sulfur isotope composition of carbonate-associated sulfate from the Mesoproterozoic Jixian Group, North China: Implications for the marine sulfur cycle. *Precambrian Research,* 319–336 (2015)

Pruss, S. & Bottjer, D. Late Early Triassic microbial reefs of the western United States: a description and model for their deposition in the aftermath of the end-Permian mass extinction. *Palaeogeography, Palaeoclimatology, Palaeoecology* **211**, 127–137 (2004)

Runnegar, B. Precambrian oxygen levels estimated from the biochemistry and physiology of early eukaryotes. *Palaeogeography, Palaeoclimatology, Palaeoecology* **97**, 97–111 (1991)

Larue, D. The Chocolay Group, Lake Superior region, U.S.A.: Sedimentologic evidence for deposition in basinal and platform settings on an early Proterozoic craton. *Geol Soc America Bull* **92**, 417 (1981)

MacLean, B. & Miles, W. Potential-field modeling of a Proterozoic half-graben near Blackwater Lake, Northwest Territories, Canada, and its implications for the Fort Simpson Magnetic Anomaly. *Canadian Journal of Earth Sciences* **39**, 169–187 (2002)

Collette, J., Hagadorn, J. & Lacelle, M. Dead In Their Tracks–cambrian Arthropods And Their Traces From Intertidal Sandstones Of Quebec And Wisconsin. *Palaios* **25**, 475–486 (2010)

Dong, L., Xiao, S., Shen, B., Yuan, X., Yan, X. & Peng, Y. Restudy of the worm-like carbonaceous compression fossils Protoarenicola, Pararenicola, and Sinosabellidites from early Neoproterozoic successions in North China. *Palaeogeography, Palaeoclimatology, Palaeoecology* **258**, 138–161 (2008)

Onasch, C. & Kahle, C. Recurrent tectonics in a cratonic setting: An example from northwestern Ohio. *Geological Society of America Bulletin* **103**, 1259–1269 (1991)

Mary, M. & Woods, A. Stromatolites of the Lower Triassic Union Wash Formation, CA: Evidence for continued post-extinction environmental stress in western North America through the Spathian. *Palaeogeography, Palaeoclimatology, Palaeoecology* **261**, 78–86 (2008)

Edited by Pratt, W. The Conterminous United States Mineral-Resource Assessment Program; background information to accompany folios of geologic and mineral-resource maps of the Harrison 1 degree x 2 degrees quadrangle, Missouri and Arkansas, and the Joplin 1 degree x 2 degrees quadrangle Kansas and Missouri. Tech. Rep., USGS (1997)

Dewing, K., Harrison, J., Pratt, B. & Mayr, U. A probable late Neoproterozoic age for the Kennedy Channel and Ella Bay formations, northeastern Ellesmere Island and its implications for passive margin history of the Canadian Arctic. *Canadian Journal of Earth Sciences* **41**, 1013–1025 (2004)

Frimmel, H. & Fölling, P. Late Vendian Closure of the Adamastor Ocean: Timing of Tectonic Inversion and Syn-orogenic Sedimentation in the Gariep Basin. *Gondwana Research* **7**, 685–699 (2004)

Macdonald, F., Strauss, J., Sperling, E., Halverson, G., Narbonne, G., Johnston, D., Kunzmann, M., Schrag, D. & Higgins, J. The stratigraphic relationship between the Shuram carbon isotope excursion, the oxygenation of Neoproterozoic oceans, and the first appearance of the Ediacara biota and bilaterian trace fossils in northwestern Canada. *Chemical Geology,* 250–272 (2013)

Stasiuk, L., Kybett, B. & Bend, S. Reflected light microscopy and micro-FTIR of Upper Ordovician Gloeocapsomorpha prisca alginite in relation to paleoenvironment and petroleum generation, Saskatchewan, Canada. *Organic Geochemistry* **20**, 707–719 (1993)

McCahon, T. & Miller, K. Environmental significance of lungfish burrows (Gnathorhiza) within Lower Permian (Wolfcampian) paleosols of the US midcontinent. *Palaeogeography, Palaeoclimatology, Palaeoecology,* 1–12 (2015)

Thomson, D., Rainbird, R. & Dix, G. Architecture of a Neoproterozoic intracratonic carbonate ramp succession: Wynniatt Formation, Amundsen Basin, Arctic Canada. *Sedimentary Geology,* 119–138 (2014)

Franklin, J. & Mitchell, R. Lead–zinc–barite veins of the Dorion Area, Thunder Bay District, Ontario. *Canadian Journal of Earth Sciences* **14**, 1963–1979 (1977)

Pufahl, P. & Hiatt, E. Oxygenation of the Earth's atmosphere–ocean system: A review of physical and chemical sedimentologic responses. *Marine and Petroleum Geology* **32**, 1–20 (2012)

Armstrong, A. & Mamet, B. Carboniferous biostratigraphy, northeastern Brooks Range, Arctic Alaska. Tech. Rep., USGS (1975)

Crossey, L., Karlstrom, K., Dorsey, R., Pearce, J., Wan, E., Beard, L., Asmerom, Y., Polyak, V., Crow, R., Cohen, A., Bright, J. & Pecha, M. Importance of groundwater in propagating downward integration of the 6-5 Ma Colorado River system: Geochemistry of springs, travertines, and lacustrine carbonates of the Grand Canyon region over the past 12 Ma. *Geosphere* **11**, 660–682 (2015)

Kah, L., Sherman, A., Narbonne, G., Knoll, A. & Kaufman, A. δ 13 C stratigraphy of the Proterozoic Bylot Supergroup, Baffin Island, Canada: implications for regional lithostratigraphic correlations. *Canadian Journal of Earth Sciences* **36**, 313–332 (1999)

Swadley, W. & Rowley, P. Geologic map of the Pahroc Spring SE Quadrangle, Lincoln County, Nevada. Tech. Rep., USGS (1992)

Mcloughlin, N., Wilson, L. & Brasier, M. Growth of synthetic stromatolites and wrinkle structures in the absence of microbes – implications for the early fossil record. *Geobiology* **6**, 95–105 (2008)

Sherman, A., James, N. & Narbonne, G. Evidence for reversal of basin polarity during carbonate ramp development in the Mesoproterozoic Borden Basin, Baffin Island. *Canadian Journal of Earth Sciences* **39**, 519–538 (2002)

Bodine, M. Sediment diagenesis A. Parker and B.W. Sellwood (Editors), 1983. Reidel Publishing Company, Dordrecht, vii + 427 pp., Dfl.140.00, U.S.$53.00 (hardback). *Earth-Science Reviews* **22**, 168–169 (1985)

Skehan, J. Assembly and dispersal of supercontinents: The view from Avalon. *Journal of Geodynamics* **23**, 237–262 (1997)

Karl, S., Dumoulin, J., Ellersieck, I., Harris, A. & Schmidt, J. Preliminary Geologic map of the Baird Mountains and part of the Selawik quadrangles, Alaska. Tech. Rep., USGS (1989)

Schmidt, R. Rocks and mineral resources of the Wolf Creek area, Lewis and Clark and Cascade counties, Montana. Tech. Rep., USGS (1978)

Long, D. & Turner, E. Tectonic, sedimentary and metallogenic re-evaluation of basal strata in the Mesoproterozoic Bylot basins, Nunavut, Canada: Are unconformity-type uranium concentrations a realistic expectation? *Precambrian Research,* 192–209 (2012)

Mukherjee, D., Heggy, E. & Khan, S. Geoelectrical constraints on radar probing of shallow water-saturated zones within karstified carbonates in semi-arid environments. *Journal of Applied Geophysics* **70**, 181–191 (2010)

Retallack, G., Dunn, K. & Saxby, J. Problematic Mesoproterozoic fossil Horodyskia from Glacier National Park, Montana, USA. *Precambrian Research,* 125–142 (2013)

Awramik, S. & Barghoorn, E. The Gunflint microbiota. *Precambrian Research* **5**, 121–142 (1977)

Medig, K., Turner, E., Thorkelson, D. & Rainbird, R. Rifting of Columbia to form a deep-water siliciclastic to carbonate succession: The Mesoproterozoic Pinguicula Group of northern Yukon, Canada. *Precambrian Research,* 179–206 (2016)

Hoffman, P. Corrigendum : Strange bedfellows: glacial diamictite and cap carbonate from the Marinoan (635   Ma) glaciation in Namibia. *Sedimentology* **60**, 631–634 (2013)

Jo, H. Depositional environments, architecture, and controls of Early Cretaceous non-marine successions in the northwestern part of Kyongsang Basin, Korea. *Sedimentary Geology* **161**, 269–294 (2003)

Lewan, M. Stable carbon isotopes of amorphous kerogens from Phanerozoic sedimentary rocks. *Geochimica et Cosmochimica Acta* **50**, 1583–1591 (1986)

Schenk, P. Carbonate–sulphate–redbed facies and cyclic sedimentation of the Windsorian Stage (Middle Carboniferous), Maritime Provinces. *Canadian Journal of Earth Sciences* **6**, 1037–1066 (1969)

Guilbault, J. & Mamet, B. Codiacées (Algues) ordoviciennes des Basses-Terres du Saint-Laurent. *Canadian Journal of Earth Sciences* **13**, 636–660 (1976)

Middendorf, M., Thomas, K., Robertson, C., Whitfield, J., Glick, E., Bush, W., Haley, B. & McFarland, J. Geologic map of the Harrison 1 degree x 2 degrees quadrangle, Missouri and Arkansas. Tech. Rep., USGS (1994)

Woods, A. Assessing Early Triassic paleoceanographic conditions via unusual sedimentary fabrics and features. *Earth-Science Reviews,* 6–18 (2014)

Fagerstrom, J. & Burchett, R. Upper Pennsylvanian Shoreline Deposits from Iowa and Nebraska: Their Recognition, Variation, and Significance. *Geol Soc America Bull* **83**, 367 (1972)

Dewing, K. & Copper, P. Upper Ordovician stratigraphy of Southampton Island, Northwest Territories. *Canadian Journal of Earth Sciences* **28**, 283–291 (1991)

Stelck, C. & Hedinger, A. Archaeocyathids and the Lower Cambrian Continental Shelf of the Canadian Cordillera. *Canadian Journal of Earth Sciences* **12**, 2014–2020 (1975)

(2), N. & Dappl, E. Feldspars of the Tunnel City Group (Cambrian), Western Wisconsin. *SEPM Journal of Sedimentary Research* **Vol. 47** (1977)

Amard, B. & Bertrand-Sarfati, J. Microfossils in 2000 Ma old cherty stromatolites of the Franceville Group, Gabon. *Precambrian Research* **81**, 197–221 (1997)

Gans, W. Correlation and Redefinition of the Goodsprings Dolomite, Southern Nevada and Eastern California. *Geol Soc America Bull* **85**, 189 (1974)

Webb, G. Paleokarst, paleosol, and rocky-shore deposits at the Mississippian-Pennsylvanian unconformity, northwestern Arkansas. *Geol Soc America Bull* **106**, 634 (1994)

Frantz, C., Petryshyn, V. & Corsetti, F. Grain trapping by filamentous cyanobacterial and algal mats: implications for stromatolite microfabrics through time. *Geobiology* **13**, 409–423 (2015)

Melezhik, V., Fallick, A., Makarikhin, V. & Lyubtsov, V. Links between Palaeoproterozoic palaeogeography and rise and decline of stromatolites: Fennoscandian Shield. *Precambrian Research* **82**, 311–348 (1997)

Soule, J. Late Precambrian to earliest Mississippian stratigraphy, geologic history, and paleogeography of northwestern and west-central Colorado. Tech. Rep., USGS (1992)

Dimroth, E. The Attikamagen–Ferriman Transition in Part of the Central Labrador Trough. *Canadian Journal of Earth Sciences* **8**, 1432–1454 (1971)

Hofmann, H. On Aphebian stromatolites and Riphean stromatolite stratigraphy. *Precambrian Research* **5**, 175–205 (1977)

Dixon, J. Revised Stratigraphy of the Hunting Formation (Proterozoic), Somerset Island, Northwest Territories. *Canadian Journal of Earth Sciences* **11**, 635–642 (1974)

Lochman-balk, C. Upper Cambrian Faunal Patterns on the Craton: Reply. *Geol Soc America Bull* **83**, 931 (1972)

Stasiuk, L. Fluorescence properties of Palaeozoic oil-prone alginite in relation to hydrocarbon generation, Williston Basin, Saskatchewan, Canada. *Marine and Petroleum Geology* **11**, 219–231 (1994)

Mortensen, P. & Jones, B. The role of contemporaneous faulting on Late Silurian sedimentation in the eastern M'Clintock Basin, Prince of Wales Island, Arctic Canada. *Canadian Journal of Earth Sciences* **23**, 1401–1411 (1986)

Shixing,, Z. An outline of studies on the Precambrian stromatolites of China. *Precambrian Research* **18**, 367–396 (1982)

Eberlein, G. & Lanphere, M. Precambrian rocks of Alaska. Tech. Rep., USGS (1988)

Hofmann, H. & Davidson, A. Paleoproterozoic stromatolites, Hurwitz Group, Quartzite Lake area, Northwest Territories, Canada. *Canadian Journal of Earth Sciences* **35**, 280–289 (1998)

Harwood Theisen, C. & Sumner, D. Thrombolite fabrics and origins: Influences of diverse microbial and metazoan processes on Cambrian thrombolite variability in the Great Basin, California and Nevada. *Sedimentology* (2016)

Hofmann, H., Grey, K., Hickman, A. & Thorpe, R. Origin of 3.45 Ga coniform stromatolites in Warrawoona Group, Western Australia. *Geological Society of America Bulletin* **111**, 1256–1262 (1999)

Hajnal, Z., Takacs, E., Pandit, B. & Annesley, I. Uranium mineralization indicators from seismic and well log data in the Shea Creek area at the southern margin of the Carswell impact structure, Athabasca Basin, Canada. *Geophysical Prospecting* **63**, 861–880 (2015)

compiled by Gautier, D. & Varnes, K. Plays for assessment in Region IV, Rocky Mountains and Northern Great Plains as of October 4, 1993; 1995 National Assessment of oil and gas. Tech. Rep., USGS (1993)

Kholeif, S. & Ibrahim, M. Palynofacies Analysis of Inner Continental Shelf and Middle Slope Sediments offshore Egypt, South-eastern Mediterranean. *Geobios* **43**, 333–347 (2010)

Winter, B. & Johnson, C. U-Pb dating of a carbonate subaerial exposure event. *Earth and Planetary Science Letters* **131**, 177–187 (1995)

Glikson, A. Precambrian sial-sima relations: evidence for earth expansion. *Tectonophysics* **63**, 193–234 (1980)

Baars, D. & See, P. Pre-Pennsylvanian Stratigraphy and Paleotectonics of the San Juan Mountains, Southwestern Colorado. *Geol Soc America Bull* **79**, 333 (1968)

(2), J. Dedolomitization in the Taum Sauk Limestone (Upper Cambrian), Southeast Missouri. *SEPM Journal of Sedimentary Research* **Vol. 51** (1981)

Horodyski, R. Lyngbya Mats at Laguna Mormona, Baja California, Mexico: Comparison with Proterozoic Stromatolites. *SEPM Journal of Sedimentary Research* **Vol. 47** (1977)

Hoffman, P. & Macdonald, F. Sheet-crack cements and early regression in Marinoan (635Ma) cap dolostones: Regional benchmarks of vanishing ice-sheets? *Earth and Planetary Science Letters* **3-4**, 374–384 (2010)

Myrow, P., Chen, J. & Baas, J. Estimates of large magnitude Late Cambrian earthquakes from seismogenic soft-sediment deformation structures: Central Rocky Mountains. *Sedimentology* **62**, 621–644 (2015)

Young, G. The Grenville orogenic belt in the North Atlantic continents. *Earth-Science Reviews,* 277–288 (1980)

Myrow, P., Taylor, J., Runkel, A. & Ripperdan, R. Mixed Siliciclastic-Carbonate Upward-Deepening Cycles of the Upper Cambrian Inner Detrital Belt of Laurentia. *Journal of Sedimentary Research* **82**, 216–231 (2012)

McCall, G. The Vendian (Ediacaran) in the geological record: Enigmas in geology's prelude to the Cambrian explosion. *Earth-Science Reviews* **1-3**, 1–229 (2006)

edited by Pratt, W. Metallic mineral-resource potential of the Rolla 1 degree x 2 degrees Quadrangle, Missouri, as appraised in September 1980. Tech. Rep., USGS (1981)

Hotinski, R., Kump, L. & Arthur, M. The effectiveness of the Paleoproterozoic biological pump: A δ13C gradient from platform carbonates of the Pethei Group (Great Slave Lake Supergroup, NWT). *Geological Society of America Bulletin* **116**, 539 (2004)

Schieber, J. Microbial Mats in Terrigenous Clastics: The Challenge of Identification in the Rock Record. *Palaios* **14**, 3 (1999)

Gellatly, A. & Lyons, T. Trace sulfate in mid-Proterozoic carbonates and the sulfur isotope record of biospheric evolution. *Geochimica et Cosmochimica Acta* **69**, 3813–3829 (2005)

Wanless, H. Limestone Response to Stress: Pressure Solution and Dolomitization. *SEPM Journal of Sedimentary Research* **Vol. 49** (1979)

Witkind, I. Geology of the Tepee Creek quadrangle, Montana-Wyoming. Tech. Rep., USGS (1969)

Rust, B. & Gibling, M. Three-dimensional antidunes as HCS mimics in a fluvial sandstone; the Pennsylvanian South Bar Formation near Sydney, Nova Scotia. *Journal of Sedimentary Research* **60**, 540–548 (1990)

Fagerstrom, J. Petrology and Regional Significance of a Devonian Carbonate/Evaporite Complex, Eastern Michigan Basin. *SEPM Journal of Sedimentary Research* **Vol. 53** (1983)

Hickman-Lewis, K., Garwood, R., Brasier, M., Goral, T., Jiang, H., McLoughlin, N. & Wacey, D. Carbonaceous microstructures from sedimentary laminated chert within the 3.46Ga Apex Basalt, Chinaman Creek locality, Pilbara, Western Australia. *Precambrian Research,* 161–178 (2016)

Tucker, M. Precambrian dolomites: Petrographic and isotopic evidence that they differ from Phanerozoic dolomites. *Geol* **10**, 7 (1982)

McGimsey, R. The Purcell Lava, Glacier National Park, Montana. Tech. Rep., USGS (1985)

Vercoutere, T. & Mull, H. Sedimentation Across the Central California Oxygen Minimum Zone: An Alternative Coastal Upwelling Sequence. *SEPM Journal of Sedimentary Research* **Vol. 57** (1987)

Connan, J., Bouroullec, J., Dessort, D. & Albrecht, P. The microbial input in carbonate-anhydrite facies of a sabkha palaeoenvironment from Guatemala: A molecular approach. *Organic Geochemistry* **10**, 29–50 (1986)

Dutro, J. Paleontology and The Geological Society of America: The first 100 years. *Geological Society of America Bulletin* **100**, 1528–1532 (1988)

Sommers, M., Awramik, S. & Woo, K. Evidence for initial calcite-aragonite composition of Lower Algal Chert Member ooids and stromatolites, Paleoproterozoic Gunflint Formation, Ontario, Canada. *Canadian Journal of Earth Sciences* **37**, 1229–1243 (2000)

Stolz, J. & Margulis, L. Obituary. *Precambrian Research* **27**, 401–402 (1985)

Achauer, C. & Johnson, J. Algal Stromatolites in the James Reef Complex (Lower Cretaceous), Fairway Field, Texas. *SEPM Journal of Sedimentary Research* **Vol. 39** (1969)

Barlow, E., Van Kranendonk, M., Yamaguchi, K., Ikehara, M. & Lepland, A. Lithostratigraphic analysis of a new stromatolite-thrombolite reef from across the rise of atmospheric oxygen in the Paleoproterozoic Turee Creek Group, Western Australia. *Geobiology* **14**, 317–343 (2016)

Kidder, D. Facies-controlled shrinkage-crack assemblages in Middle Proterozoic mudstones from Montana, USA. *Sedimentology* **37**, 943–951 (1990)

Levy, M. & Christie-blick, N. Tectonic subsidence of the early Paleozoic passive continental margin in eastern California and southern Nevada. *Geological Society of America Bulletin* **103**, 1590–1606 (1991)

Douglas Elmore, R., Milavec, G., Imbus, S. & Engel, M. The Precambrian nonesuch formation of the North American mid-continent rift, sedimentology and organic geochemical aspects of lacustrine deposition. *Precambrian Research* **43**, 191–213 (1989)

Noffke, N., Hazen, R. & Nhleko, N. Earth's earliest microbial mats in a siliciclastic marine environment (2.9 Ga Mozaan Group, South Africa). *Geol* **31**, 673 (2003)

Ekren, E., Anderson, R., Rogers, C. & Noble, D. Geology of northern Nellis Air Force Base bombing and gunnery range, Nye County, Nevada. Tech. Rep., USGS (1971)

Knoll, A. & Semikhatov, M. The Genesis and Time Distribution of Two Distinctive Proterozoic Stromatolite Microstructures. *Palaios* **13**, 408 (1998)

Anderson, R. & Dean, W. Lacustrine varve formation through time. *Palaeogeography, Palaeoclimatology, Palaeoecology* **62**, 215–235 (1988)

Siedlecka, A. Supralittoral ponded algal stromatolites of the late Precambrian Annijokka Member of the Båtsfjord formation, Varanger peninsula, north Norway. *Precambrian Research* **18**, 319–345 (1982)

Bekker, A., Karhu, J., Eriksson, K. & Kaufman, A. Chemostratigraphy of Paleoproterozoic carbonate successions of the Wyoming Craton: tectonic forcing of biogeochemical change? *Precambrian Research* **120**, 279–325 (2003)

Silberling, N. & Wallace, R. Stratigraphy of the Star Peak Group (Triassic) and overlying lower Mesozoic rocks, Humboldt Range, Nevada. Tech. Rep., USGS (1969)

Kahle, C. Biosedimentology of a Silurian Thrombolite Reef with Meter-Scale Growth Framework Cavities. *Journal of Sedimentary Research* **71**, 410–422 (2001)

(2), C. & Osborn, R. Petrology of Late Precambrian-Cambrian Quartzose Sandstones in the Eastern Mojave Desert, Southeastern California. *SEPM Journal of Sedimentary Research* **Vol. 46** (1976)

Miller, R. Discovery of the Holotype of Cyathospongia (?) eozoica Matthew, a supposed Precambrian sponge from Saint John, New Brunswick. *Canadian Journal of Earth Sciences* **27**, 473–475 (1990)

Barr, S., Davis, D., Kamo, S. & White, C. Significance of U–Pb detrital zircon ages in quartzite from peri-Gondwanan terranes, New Brunswick and Nova Scotia, Canada. *Precambrian Research* **126**, 123–145 (2003)

Trompette, R. Upper Proterozoic (1800-570 Ma) stratigraphy: A survey of lithostratigraphic, paleontological, radiochronological and magnetic correlations. *Precambrian Research* **18**, 27–52 (1982)

Blokker, P., van Bergen, P., Pancost, R., Collinson, M., de Leeuw, J. & Sinninghe Damste, J. The chemical structure of Gloeocapsomorpha prisca microfossils: implications for their origin. *Geochimica et Cosmochimica Acta* **65**, 885–900 (2001)

Becher, A. Ground-water resources of Cambrian and Ordovician carbonate rocks in the valley and ridge physiographic province of Pennsylvania. Tech. Rep., USGS (1996)

McKINNEY, F. & Gault, H. Paleoenvironment of Late Mississippian fenestrate bryozoans, eastern United States. *Lethaia* **13**, 127–146 (1980)

(2), I. Sedimentation and Origin of a Late Precambrian 'Dolomite' from Scotland. *SEPM Journal of Sedimentary Research* **Vol. 50** (1980)

Tweto, O. & Lovering, T. Geology of the Minturn 15-minute quadrangle, Eagle and Summit counties, Colorado. Tech. Rep., USGS (1977)

Young, G. & Long, D. A tide-influenced delta complex in the upper Proterozoic Shaler Group, Victoria Island, Canada. *Canadian Journal of Earth Sciences* **14**, 2246–2261 (1977)

Sarin, D. Cyclic Sedimentation of Primary Dolomite and Limestone. *SEPM Journal of Sedimentary Research* **Vol. 32** (1962)

Di Geronimo, I., Di Geronimo, R., Rosso, A. & Sanfilippo, R. Structural and taphonomic analysis of a columnar coralline algal build-up from SE Sicily. *Geobios* **35**, 86–95 (2002)

Aitken, J. Classification and Environmental Significance of Cryptalgal Limestones and Dolomites, with Illustrations from the Cambrian and Ordovician of Southwestern Alberta. *SEPM Journal of Sedimentary Research* **Vol. 37** (1967)

Wellman, C., Strother, P. & Smith, A. The terrestrial biota prior to the origin of land plants (embryophytes): a review of the evidence. *Palaeontology* **58**, 601–627 (2015)

Hoffman, P. Proterozoic paleocurrents and depositional history of the East Arm fold belt, Great Slave Lake, Northwest Territories. *Canadian Journal of Earth Sciences* **6**, 441–462 (1969)

Hofmann, H., Mountjoy, E. & Teitz, M. Ediacaran fossils and dubiofossils, Miette Group of Mount Fitzwilliam area, British Columbia. *Canadian Journal of Earth Sciences* **28**, 1541–1552 (1991)

Henry, M. Review of the geology of the southern Oklahoma fold belt province as a basis for estimates of undiscovered hydrocarbon resources. Tech. Rep., USGS (1988)

Mountjoy, E., Qing, H. & McNutt, R. Strontium isotopic composition of Devonian dolomites, Western Canada Sedimentary Basin: significance of sources of dolomitizing fluids. *Applied Geochemistry* **7**, 59–75 (1992)

Mortensen, P. & Jones, B. Anatomy of an Upper Silurian transgressive–regressive cycle, Prince of Wales Island, Arctic Canada. *Canadian Journal of Earth Sciences* **32**, 24–36 (1995)

Gallagher, M., Turner, E. & Kamber, B. In situ trace metal analysis of Neoarchaean - Ordovician shallow-marine microbial-carbonate-hosted pyrites. *Geobiology* **13**, 316–339 (2015)

Mariotti, G., Perron, J. & Bosak, T. Feedbacks between flow, sediment motion and microbial growth on sand bars initiate and shape elongated stromatolite mounds. *Earth and Planetary Science Letters,* 93–100 (2014)

Young, G. & Jefferson, C. Late Precambrian Shallow Water Deposits, Banks and Victoria Islands, Arctic Archipelago. *Canadian Journal of Earth Sciences* **12**, 1734–1748 (1975)

Harrison, J. & Campbell, A. Correlations and Problems in Belt Series Stratigraphy, Northern Idaho and Western Montana. *Geol Soc America Bull* **74**, 1413 (1963)

Erlich, R., Astorga, A., Sofer, Z., Pratt, L. & Palmer, S. Palaeoceanography of organic-rich rocks of the Loma Chumico Formation of Costa Rica, Late Cretaceous, eastern Pacific. *Sedimentology* **43**, 691–718 (1996)

Bayley, R., Dutton, C. & Lamey, C. Geology of the Menominee iron-bearing district, Dickinson County, Michigan, and Florence and Marinette Counties, Wisconsin. Tech. Rep., USGS (1966)

Pruss, S. & Bottjer, D. The reorganization of reef communities following the end-Permian mass extinction. *Comptes Rendus Palevol* **4**, 553–568 (2005)

Jefferson, C. & Parrish, R. Late Proterozoic stratigraphy, U–Pb zircon ages, and rift tectonics, Mackenzie Mountains, northwestern Canada. *Canadian Journal of Earth Sciences* **26**, 1784–1801 (1989)

Barr, S., White, C., Davis, D., McClelland, W. & van Staal, C. Infrastructure and provenance of Ganderia: Evidence from detrital zircon ages in the Brookville terrane, southern New Brunswick, Canada. *Precambrian Research,* 358–370 (2014)

Horodyski, R., Dudek, K., Ross, G. & Donaldson, J. Microfossils from the Early Proterozoic Hornby Bay Group, District of Mackenzie, Northwest Territories, Canada. *Canadian Journal of Earth Sciences* **22**, 758–767 (1985)

Hofmann, H. & Mountjoy, E. Namacalathus-Cloudina assemblage in Neoproterozoic Miette Group (Byng Formation), British Columbia: Canada's oldest shelly fossils. *Geol* **29**, 1091 (2001)

Strother, P. & Tobin, K. Observations on the genus huroniospora barghoorn: Implications for paleoecology of the gunflint microbiota. *Precambrian Research* **36**, 323–333 (1987)

O'Brien, S., Wardle, R. & King, A. The Avalon Zone: A Pan-African terrane in the Appalachian Orogen of Canada. *Geological Journal* **18**, 195–222 (1983)

Cavaroc, V. & Flores, R. Red beds of the Triassic Chugwater Group, southwestern Powder River basin, Wyoming. Tech. Rep., USGS (1991)

Hunter, G. Postglacial uplift at Fort Albany, James Bay. *Canadian Journal of Earth Sciences* **7**, 547–548 (1970)

Ji, Z. & Barnes, C. A major conodont extinction event during the early Ordovician within the Midcontinent realm. *Palaeogeography, Palaeoclimatology, Palaeoecology* **1-4**, 37–47 (1993)

Gill, D. Salina A-1 Sabkha Cycles and the Late Silurian Paleogeography of the Michigan Basin. *SEPM Journal of Sedimentary Research* **Vol. 47** (1977)

Hurley, N. & Voo, R. Magnetostratigraphy, Late Devonian iridium anomaly, and impact hypotheses. *Geol* **18**, 291 (1990)

Gutstadt, A. Petrology and Depositional Environments of the Beck Spring Dolomite (Precambrian), Kingston Range, California. *SEPM Journal of Sedimentary Research* **Vol. 38** (1968)

Turner, C. & Peterson, F. Reconstruction of the Upper Jurassic Morrison Formation extinct ecosystem—a synthesis. *Sedimentary Geology* **167**, 309–355 (2004)

Miller, J., Ripperdan, R., Loch, J., Freeman, R., Evans, K., Taylor, J. & Tolbart, Z. Proposed GSSP for the base of Cambrian Stage 10 at the lowest occurrence of Eoconodontus notchpeakensis in the House Range, Utah, USA. *Annales de Paléontologie* **101**, 199–211 (2015)

Swennen, R., Vandeginste, V. & Ellam, R. Genesis of zebra dolomites (Cathedral Formation: CanadianCordillera Fold and Thrust Belt, British Columbia). *Journal of Geochemical Exploration,* 571–577 (2003)

Ricketts, B. The Evolution of a Middle Precambrian Dolostone Sequence–A Spectrum of Dolomitization Regimes. *SEPM Journal of Sedimentary Research* **Vol. 53** (1983)

Mahran, T. Late Oligocene lacustrine deposition of the Sodmin formation, Abu Hammad Basin, Red Sea, Egypt: sedimentology and factors controlling palustrine carbonates. *Journal of African Earth Sciences* **29**, 567–592 (1999)

Hasiotis, S. Reply to the Comments by Bromley et al. of the paper "Reconnaissance of the Upper Jurassic Morrison Formation ichnofossils, Rocky Mountain Region, USA: Paleoenvironmental, stratigraphic, and paleoclimatic significance of terrestrial and freshwater ichnocoenoses" by Stephen T. Hasiotis. *Sedimentary Geology* **208**, 61–68 (2008)

Johnson, M. Paleoecological structure in early silurian platform seas of the north American midcontinent. *Palaeogeography, Palaeoclimatology, Palaeoecology,* 191–215 (1980)

Pope, M. & Read, J. Ordovician metre-scale cycles: implications for climate and eustatic fluctuations in the central Appalachians during a global greenhouse, non-glacial to glacial transition. *Palaeogeography, Palaeoclimatology, Palaeoecology* **138**, 27–42 (1998)

Pelechaty, S., James, N., Kerans, C. & Grotzinger, J. A middle Proterozoic palaeokarst unconformity and associated sedimentary rocks, Elu Basin, northwest Canada. *Sedimentology* **38**, 775–797 (1991)

Nance, R. Model for the Precambrian evolution of the Avalon terrane in southern New Brunswick, Canada. *Geol* **15**, 753 (1987)

Whittaker, S., Sami, T., Kyser, T. & James, N. Petrogenesis of 1.9 Ga limestones and dolostones and their record of Paleoproterozoic environments. *Precambrian Research* **90**, 187–202 (1998)

Fahrig, W., Irving, E. & Jackson, G. Paleomagnetism of the Franklin Diabases. *Canadian Journal of Earth Sciences* **8**, 455–467 (1971)

Bergmann, K., Zentmyer, R. & Fischer, W. The stratigraphic expression of a large negative carbon isotope excursion from the Ediacaran Johnnie Formation, Death Valley. *Precambrian Research* **188**, 45–56 (2011)

Duane, M. & Al-Zamel, A. Syngenetic textural evolution of modern sabkha stromatolites (Kuwait). *Sedimentary Geology* **127**, 237–245 (1999)

Dixon, J. & Tirrul, R. Centrifuge modelling of fold—thrust structures in a tripartite stratigraphic succession. *Journal of Structural Geology* **13**, 3–20 (1991)

Surlyk, F. & Hurst, J. The evolution of the early Paleozoic deep-water basin of North Greenland. *Geol Soc America Bull* **95**, 131 (1984)

Bosak, T., Bush, J., Flynn, M., Liang, B., Ono, S., Petroff, A. & Sim, M. Formation and stability of oxygen-rich bubbles that shape photosynthetic mats. *Geobiology* **8**, 45–55 (2010)

Powell, W. Comparison of geochemical and distinctive mineralogical features associated with the Kinzers and Burgess Shale formations and their associated units. *Palaeogeography, Palaeoclimatology, Palaeoecology* **277**, 127–140 (2009)

Johnston, D., Poulton, S., Tosca, N., O'Brien, T., Halverson, G., Schrag, D. & Macdonald, F. Searching for an oxygenation event in the fossiliferous Ediacaran of northwestern Canada. *Chemical Geology,* 273–286 (2013)

Kvale, E., Johnson, A., Mickelson, D., Keller, K., Furer, L. & Archer, A. Middle Jurassic (Bajocian and Bathonian) Dinosaur Megatracksites, Bighorn Basin, Wyoming, U.S.A. *Palaios* **16**, 233–254 (2001)

Hill, A., Cotter, K. & Grey, K. Mid-Neoproterozoic biostratigraphy and isotope stratigraphy in Australia. *Precambrian Research* **1-3**, 281–298 (2000)

Noble, J. & Stempvoor, D. Early Burial Quartz Authigenesis in Silurian Platform Carbonates, New Brunswick, Canada. *SEPM Journal of Sedimentary Research* **Vol. 59** (1989)

Mudge, M. Structural geology of the Sun River Canyon and adjacent areas, northwestern Montana. Tech. Rep., USGS (1972)

Ojakangas, R., Morey, G. & Southwick, D. Paleoproterozoic basin development and sedimentation in the Lake Superior region, North America. *Sedimentary Geology,* 319–341 (2001)

Pratt, B. Oceanography, bathymetry and syndepositional tectonics of a Precambrian intracratonic basin: integrating sediments, storms, earthquakes and tsunamis in the Belt Supergroup (Helena Formation, ca. 1.45Ga), western North America. *Sedimentary Geology,* 371–394 (2001)

Howley, R., Rees, M. & Jiang, G. Significance of Middle Cambrian mixed carbonate-siliciclastic units for global correlation: southern Nevada, USA. *Palaeoworld* **15**, 360–366 (2006)

Cole, J. Major structural controls on the distribution of pre-Tertiary rocks, Nevada Test Site vicinity, southern Nevada. Tech. Rep., USGS (1997)

Nyberg, A. & William Schopf, J. Microfossils in stromatolitic cherts from the proterozoic allamoore formation of west texas. *Precambrian Research* **16**, 129–141 (1981)

Cook, H. & Taylor, M. Early Paleozoic continental margin sedimentation, trilobite biofacies, and the thermocline, western United States. *Geol* **3**, 559 (1975)

Lindsey, D. & Clark, R. Copper and uranium in Pennsylvanian and Permian sedimentary rocks, northern Sangre de Cristo Range, Colorado. Tech. Rep., USGS (1995)

Mazzullo, S. Significance of authigenic K-feldspar in Cambrian-Ordovician carbonate rocks of the proto-Atlantic shelf in North America; a discussion. *Journal of Sedimentary Research* **46**, 1035–1040 (1976)

Bromley, R. Marine phosphorites as depth indicators. *Marine Geology* **5**, 503–509 (1967)

Ridgley, J., Green, M., Pierson, C., Finch, W. & Lupe, R. Summary of the geology and resources of uranium in the San Juan Basin and adjacent region, New Mexico, Arizona, Utah, and Colorado. Tech. Rep., USGS (1978)

Young, G. Proterozoic plate tectonics, glaciation and iron-formations. *Sedimentary Geology* **58**, 127–144 (1988)

Tucker, M. Formerly Aragonitic Limestones Associated with Tillites in the Late Proterozoic of Death Valley, California. *SEPM Journal of Sedimentary Research* **Vol. 56** (1986)

Nance, R. & Dallmeyer, R. Structural and 40Ar/39Ar mineral age constraints for the tectonothermal evolution of the Green Head Group and Brookville Gneiss, southern New Brunswick, Canada: Implications for the configuration of the Avalon composite terrane. *Geological Journal* **29**, 293–322 (1994)

Edited by Sando, W. Shorter contributions to paleontology and stratigraphy. Tech. Rep., USGS (1991)

Turner, E., James, N. & Narbonne, G. Taphonomic Control on Microstructure in Early Neoproterozoic Reefal Stromatolites and Thrombolites. *Palaios* **15**, 87 (2000)

Narbonne, G., Kaufman, A. & Knoll, A. Integrated chemostratigraphy and biostratigraphy of the Windermere Supergroup, northwestern Canada: Implications for Neoproterozoic correlations and the early evolution of animals. *Geological Society of America Bulletin* **106**, 1281–1292 (1994)

McCollum, L. & Miller, D. Cambrian stratigraphy of the Wendover area, Utah and Nevada. Tech. Rep., USGS (1991)

Johnson, A. & Sorensen, H. Evaluation of high-purity limestones and dolostones in northern Michigan. *Geol Soc America Bull* **92**, 634 (1981)

Dornbos, S. Evolutionary palaeoecology of early epifaunal echinoderms: Response to increasing bioturbation levels during the Cambrian radiation. *Palaeogeography, Palaeoclimatology, Palaeoecology* **237**, 225–239 (2006)

Bose, S. & Chafetz, H. Topographic control on distribution of modern microbially induced sedimentary structures (MISS): A case study from Texas coast. *Sedimentary Geology* **213**, 136–149 (2009)

Schieber, J. The possible role of benthic microbial mats during the formation of carbonaceous shales in shallow Mid-Proterozoic basins. *Sedimentology* **33**, 521–536 (1986)

Armstrong, A. & MacKevett, E. The Triassic Chitistone Limestone, Wrangell Mountains, Alaska: stressing detailed descriptions of sabkha facies and other rocks in lower parts of the Chitistone and their relations to Kennecott-type copper deposits. Tech. Rep., USGS (1977)

Overstreet, R., Oboh-Ikuenobe, F. & Gregg, J. Sequence Stratigraphy and Depositional Facies of Lower Ordovician Cyclic Carbonate Rocks, Southern Missouri, U.S.A. *Journal of Sedimentary Research* **73**, 421–433 (2003)

Rodland, D. & Bottjer, D. Biotic Recovery from the End-Permian Mass Extinction: Behavior of the Inarticulate Brachiopod Lingula as a Disaster Taxon. *Palaios* **16**, 95 (2001)

Macdonald, F., Prave, A., Petterson, R., Smith, E., Pruss, S., Oates, K., Waechter, F., Trotzuk, D. & Fallick, A. The Laurentian record of Neoproterozoic glaciation, tectonism, and eukaryotic evolution in Death Valley, California. *Geological Society of America Bulletin* **125**, 1203–1223 (2013)

Fairchild, I., Einsele, G. & Song, T. Possible seismic origin of molar tooth structures in Neoproterozoic carbonate ramp deposits, north China. *Sedimentology* **44**, 611–636 (1997)

Fraiser, M. & Corsetti, F. Neoproterozoic Carbonate Shrubs: Interplay of Microbial Activity and Unusual Environmental Conditions in Post-Snowball Earth Oceans. *Palaios* **18**, 378–387 (2003)

Kahle, C. Facies and evolution of Silurian coral-microbialite reef complex, Maumee, Ohio, USA. *Journal of Sedimentary Research* **64**, 711–725 (1994)

Tysdal, R. Geology of the north end of the Ruby Range, southwestern Montana. Tech. Rep., USGS (1970)

Denson, N. & Waage, K. Some bauxite and clay deposits in northeastern Alabama. Tech. Rep., USGS (1966)

Parrish, J., Peterson, F. & Turner, C. Jurassic "savannah"—plant taphonomy and climate of the Morrison Formation (Upper Jurassic, Western USA). *Sedimentary Geology* **167**, 137–162 (2004)

Bertrand-sarfati, J. & Awramik, S. Stromatolites of the Mescal Limestone (Apache Group, middle Proterozoic, central Arizona): Taxonomy, biostratigraphy, and paleoenvironments. *Geological Society of America Bulletin* **104**, 1138–1155 (1992)

Gerdes, G., Klenke, T. & Noffke, N. Microbial signatures in peritidal siliciclastic sediments: a catalogue. *Sedimentology* **47**, 279–308 (2000)

Knox, L. & Gordon, E. Ostracodes as indicators of brackish water environments in the Catskill Magnafacies (Devonian) of New York State. *Palaeogeography, Palaeoclimatology, Palaeoecology* **148**, 9–22 (1999)

Zenger, D. Calcite-dolomite ratios vs. insoluble content in the Lockport Formation (Niagaran) in New York State. *Journal of Sedimentary Research* **35**, 262–265 (1965)

Beukes, N. Facies relations, depositional environments and diagenesis in a major early Proterozoic stromatolitic carbonate platform to basinal sequence, Campbellrand Subgroup, Transvaal Supergroup, Southern Africa. *Sedimentary Geology* **54**, 1–46 (1987)

Barnes, C. Stratigraphy And Sedimentary Environments Of Some Wilderness (ordovician) Limestones, Ottawa Valley, Ontario. *Canadian Journal of Earth Sciences* **4**, 209–244 (1967)

Hurley, N. & Van Der Voo, R. Paleomagnetism of Upper Devonian reefal limestones, Canning basin, Western Australia. *Geol Soc America Bull* **98**, 138 (1987)

Coulson, K. & Brand, L. Lithistid Sponge-microbial Reef-building Communities Construct Laminated, Upper Cambrian (furongian) 'stromatolites'. *Palaios* **31**, 358–370 (2016)

Tobin, K. The paleoecology and significance of the Gunflint-type microbial assemblages from the Frere Formation (Early Proterozoic), Nabberu Basin, Western Australia. *Precambrian Research* **47**, 71–81 (1990)

Lozano, R., Delvene, G., Piñuela, L. & García-Ramos, J. Late Jurassic biogeochemical microenvironments associated with microbialite-coated unionids (Bivalvia), Asturias (N Spain). *Palaeogeography, Palaeoclimatology, Palaeoecology,* 80–97 (2016)

Cloud, J. Geology and bauxite deposits of the Rock Run and Goshen Valley areas, northeast Alabama. Tech. Rep., USGS (1967)

Thomas, M., Gibb, R. & Quince, J. New evidence from offset aeromagnetic anomalies for transcurrent faulting associated with the Bathurst and McDonald faults, Northwest Territories. *Canadian Journal of Earth Sciences* **13**, 1244–1250 (1976)

Fagerstrom, J. Stratigraphic And Paleogeographic Significance Of The Holland Quarry Shale (lower Devonian), Northwestern Ohio. *Geol Soc America Bull* **78**, 1185 (1967)

Rankey, E. & Lehrmann, D. Anatomy and origin of toplap in a mixed carbonate-clastic system, Seven Rivers Formation (Permian, Guadalupian), Guadalupe Mountains, New Mexico, USA. *Sedimentology* **43**, 807–826 (1996)

edited by Bartsch-Winkler, S. Mineral and energy resources of the BLM Roswell Resource Area, east-central New Mexico. Tech. Rep., USGS (1992)

Fraser, J. & Tremblay, L. Correlation of Proterozoic strata in the northwestern Canadian Shield. *Canadian Journal of Earth Sciences* **6**, 1–9 (1969)

Ryder, R., Fouch, T. & Elison, J. Early Tertiary sedimentation in the western Uinta Basin, Utah. *Geol Soc America Bull* **87**, 496 (1976)

Riding, R. Microbial carbonate abundance compared with fluctuations in metazoan diversity over geological time. *Sedimentary Geology* **185**, 229–238 (2006)

Bryant, B. Geology of the Aspen 15-minute quadrangle, Pitkin and Gunnison counties, Colorado. Tech. Rep., USGS (1979)

Keller, M. & Lehnert, O. Ordovician paleokarst and quartz sand: Evidence of volcanically triggered extreme climates? *Palaeogeography, Palaeoclimatology, Palaeoecology* **296**, 297–309 (2010)

Baudet, D., Aitken, J. & Vanguestaine, M. Palynology of uppermost Proterozoic and lowermost Cambrian formations, central Mackenzie Mountains, northwestern Canada. *Canadian Journal of Earth Sciences* **26**, 129–148 (1989)

Kah, L. & Knoll, A. Microbenthic distribution of Proterozoic tidal flats: Environmental and taphonomic considerations. *Geol* **24**, 79 (1996)

Hayes, P. & assisted by Cone, G. Cambrian and Ordovician rocks of southern Arizona and New Mexico and westernmost Texas. Tech. Rep., USGS (1975)

Simonson, B. Sedimentology of cherts in the Early Proterozoic Wishart Formation, Quebec-Newfoundland, Canada. *Sedimentology* **32**, 23–40 (1985)

Young, G. Origin of Carbonate-Rich Early Proterozoic Espanola Formation, Ontario, Canada. *Geol Soc America Bull* **84**, 135 (1973)

Sando, W. Shorter contributions to paleontology and stratigraphy. Tech. Rep., USGS (1990)

Brett, C., Liddell, W. & Derstler, K. Late Cambrian hard substrate communities from Montana/Wyoming: the oldest known hardground encrusters. *Lethaia* **16**, 281–289 (1983)

Gore, P. Toward a model for open- and closed-basin deposition in ancient lacustrine sequences: The Newark Supergroup (Triassic-Jurassic), Eastern North America. *Palaeogeography, Palaeoclimatology, Palaeoecology* **70**, 29–51 (1989)

Wade, M., Agresti, D., Wdowiak, T., Armendarez, L. & Farmer, J. A Mössbauer investigation of iron-rich terrestrial hydrothermal vent systems: Lessons for Mars exploration. *Journal of Geophysical Research: Planets* **104**, 8489–8507 (1999)

Corsetti, F. Origin and Significance of Tube Structures in Neoproterozoic Post-glacial Cap Carbonates: Example from Noonday Dolomite, Death Valley, United States. *Palaios* **20**, 348–362 (2005)

Bosak, T., Souza-Egipsy, V., Corsetti, F. & Newman, D. Micrometer-scale porosity as a biosignature in carbonate crusts. *Geol* **32**, 781 (2004)

Walter, M. & Heys, G. Links between the rise of the metazoa and the decline of stromatolites. *Precambrian Research* **29**, 149–174 (1985)

Wright, L., Williams, E. & Cloud, P. Algal and cryptalgal structures and platform environments of the late pre-Phanerozoic Noonday Dolomite, eastern California. *Geol Soc America Bull* **89**, 321 (1978)

Dumoulin, J. & Harris, A. Depositional framework and regional correlation of pre-Carboniferous metacarbonate rocks of the Snowden Mountain area, central Brooks Range, Northern Alaska. Tech. Rep., USGS (1994)

Yochelson, E. The Bulletin of the Geological Society of America and Charles Doolittle Walcott. *Geological Society of America Bulletin* **100**, 3–11 (1988)

Laymon, C. Glacial geology of western Hudson Strait, Canada, with reference to Laurentide Ice Sheet dynamics. *Geological Society of America Bulletin* **104**, 1169–1177 (1992)

Elmore, R., Cates, K., Gao, G. & Land, L. Geochemical constraints on the origin of secondary magnetizations in the Cambro-Ordovician Royer Dolomite, Arbuckle Mountains, southern Oklahoma. *Physics of the Earth and Planetary Interiors* **85**, 3–13 (1994)

Reolid, M. & Molina, J. Serpulid-frutexites Assemblage From Shadow-cryptic Environments In Jurassic Marine Caves, Betic Cordillera, Southern Spain. *Palaios* **25**, 468–474 (2010)

Nehza, O., Dix, G. & Jin, J. Stratigraphic restriction of stromatolites in a Middle and Upper Ordovician foreland-platform succession (Ottawa Embayment, eastern Ontario). *Canadian Journal of Earth Sciences* **49**, 1177–1199 (2012)

Mahon, R., Dehler, C., Link, P., Karlstrom, K. & Gehrels, G. Geochronologic and stratigraphic constraints on the Mesoproterozoic and Neoproterozoic Pahrump Group, Death Valley, California: A record of the assembly, stability, and breakup of Rodinia. *Geological Society of America Bulletin* **126**, 652–664 (2014)

Labotka, T., Albee, A., Lanphere, M. & McDowell, S. Stratigraphy, Structure, and Metamorphism in the Central Panamint Mountains (Telescope Peak Quadrangle), Death Valley Area, California. *Geological Society of America Bulletin* **91**, 843–933 (1980)

Rast, N., O'brien, B. & Wardle, R. Relationships between Precambrian and Lower Palaeozoic rocks of the 'Avalon Platform' in New Brunswick, the northeast Appalachians and the British Isles. *Tectonophysics* **30**, 315–338 (1976)

Chauvel, J. & Dimroth, E. Facies Types and Depositional Environment of the Sokoman Iron Formation, Central Labrador Trough, Quebec, Canada. *SEPM Journal of Sedimentary Research* **Vol. 44** (1974)

Clapham, M. & Corsetti, F. Deep valley incision in the terminal Neoproterozoic (Ediacaran) Johnnie Formation, eastern California, USA: Tectonically or glacially driven? *Precambrian Research* **141**, 154–164 (2005)

Mata, S., Harwood, C., Corsetti, F., Stork, N., Eilers, K., Berelson, W. & Spear, J. Influence Of Gas Production And Filament Orientation On Stromatolite Microfabric. *Palaios* **27**, 206–219 (2012)

Myrow, P., Strauss, J., Creveling, J., Sicard, K., Ripperdan, R., Sandberg, C. & Hartenfels, S. A carbon isotopic and sedimentological record of the latest Devonian (Famennian) from the Western U.S. and Germany. *Palaeogeography, Palaeoclimatology, Palaeoecology* **306**, 147–159 (2011)

Cailteux, J., Kampunzu, A. & Lerouge, C. The Neoproterozoic Mwashya–Kansuki sedimentary rock succession in the central African Copperbelt, its Cu–Co mineralisation, and regional correlations. *Gondwana Research* **11**, 414–431 (2007)

Rodland, D. & Bottjer, D. Biotic Recovery from the End-Permian Mass Extinction: Behavior of the Inarticulate Brachiopod Lingula as a Disaster Taxon. *Palaios* **16**, 95–101 (2001)

Markun, C. & Randazzo, A. Sedimentary structures in the Gunflint Iron Formation, Schreiber Beach, Ontario. *Precambrian Research* **12**, 287–310 (1980)

Grosjean, E., Love, G., Stalvies, C., Fike, D. & Summons, R. Origin of petroleum in the Neoproterozoic–Cambrian South Oman Salt Basin. *Organic Geochemistry* **40**, 87–110 (2009)

Pruss, S., Bottjer, D., Corsetti, F. & Baud, A. A global marine sedimentary response to the end-Permian mass extinction: Examples from southern Turkey and the western United States. *Earth-Science Reviews* **3-4**, 193–206 (2006)

McMenamin, D., Kumar, S. & Awramik, S. Microbial fossils from the Kheinjua Formation, Middle Proterozoic Semri Group (Lower Vindhyan) Son Valley area, central India. *Precambrian Research* **3-4**, 247–271 (1983)

Strauss, H. The sulfur isotopic record of Precambrian sulfates: new data and a critical evaluation of the existing record. *Precambrian Research* **63**, 225–246 (1993)

Edited by Bartsch-Winkler, S. & Donatich, A. Mineral and Energy Resources of the Roswell Resource Area, East-Central New Mexico. Tech. Rep., USGS (1995)

Hofmann, H. & Jackson, G. Proterozoic ministromatolites with radial-fibrous fabric. *Sedimentology* **34**, 963–971 (1987)

Rivers, T. & Corrigan, D. Convergent margin on southeastern Laurentia during the Mesoproterozoic: tectonic implications. *Canadian Journal of Earth Sciences* **37**, 359–383 (2000)

Skotnicki, S. & Knauth, L. The Middle Proterozoic Mescal Paleokarst, Central Arizona, U.S.A.: Karst Development, Silicification, and Cave Deposits. *Journal of Sedimentary Research* **77**, 1046–1062 (2007)

Misi, A. & Kyle, J. Upper Proterozoic Carbonate Stratigraphy, Diagenesis, and Stromatolitic Phosphorite Formation, Irece Basin, Bahia, Brazil. *SEPM Journal of Sedimentary Research* **Vol. 64A** (1994)

McCracken, A. & Nowlan, G. Conodont paleontology and biostratigraphy of Ordovician carbonates and petroliferous carbonates on Southampton, Baffin, and Akpatok islands in the eastern Canadian Arctic. *Canadian Journal of Earth Sciences* **26**, 1880–1903 (1989)

Swett, K. & Knoll, A. Stromatolitic bioherms and microphytolites from the late proterozoic draken conglomerate formation, spitsbergen. *Precambrian Research* **28**, 327–347 (1985)

Campbell, K., Guido, D., Gautret, P., Foucher, F., Ramboz, C. & Westall, F. Geyserite in hot-spring siliceous sinter: Window on Earth's hottest terrestrial (paleo)environment and its extreme life. *Earth-Science Reviews,* 44–64 (2015)

Bickford, M., Soegaard, K., Nielsen, K. & McLelland, J. Geology and geochronology of Grenville-age rocks in the Van Horn and Franklin Mountains area, west Texas: Implications for the tectonic evolution of Laurentia during the Grenville. *Geological Society of America Bulletin* **112**, 1134–1148 (2000)

Olszewski, T. & Patzkowsky, M. From Cyclothems to Sequences: The Record of Eustasy and Climate on an Icehouse Epeiric Platform (Pennsylvanian-Permian, North American Midcontinent). *Journal of Sedimentary Research* **73**, 15–30 (2003)

Davis, B. & Mosher, S. Complex structural and fluid flow evolution along the Grenville Front, west Texas. *Geosphere* **11**, 868–898 (2015)

Ludvigsen, R. Ordovician Formations and Faunas, Southern Mackenzie Mountains. *Canadian Journal of Earth Sciences* **12**, 663–697 (1975)

(2), G. & Land, L. Early Ordovician Cool Creek Dolomite, Middle Arbuckle Group, Slick Hills, Sw Oklahoma, U.S.A.: Origin and Modification. *SEPM Journal of Sedimentary Research* **Vol. 61** (1991)

Tysdal, R. Paleozoic and Mesozoic stratigraphy of the northern part of the Ruby Range, southwestern Montana. Tech. Rep., USGS (1976)

Palmer, A. & Halley, R. Physical stratigraphy and trilobite biostratigraphy of the Carrara Formation (Lower and Middle Cambrian) in the southern Great Basin. Tech. Rep., USGS (1979)

Soja, C. Island Arc Carbonates from the Silurian Heceta Formation of Southeastern Alaska (Alexander Terrane). *SEPM Journal of Sedimentary Research* **Vol. 60** (1990)

Krajewski, K. Early diagenetic phosphate cements in the Albian condensed glauconitic limestone of the Tatra Mountains, Western Carpathians. *Sedimentology* **31**, 443–470 (1984)

Acharyya, S. India and Southeast Asia in Gondwanaland fit. *Tectonophysics* **56**, 261–275 (1979)

Whipple, J. Depositional environment of the middle Proterozoic Spokane Formation; Empire Formation transition zone, west-central Montana. Tech. Rep., USGS (1980)

Topping, D. Paleogeographic reconstruction of the Death Valley extended region: Evidence from Miocene large rock-avalanche deposits in the Amargosa Chaos Basin, California. *Geological Society of America Bulletin* **105**, 1190–1213 (1993)

Wrucke, C., Kelley, J. & Armstrong, A. Preliminary geologic map and structural setting of the Katakuruk Dolomite in the Sadlerochit Mountains, northeastern Alaska. Tech. Rep., USGS (1989)

Barnett, S. Upper Cayugan and Helderbergian Stratigraphy of Southeastern New York and Northern New Jersey. *Geol Soc America Bull* **81**, 2375 (1970)

Davis, R. Algal stromatolites composed of quartz sandstone. *Journal of Sedimentary Research* **38**, 953–955 (1968)

Loope, D. Eolian Origin of Upper Paleozoic Sandstones, Southeastern Utah. *SEPM Journal of Sedimentary Research* **Vol. 54** (1984)

James, H., Clark, L., Lamey, C. & Pettijohn, F. Geology of central Dickinson County, Michigan. Tech. Rep., USGS (1961)

Cole, D., Myrow, P., Fike, D., Hakim, A. & Gehrels, G. Uppermost Devonian (Famennian) to Lower Mississippian events of the western U.S.: Stratigraphy, sedimentology, chemostratigraphy, and detrital zircon geochronology. *Palaeogeography, Palaeoclimatology, Palaeoecology,* 1–19 (2015)

Horodyski, R. Sedimentary geology and stromatolites of the Middle Proterozoic Belt Supergroup, Glacier National Park, Montana. *Precambrian Research* **20**, 391–425 (1983)

Beyer, L. & Bartow, J. Summary of geology and petroleum plays used to assess undiscovered recoverable petroleum resources, San Joaquin Basin Province, California. Tech. Rep., USGS (1988)

Jones, B. & Dixon, O. Stratigraphy and sedimentology of Upper Silurian rocks, northern Somerset Island, Arctic Canada. *Canadian Journal of Earth Sciences* **14**, 1427–1452 (1977)

Pratt, B. Seismites in the Mesoproterozoic Altyn Formation (Belt Supergroup), Montana: A test for tectonic control of peritidal carbonate cyclicity. *Geol* **22**, 1091 (1994)

Horodyski, R. & Allan Donaldson, J. Microfossils from the Middle Proterozoic Dismal Lakes Groups, Arctic Canada. *Precambrian Research* **11**, 125–159 (1980)

King, P. Precambrian geology of the United States; an explanatory text to accompany the geologic map of the United States. Tech. Rep., USGS (1976)

Bertrand-Sarfati, J. & Walter, M. Stromatolite biostratigraphy. *Precambrian Research* **15**, 353–371 (1981)

Young, G. Upper proterozoic supracrustal rocks of North America: A brief review. *Precambrian Research* **15**, 305–330 (1981)

Alberstadt, L., Walker, K. & Zurawski, R. Patch Reefs in the Carters Limestone (Middle Ordovician) in Tennessee, and Vertical Zonation in Ordovician Reefs. *Geol Soc America Bull* **85**, 1171 (1974)

Aspler, L., Cousens, B. & Chiarenzelli, J. Griffin gabbro sills (2.11 Ga), Hurwitz Basin, Nunavut, Canada: long-distance lateral transport of magmas in western Churchill Province crust. *Precambrian Research* **117**, 269–294 (2002)

Cheadle, B. Alluvial–playa sedimentation in the lower Keweenawan Sibley Group, Thunder Bay District, Ontario. *Canadian Journal of Earth Sciences* **23**, 527–542 (1986)

Weir, G., Peterson, W. & Swadley, W. Lithostratigraphy of Upper Ordovician strata exposed in Kentucky. Tech. Rep., USGS (1984)

Karlstrom, K., Bowring, S., Dehler, C., Knoll, A., Porter, S., Des Marais, D., Weil, A., Sharp, Z., Geissman, J., Elrick, M., Timmons, J., Crossey, L. & Davidek, K. Chuar Group of the Grand Canyon: Record of breakup of Rodinia, associated change in the global carbon cycle, and ecosystem expansion by 740 Ma. *Geol* **28**, 619 (2000)

Romero, G., Sanchez, E., Morais, L., Boggiani, P. & Fairchild, T. Tubestone microbialite association in the Ediacaran cap carbonates in the southern Paraguay Fold Belt (SW Brazil): Geobiological and stratigraphic implications for a Marinoan cap carbonate. *Journal of South American Earth Sciences,* 172–181 (2016)

Kosa, E. & Hunt, D. Heterogeneity in Fill and Properties of Karst-Modified Syndepositional Faults and Fractures: Upper Permian Capitan Platform, New Mexico, U.S.A. *Journal of Sedimentary Research* **76**, 131–151 (2006)

Dean, W. & Eggleston, J. Freshwater oncolites created by industrial pollution, Onondaga Lake, New York. *Sedimentary Geology* **40**, 217–232 (1984)

Fairchild, T. & Subacius, S. Microfossils associated with silicified Stratifera undata Komar 1966 from the late Proterozoic Bambuí Group, south-central Brazil. *Precambrian Research* **33**, 323–339 (1986)

Lanier, W. Structure and Morphogenesis of Microstromatolites from the Transvaal Supergroup, South Africa. *SEPM Journal of Sedimentary Research* **Vol. 58** (1988)

Yuzuo,, L., Shixing,, Z., Luyi,, Z., Renguan,, C., Zhenjia,, G. & De'An,, B. Stromatolite assemblages of the late precambrian in China. *Precambrian Research* **29**, 15–32 (1985)

James, N., Narbonne, G. & Kyser, T. Late Neoproterozoic cap carbonates: Mackenzie Mountains, northwestern Canada: precipitation and global glacial meltdown. *Canadian Journal of Earth Sciences* **38**, 1229–1262 (2001)

Ryder, R. Oil and gas resources of the Cincinnati arch, Ohio, Indiana, Kentucky, and Tennessee. Tech. Rep., USGS (1987)

Planavsky, N., Rouxel, O., Bekker, A., Shapiro, R., Fralick, P. & Knudsen, A. Iron-oxidizing microbial ecosystems thrived in late Paleoproterozoic redox-stratified oceans. *Earth and Planetary Science Letters* **286**, 230–242 (2009)

Altermann, W. & Schopf, J. Microfossils from the Neoarchean Campbell Group, Griqualand West Sequence of the Transvaal Supergroup, and their paleoenvironmental and evolutionary implications. *Precambrian Research* **75**, 65–90 (1995)

Wisniowiecki, M., Van der Voo, R., McCabe, C. & Kelly, W. A Pennsylvanian paleomagnetic pole from the mineralized Late Cambrian Bonneterre Formation, southeast Missouri. *Journal of Geophysical Research* **88**, 6540 (1983)

Hoffman, P., Halverson, G., Domack, E., Husson, J., Higgins, J. & Schrag, D. Are basal Ediacaran (635 Ma) post-glacial "cap dolostones" diachronous? *Earth and Planetary Science Letters* **258**, 114–131 (2007)

Williams, L. Deposition of the Bear Gulch Limestone: a Carboniferous Plattenkalk from central Montana. *Sedimentology* **30**, 843–860 (1983)

Hurst, J. & Sheehan, P. Depositional environments along a carbonate shelf to basin transect in the Silurian of Nevada, U.S.A. *Sedimentary Geology* **44**, 143–171 (1985)

Zhan, R., Jin, J., Liu, J., Corcoran, P., Luan, X. & Wei, X. Meganodular limestone of the Pagoda Formation: A time-specific carbonate facies in the Upper Ordovician of South China. *Palaeogeography, Palaeoclimatology, Palaeoecology* (2015)

Pruss, S., Bosak, T., Macdonald, F., McLane, M. & Hoffman, P. Microbial facies in a Sturtian cap carbonate, the Rasthof Formation, Otavi Group, northern Namibia. *Precambrian Research* **181**, 187–198 (2010)

Kaufman, A., Corsetti, F. & Varni, M. The effect of rising atmospheric oxygen on carbon and sulfur isotope anomalies in the Neoproterozoic Johnnie Formation, Death Valley, USA. *Chemical Geology* **237**, 47–63 (2007)

Kendall, C. An Environmental Re-interpretation of the Permian Evaporite/Carbonate Shelf Sediments of the Guadalupe Mountains. *Geol Soc America Bull* **80**, 2503 (1969)

Mozley, P., Heath, J., Dewers, T. & Bauer, S. Origin and heterogeneity of pore sizes in the Mount Simon Sandstone and Eau Claire Formation: Implications for multiphase fluid flow. *Geosphere* **12**, 1341–1361 (2016)

Howell, B., Roberts, H. & Willard, B. Subdivision And Dating Of The Cambrian Of Eastern Pennsylvania. *Geol Soc America Bull* **61**, 1355 (1950)

Silberling, N., Nichols, K., Macke, D. & Trappe, J. Upper Devonian-Mississippian stratigraphic sequences in the Distal Antler Foreland of western Utah and adjoining Nevada. Tech. Rep., USGS (1995)

Zenger, D. Significance of Supratidal Dolomitization in the Geologic Record. *Geol Soc America Bull* **83**, 1 (1972)

Frank, T. & Lyons, T. "Molar-tooth" structures: A geochemical perspective on a Proterozoic enigma. *Geol* **26**, 683 (1998)

Lan, Z. Paleoproterozoic microbially induced sedimentary structures from lagoonal depositional settings in northern China. *Sedimentary Geology,* 87–95 (2015)

Edited by Silberman, M., Field, C. & Berry, A. Proceedings of the Symposium on Mineral Deposits of the Pacific Northwest: Geological Society of America, Cordilleran Section meeting at Corvallis, Oregon, MArch 20-21, 1980. Tech. Rep., USGS (1981)

Englund, K. & Thomas, R. Late Paleozoic depositional trends in the central Appalachian Basin. Tech. Rep., USGS (1990)

Stevenson, G. & Beus, S. Stratigraphy and depositional setting of the upper Precambrian Dox Formation in Grand Canyon. *Geol Soc America Bull* **93**, 163 (1982)

Cappa, J. & Rice, D. Carbon dioxide in Mississippian rocks of the Paradox Basin and adjacent areas, Colorado, Utah, New Mexico, and Arizona. Tech. Rep., USGS (1995)

Kendall, A. Compaction in halite-cemented carbonates - the Dawson Bay Formation (Middle Devonian) of Saskatchewan, Canada. *Sedimentology* **47**, 151–171 (2000)

Maliva, R. Silicification in the Belt Supergroup (Mesoproterozoic), Glacier National Park, Montana, USA. *Sedimentology* **48**, 887–896 (2001)

Papineau, D., Mojzsis, S. & Schmitt, A. Multiple sulfur isotopes from Paleoproterozoic Huronian interglacial sediments and the rise of atmospheric oxygen. *Earth and Planetary Science Letters* **255**, 188–212 (2007)

Schröder, S., Grotzinger, J., Amthor, J. & Matter, A. Carbonate deposition and hydrocarbon reservoir development at the Precambrian–Cambrian boundary: The Ara Group in South Oman. *Sedimentary Geology* **1-2**, 1–28 (2005)

Algouti, A., Algouti, A., Chbani, B. & Zaim, M. Sedimentation et volcanisme synsédimentaire de la série de base de l'adoudounien infra-cambrien à travers deux exemples de l'Anti-Atlas du Maroc. *Journal of African Earth Sciences* **32**, 541–556 (2001)

Markello, J. & Read, J. Carbonate ramp-to-deeper shale shelf transitions of an Upper Cambrian intrashelf basin, Nolichucky Formation, Southwest Virginia Appalachians. *Sedimentology* **28**, 573–597 (1981)

Gray, J. Evolution of the freshwater ecosystem: The fossil record. *Palaeogeography, Palaeoclimatology, Palaeoecology* **62**, 1–214 (1988)

Shaver, R. Silurian Reef Geometry–New Dimensions to Explore SEPM Presidential Address, Washington, D.C., June 13, 1977. *SEPM Journal of Sedimentary Research* **Vol. 47** (1977)

Perry, C. Freshwater tufa stromatolites in the basal Purbeck Formation (Upper Jurassic), Isle of Portland, Dorset. *Geological Journal* **29**, 119–135 (1994)

Young, F. Early Cambrian and Older Trace Fossils from the Southern Cordillera of Canada. *Canadian Journal of Earth Sciences* **9**, 1–17 (1972)

Nelson, G., Pufahl, P. & Hiatt, E. Paleoceanographic constraints on Precambrian phosphorite accumulation, Baraga Group, Michigan, USA. *Sedimentary Geology* **226**, 9–21 (2010)

Murphy, R., Van Kranendonk, M., Kelloway, S. & Wainwright, I. Complex patterns in fossilized stromatolites revealed by hyperspectral imaging (400-2496 nm). *Geobiology* **14**, 419–439 (2016)

Vidal, G. & Ford, T. Microbiotas from the late proterozoic chuar group (northern Arizona) and uinta mountain group (Utah) and their chronostratigraphic implications. *Precambrian Research* **28**, 349–389 (1985)

Sheridan, D., Maxwell, C., Albee, A. & Van Horn, R. Geology and uranium deposits of the Ralston Buttes district, Jefferson County, Colorado, with sections on Paleozoic and younger sedimentary rocks. Tech. Rep., USGS (1967)

Rieu, R., Allen, P., Etienne, J., Cozzi, A. & Wiechert, U. A Neoproterozoic glacially influenced basin margin succession and 'atypical' cap carbonate associated with bedrock palaeovalleys, Mirbat area, southern Oman. *Basin Research* **18**, 471–496 (2006)

Geeslin, J. & Chafetz, H. Ordovician Aleman Ribbon Cherts: An Example of Silicification Prior to Carbonate Lithification. *SEPM Journal of Sedimentary Research* **Vol. 52** (1982)

Spinks, S., Parnell, J., Bowden, S., Taylor, R. & Maclean, M. Enhanced organic carbon burial in large Proterozoic lakes: Implications for atmospheric oxygenation. *Precambrian Research* **255**, 202–215 (2014)

Gunatilaka, A. Some aspects of the biology and sedimentology of laminated algal mats from mannar lagoon, Northwest Ceylon. *Sedimentary Geology* **14**, 275–300 (1975)

Wood, G. & Armstrong, A. Diagenesis and stratigraphy of the Lisburne Group limestones of the Sadlerochit Mountains and adjacent areas, northeastern Alaska. Tech. Rep., USGS (1975)

Elmore, R. Precambrian non-marine stromatolites in alluvial fan deposits, the Copper Harbor Conglomerate, upper Michigan. *Sedimentology* **30**, 829–842 (1983)

Brasier, A. Searching for travertines, calcretes and speleothems in deep time: Processes, appearances, predictions and the impact of plants. *Earth-Science Reviews* **104**, 213–239 (2011)

Butterfield, N. Paleobiology of the late Mesoproterozoic (ca. 1200 Ma) Hunting Formation, Somerset Island, arctic Canada. *Precambrian Research* **111**, 235–256 (2001)

Fralick, P. & Riding, R. Steep Rock Lake: Sedimentology and geochemistry of an Archean carbonate platform. *Earth-Science Reviews* (2015)

McGILL, G. & Sommers, D. Stratigraphy and Correlation of the Precambrian Belt Supergroup of the Southern Lewis and Clark Range, Montana. *Geol Soc America Bull* **78**, 343 (1967)

Sando, W. Shorter contributions to paleontology and stratigraphy. Tech. Rep., USGS (1988)

Erlich, R., Farfan, P. & Hallock, P. Biostratigraphy, depositional environments, and diagenesis of the Tamana Formation, Trinidad: a tectonic marker horizon. *Sedimentology* **40**, 743–768 (1993)

Rhodes, F. The course of evolution. *Proceedings of the Geologists' Association* **77**, 1–53 (1966)

(U.S.), G. Geological Survey Research 1966, Chapter C. Tech. Rep., USGS (1966)

Golyshev, S., Verkhovskaya, N., Burkova, V. & Matis, E. Stable carbon isotopes in source-bed organic matter of West and East Siberia. *Organic Geochemistry* **17**, 277–291 (1991)

Park, A., Williams, P., Ralser, S. & Léger, A. Geometry and kinematics of a major crustal shear zone segment in the Appalachians of southern New Brunswick. *Canadian Journal of Earth Sciences* **31**, 1523–1535 (1994)

Harris, A., Stamm, N., Weary, D., Repetski, J., Stamm, R. & Parker, R. Conodont color alteration index (CAI) map and conodont-based age determinations for the Winchester 30' x 60' Quadrangle and adjacent area, Virginia, West Virginia, and Maryland. Tech. Rep., USGS (1994)

Harland, T. & Pickerill, R. A review of Middle Ordovician sedimentation in the St. Lawrence Lowland, eastern Canada. *Geological Journal* **17**, 135–156 (1982)

Kauffman, E., Arthur, M., Howe, B. & Scholle, P. Widespread venting of methane-rich fluids in Late Cretaceous (Campanian) submarine springs (Tepee Buttes), Western Interior seaway, U.S.A. *Geol* **24**, 799 (1996)

Morris, H. Preliminary geologic map of the Delta 2 degrees Quadrangle Tooele, Juab, Millard, and Utah Counties, Utah. Tech. Rep., USGS (1987)

Wright, L. Acknowledgements of a professional lifetime. *Earth-Science Reviews* **1-4**, 3–11 (2005)

Willard, B. Stratigraphy of the Cambrian Sedimentary Rocks of Eastern Pennsylvania. *Geol Soc America Bull* **72**, 1765 (1961)

Milliman, J. & Manheim, F. Submarine encrustation of a Byzantine nail. *Journal of Sedimentary Research* **38**, 950–953 (1968)

Myrow, P., Taylor, J., Miller, J., Ethington, R., Ripperdan, R. & Allen, J. Fallen arches: Dispelling myths concerning Cambrian and Ordovician paleogeography of the Rocky Mountain region. *Geological Society of America Bulletin* **115**, 695–713 (2003)

Coniglio, M., Frizzell, R. & Pratt, B. Reef-capping laminites in the Upper Silurian carbonate- to-evaporite transition, Michigan Basin, south-western Ontario. *Sedimentology* **51**, 653–668 (2004)

Schleicher, D. A model for earthquakes near Palisades Reservoir, southeast Idaho. Tech. Rep., USGS (1975)

Shields, G. 'Molar-tooth microspar': a chemical explanation for its disappearance ∼ 750 Ma. *Terra Nova* **14**, 108–113 (2002)

Pollock, M., Kah, L. & Bartley, J. Morphology of Molar-Tooth Structures in Precambrian Carbonates: Influence of Substrate Rheology and Implications for Genesis. *Journal of Sedimentary Research* **76**, 310–323 (2006)

Bond, I. & Greggs, R. Revision of the Oxford Formation (Arenig) of southeastern Ontario and northern New York State. *Canadian Journal of Earth Sciences* **13**, 19–26 (1976)

Snavely, P., Niem, A., Macleod, N., Pearl, J. & Rau, W. Makah Formation; a deep-marginal-basin sequence of late Eocene and Oligocene age in the northwestern Olympic Peninsula, Washington. Tech. Rep., USGS (1980)

Dix, G., Nehza, O. & Okon, I. Tectonostratigraphy of the Chazyan (Late Middle-Early Late Ordovician) Mixed Siliciclastic-Carbonate Platform, Quebec Embayment. *Journal of Sedimentary Research* **83**, 451–474 (2013)

Young, G. & (2), D. Carbonate Sedimentation in a Late Precambrian Shelf Sea, Victoria Island, Canadian Arctic Archipelago. *SEPM Journal of Sedimentary Research* **Vol. 47** (1977)

Walsh, M. Microfossils and possible microfossils from the early archean onverwacht group, Barberton mountain land, South Africa. *Precambrian Research* **54**, 271–293 (1992)

Foster, C., Reed, J. & Wicander, R. Gloeocapsomorpha prisca Zalessky, 1917: A new study Part I: Taxonomy, Geochemistry, and paleoecology. *Geobios* **22**, 735–759 (1989)

Young, G. Stratigraphy, paleocurrents and stromatolites of Hadrynian (Upper Precambrian) rocks of Victoria Island, Arctic Archipelago, Canada. *Precambrian Research* **1**, 13–41 (1974)

Blair, T. Mixed Siliciclastic-Carbonate Marine and Continental Syn-Rift Sedimentation, Upper Jurassic-Lowermost Cretaceous Todos Santos and San Ricardo Formations, Western Chiapas, Mexico. *SEPM Journal of Sedimentary Research* **Vol. 58** (1988)

Craig, J., Biffi, U., Galimberti, R., Ghori, K., Gorter, J., Hakhoo, N., Le Heron, D., Thurow, J. & Vecoli, M. The palaeobiology and geochemistry of Precambrian hydrocarbon source rocks. *Marine and Petroleum Geology,* 1–47 (2013)

Ross, G., Villeneuve, M. & Theriault, R. Isotopic provenance of the lower Muskwa assemblage (Mesoproterozoic, Rocky Mountains, British Columbia): new clues to correlation and source areas. *Precambrian Research* **111**, 57–77 (2001)

(2), R. Correlation Of Fine Carbonaceous Bands Across A Precambrian Stagnant Basin. *SEPM Journal of Sedimentary Research* **Vol. 43** (1973)

Keppie, J., Dallmeyer, R. & Murphy, J. Tectonic implications of 40Ar/ 39Ar hornblende ages from late Proterozoic-Cambrian plutons in the Avalon Composite Terrane, Nova Scotia, Canada. *Geological Society of America Bulletin* **102**, 516–528 (1990)

(2), J. Evolution of Early Proterozoic Passive-Margin Carbonate Platform, Rocknest Formation, Wopmay Orogen, Northwest Territories, Canada. *SEPM Journal of Sedimentary Research* **Vol. 56** (1986)

Greggs, R. & Sargent, M. Algal Bioherms of the Upper Gull River Formation (Middle Ordovician) near Kingston, Ontario. *Canadian Journal of Earth Sciences* **8**, 1373–1381 (1971)

Martin, J., Braga, J. & Robe, R. Siliciclastic Stromatolites and Thrombolites, Late Miocene, S.E. Spain. *SEPM Journal of Sedimentary Research* **Vol. 63** (1993)

Butler, W. The rationale for assessment of undiscovered, economically recoverable oil and gas in central and northern Arizona; play analyses of seven favorable areas. Tech. Rep., USGS (1988)

Tuke, M., Dineley, D. & Rust, B. The Basal Sedimentary Rocks In Somerset Island, N.w.t. *Canadian Journal of Earth Sciences* **3**, 697–711 (1966)

Woods, A. Microbial ooids and cortoids from the Lower Triassic (Spathian) Virgin Limestone, Nevada, USA: Evidence for an Early Triassic microbial bloom in shallow depositional environments. *Global and Planetary Change,* 91–101 (2013)

Aalto, K. Glacial Marine Sedimentation and Stratigraphy of the Toby Conglomerate (Upper Proterozoic), Southeastern British Columbia, Northwestern Idaho and Northeastern Washington. *Canadian Journal of Earth Sciences* **8**, 753–787 (1971)

Lovering, T., Tweto, O. & Lovering, T. Ore deposits of the Gilman District, Eagle County, Colorado. Tech. Rep., USGS (1978)

edited by Dyman, T. Geologic controls and resource potential of natural gas in deep sedimentary basins in the United States. Tech. Rep., USGS (1992)

(*), G., (1), L. & R.d., R. Multiple Episodes of Dolomitization in the Arbuckle Group, Arbuckle Mountains, South-Central Oklahoma: Field, Petrographic, and Geochemical Evidence. *SEPM Journal of Sedimentary Research* **Vol. 65A** (1995)

Kvale, E., Johnson, G., Mickelson, D., Keller, K., Furer, L. & Archer, A. Middle Jurassic (Bajocian and Bathonian) Dinosaur Megatracksites, Bighorn Basin, Wyoming, U.S.A. *Palaios* **16**, 233 (2001)

Shride, A. Younger Precambrian geology in southern Arizona. Tech. Rep., USGS (1967)

Vrazo, M., Trop, J. & Brett, C. A New Eurypterid Lagerstatte From The Upper Silurian Of Pennsylvania. *Palaios* **29**, 431–448 (2014)

Rupke, J. Stratigraphic and structural evolution of the Kumaon Lesser Himalaya. *Sedimentary Geology* **11**, 81–265 (1974)

Greene, R. Talc resources of the conterminous United States. Tech. Rep., USGS (1995)

Cumbaa, S. & Schultze, H. An Early Devonian (Emsian) acanthodian from the Bear Rock Formation, Anderson River, Northwest Territories, Canada. *Canadian Journal of Earth Sciences* **39**, 1457–1465 (2002)

Badham, J. Petrochemistry of late Aphebian (1.8 Ga) calc-alkaline diorites from the East Arm of Great Slave Lake, N.W.T., Canada. *Canadian Journal of Earth Sciences* **18**, 1018–1028 (1981)

Aspler, L. & Donaldson, J. Paleoclimatology of Nonacho Basin (early proterozoic), Northwest territories, Canada. *Palaeogeography, Palaeoclimatology, Palaeoecology* **56**, 17–34 (1986)

Karachewski, J. Facies analysis, genetic sequences, and paleogeography of the lower part of the Minturn Formation (Middle Pennsylvanian), southeastern Eagle Basin, Colorado. Tech. Rep., USGS (1992)

Sussko, R. & Davis, R. Siliciclastic-to-carbonate transition on the inner shelf embayment, southwest Florida. *Marine Geology* **107**, 51–60 (1992)

Mustard, P. Normal faulting and alluvial-fan deposition, basal Windermere Tectonic Assemblage, Yukon, Canada. *Geological Society of America Bulletin* **103**, 1346–1364 (1991)

Bertrand-Sarfati, J. & Moussine-Pouchkine, A. Evolution and environmental conditions of Conophyton—jacutophyton associations in the atar dolomite (upper proterozoic, Mauritania). *Precambrian Research* **29**, 207–234 (1985)

Melezhik, V., Fallick, A. & Pokrovsky, B. Enigmatic nature of thick sedimentary carbonates depleted in 13C beyond the canonical mantle value: The challenges to our understanding of the terrestrial carbon cycle. *Precambrian Research* **137**, 131–165 (2005)

Butler, W. The geologic setting of southern Arizona and southwestern New Mexico, with a rationale for assessment of undiscovered economically recoverable oil and gas; a summary of four potential plays. Tech. Rep., USGS (1989)

Green, M., Pierson, C., Bauer, D. & Umshler, D. A summary of the geology and mineral resources of the Paris Plateau-House Rock Valley area, Coconino County, Arizona. Tech. Rep., USGS (1977)

Smith, A. & Barnes, W. Correlation of and Facies Changes in the Carbonaceous, Calcareous, and Dolomitic Formations of the Precambrian Belt-Purcell Supergroup. *Geol Soc America Bull* **77**, 1399 (1966)

Bernstein, L. A revised lithostratigraphy of the Lower–Middle Ordovician Beekmantown Group, St. Lawrence Lowlands, Quebec and Ontario. *Canadian Journal of Earth Sciences* **29**, 2677–2694 (1992)

Marian, M. & Osborne, R. Petrology, petrochemistry, and stromatolites of the Middle to Late Proterozoic Beck Spring Dolomite, eastern Mojave Desert, California. *Canadian Journal of Earth Sciences* **29**, 2595–2609 (1992)

Warren, J. Evaporites through time: Tectonic, climatic and eustatic controls in marine and nonmarine deposits. *Earth-Science Reviews* **3-4**, 217–268 (2010)

Lovelace, D. & Lovelace, S. Paleoenvironments And Paleoecology Of A Lower Triassic Invertebrate And Vertebrate Ichnoassemblage From The Red Peak Formation (chugwater Group), Central Wyoming. *Palaios* **27**, 636–657 (2012)

Soja, C., White, B., Antoshkina, A., Joyce, S., Mayhew, L., Flynn, B. & Gleason, A. Development and Decline of a Silurian Stromatolite Reef Complex, Glacier Bay National Park, Alaska. *Palaios* **15**, 273 (2000)

Carrigan, W. & Cameron, E. Petrological and stable isotope studies of carbonate and sulfide minerals from the Gunflint Formation, Ontario: evidence for the origin of early Proterozoic iron-formation. *Precambrian Research* **52**, 347–380 (1991)

Schopf, J. Precambrian Micro-organisms And Evolutionary Events Prior To The Origin Of Vascular Plants. *Biological Reviews* **45**, 319–352 (1970)

Whalen, M., Day, J., Eberli, G. & Homewood, P. Microbial carbonates as indicators of environmental change and biotic crises in carbonate systems: examples from the Late Devonian, Alberta basin, Canada. *Palaeogeography, Palaeoclimatology, Palaeoecology* **181**, 127–151 (2002)

Asmerom, Y., Jacobsen, S., Knoll, A., Butterfield, N. & Swett, K. Strontium isotopic variations of Neoproterozoic seawater: Implications for crustal evolution. *Geochimica et Cosmochimica Acta* **55**, 2883–2894 (1991)

William Schopf, J. Biostratigraphic usefulness of stromatolitic precambrian microbiotas: A preliminary analysis. *Precambrian Research* **5**, 143–173 (1977)

McConnell, R. Biostratigraphy and depositional environment of algal stromatolites from the Mescal Limestone (Proterozoic) of central Arizona. *Precambrian Research* **2**, 317–328 (1975)

Mauk, J. & Hieshima, G. Organic matter and copper mineralization at White Pine, Michigan, U.S.A. *Chemical Geology* **99**, 189–211 (1992)

Poulsen, K., Card, K. & Franklin, J. Archean tectonic and metallogenic evolution of the superior province of the canadian shield. *Precambrian Research* **58**, 25–54 (1992)

Shixing, Z. & Huineng, C. Characteristics of Palaeoproterozoic stromatolites in China. *Precambrian Research* **57**, 135–163 (1992)

Larsson, S. & Stearn, C. Silurian stratigraphy of the Hudson Bay Lowland in Quebec. *Canadian Journal of Earth Sciences* **23**, 288–299 (1986)

Germann, K. Diagenetic Patterns in the Wettersteinkalk (Ladinian, Middle Trias), Northern Limestone Alps, Bavaria and Tyrol. *SEPM Journal of Sedimentary Research* **Vol. 38** (1968)

MacNaughton, R., Narbonne, G. & Dalrymple, R. Neoproterozoic slope deposits, Mackenzie Mountains, northwestern Canada: implications for passive-margin development and Ediacaran faunal ecology. *Canadian Journal of Earth Sciences* **37**, 997–1020 (2000)

Glumac, B. & Mutti, L. Late Cambrian (Steptoean) sedimentation and responses to sea-level change along the northeastern Laurentian margin: Insights from carbon isotope stratigraphy. *Geological Society of America Bulletin* **119**, 623–636 (2007)

Palmer, A. Upper Cambrian Faunal Patterns on the Craton: Discussion. *Geol Soc America Bull* **83**, 927 (1972)

Hoffman, S. Geochemical exploration for unconformity-type uranium deposits in permafrost terrain, Hornby bay basin, Northwest territories, Canada. *Journal of Geochemical Exploration* **19**, 11–32 (1983)

Young, G. The late Proterozoic Tindir Group, east-central Alaska: Evolution of a continental margin. *Geol Soc America Bull* **93**, 759 (1982)

Défarge, C., Trichet, J., Maurin, A. & Hucher, M. Kopara in Polynesian atolls: early stages of formation of calcareous stromatolites. *Sedimentary Geology* **89**, 9–23 (1994)

Armstrong, A. & Mamet, B. Mississippian (Lower Carboniferous) biostratigraphy, facies, and microfossils, Pedregosa Basin, southeastern Arizona and southwestern New Mexico. Tech. Rep., USGS (1988)

Long, D. Kennedy Channel Formation: key to the early history of the Franklinian continental margin, central eastern Ellesmere Island, Arctic Canada. *Canadian Journal of Earth Sciences* **26**, 1147–1159 (1989)

Whipple, J. & Johnson, S. Stratigraphy and lithocorrelation of the Snowslip Formation (Middle Proterozoic Belt Supergroup), Glacier National Park, Montana. Tech. Rep., USGS (1988)

Kahle, C. Origin of subaerial Holocene calcareous crusts: role of algae, fungi and sparmicritisation. *Sedimentology* **24**, 413–435 (1977)

Steele, K. Utilizing glacial geology in uranium exploration; Dismal Lakes, Northwest Territories, Canada. *Boreas* **17**, 183–194 (1988)

Campbell, J. Upper Cambrian stromatolitic biostrome, Clinetop Member of the Dotsero Formation, western Colorado. *Geol Soc America Bull* **87**, 1331 (1976)

Luo, M., Chen, Z., Shi, G., Fang, Y., Song, H., Jia, Z., Huang, Y. & Yang, H. Upper Lower Triassic stromatolite from Anhui, South China: Geobiologic features and paleoenvironmental implications. *Palaeogeography, Palaeoclimatology, Palaeoecology,* 40–54 (2016)

Klement, K. & Too, D. Role of the Blue-Green Alga Girvanella in Skeletal Grain Destruction and Lime-Mud Formation in the Lower Ordovician of West Texas. *SEPM Journal of Sedimentary Research* **Vol. 37** (1967)

Ford, T. The Grand Canyon of the Colorado. *Geology Today* **10**, 57–62 (1994)

Anderson, E., Goodwin, P. & Sobieski, T. Episodic accumulation and the origin of formation boundaries in the Helderberg Group of New York State. *Geol* **12**, 120 (1984)

Sears, J., Price, R. & Khudoley, A. Linking the Mesoproterozoic Belt-Purcell and Udzha basins across the west Laurentia–Siberia connection. *Precambrian Research* **129**, 291–308 (2004)

Miller, M. & Labandeira, C. Slow Crawl Across the Salinity Divide: Delayed Colonization of Freshwater Ecosystems by Invertebrates. *Gsa Today* **12**, 4 (2002)

Schubert, J. & Bottjer, D. Early Triassic stromatolites as post-mass extinction disaster forms. *Geol* **20**, 883 (1992)

Fairchild, T., Schopf, J., Shen-Miller, J., Guimarães, E., Edwards, M., Lagstein, A., Li, X., Pabst, M. & de Melo-Filho, L. Recent discoveries of Proterozoic microfossils in south-central Brazil. *Precambrian Research* **80**, 125–152 (1996)

Eriksson, K., Krapez, B. & Fralick, P. Sedimentology of archean greenstone belts: Signatures of tectonic evolution. *Earth-Science Reviews* **1-2**, 1–88 (1994)

Fairchild, I. Origins of carbonate in Neoproterozoic stromatolites and the identification of modern analogues. *Precambrian Research* **53**, 281–299 (1991)

Edwards, C. & Saltzman, M. Paired carbon isotopic analysis of Ordovician bulk carbonate (δ13Ccarb) and organic matter (δ13Corg) spanning the Great Ordovician Biodiversification Event. *Palaeogeography, Palaeoclimatology, Palaeoecology* (2015)

McGrew, A. & Brown, E. Geologic map of Kious Spring and Garrison 7.5' quadrangles, White Pine County, Nevada and Millard County, Utah. Tech. Rep., USGS (1995)

Hofmann, H. The problematic fossil Chuaria from the Late Precambrian Uinta Mountain Group, Utah. *Precambrian Research* **4**, 1–11 (1977)

Harwood, C. & Sumner, D. Origins of Microbial Microstructures In the Neoproterozoic Beck Spring Dolomite: Variations In Microbial Community and Timing of Lithification. *Journal of Sedimentary Research* **82**, 709–722 (2012)

Stanesco, J. Sedimentology and depositional environments of the Lower Permian Yeso Formation, northwestern New Mexico. Tech. Rep., USGS (1991)

Pratt, B. Stromatolite decline—A reconsideration. *Geol* **10**, 512 (1982)

Edhorn, A. Early Cambrian algae croppers. *Canadian Journal of Earth Sciences* **14**, 1014–1020 (1977)

Hagadorn, J. & Belt, E. Stranded In Upstate New York: Cambrian Scyphomedusae From The Potsdam Sandstone. *Palaios* **23**, 424–441 (2008)

Schultze, H. Interpretation of marine and freshwater paleoenvironments in Permo–Carboniferous deposits. *Palaeogeography, Palaeoclimatology, Palaeoecology* **1-2**, 126–136 (2009)

Passchier, S. & Erukanure, E. Palaeoenvironments and weathering regime of the Neoproterozoic Squantum 'Tillite', Boston Basin: no evidence of a snowball Earth. *Sedimentology* **57**, 1526–1544 (2010)

Breyer, J., Busbey, A., Hanson, R. & Roy, E. Possible new evidence for the origin of metazoans prior to 1 Ga: Sediment-filled tubes from the Mesoproterozoic Allamoore Formation, Trans-Pecos Texas. *Geol* **23**, 269 (1995)

Colville, V. & Johnson, M. Correlation of sea-level curves for the Lower Silurian of the Bruce Peninsula and Lake Timiskaming District (Ontario). *Canadian Journal of Earth Sciences* **19**, 962–974 (1982)

James, N., Narbonne, G. & Sherman, A. Molar-tooth carbonates: shallow subtidal facies of the mid- to late Proterozoic. *Journal of Sedimentary Research* **68**, 716–722 (1998)

Reid, L., Simony, P. & Ross, G. Dextral strike-slip faulting in the Cariboo Mountains, British Columbia: a natural example of wrench tectonics in relation to Cordilleran tectonics. *Canadian Journal of Earth Sciences* **39**, 953–970 (2002)

McCaffrey, M., Farrington, J. & Repeta, D. Geochemical implications of the lipid composition of Thioploca spp. from the Peru upwelling region—15°S. *Organic Geochemistry* **14**, 61–68 (1989)

Friedman, G. Sedimentology of the thacher limestone (lower devonian helderberg group), New York state-discussion. *Sedimentary Geology* **86**, 325–327 (1993)

Mirota, M. & Veizer, J. Geochemistry of precambrian carbonates: VI. Aphebian albanel formations, Quebec, Canada. *Geochimica et Cosmochimica Acta* **58**, 1735–1745 (1994)

Mathieu, J., Kontak, D. & Turner, E. A fluid inclusion study of diagenetic fluids in Proterozoic and Paleozoic carbonate rocks, Victoria Island, NWT. *Geofluids* **13**, 559–578 (2013)

Motts, W. Geology and Paleoenvironments of the Northern Segment, Capitan Shelf, New Mexico and West Texas. *Geol Soc America Bull* **83**, 701 (1972)

Al Rajaibi, I., Hollis, C., Macquaker, J. & Pufahl, P. Origin and variability of a terminal Proterozoic primary silica precipitate, Athel Silicilyte, South Oman Salt Basin, Sultanate of Oman. *Sedimentology* **62**, 793–825 (2015)

Conliffe, J., Azmy, K., Gleeson, S. & Lavoie, D. Fluids associated with hydrothermal dolomitization in St. George Group, western Newfoundland, Canada. *Geofluids* **10**, 422–437 (2010)

Hofmann, H. Stromatolites: Characteristics and utility. *Earth-Science Reviews* **9**, 339–373 (1973)

(2), M., Brady, M. & J., A. Depositional Environments of the Upper Cambrian Johns Wash Limestone (House Range, Utah). *SEPM Journal of Sedimentary Research* **Vol. 46** (1976)

Shaver, R. & Sunderman, J. Silurian seascapes: Water depth, clinothems, reef geometry, and other motifs—A critical review of the Silurian reef model. *Geological Society of America Bulletin* **101**, 939–951 (1989)

Horodyski, R., Donaldson, J. & Kerans, C. A new shale-facies microbiota from the Middle Proterozoic Dismal Lakes Group, District of Mackenzie, Northwest Territories, Canada. *Canadian Journal of Earth Sciences* **17**, 1166–1173 (1980)

Harbour, R. Geology of the Northern Franklin Mountains, Texas and New Mexico. Tech. Rep., USGS (1972)

Butterfield, N. & Rainbird, R. Diverse organic-walled fossils, including "possible dinoflagellates," from the early Neoproterozoic of arctic Canada. *Geol* **26**, 963 (1998)

Khomentovsky, V. The Upper Riphean of the Yenisei Range. *Russian Geology and Geophysics* **48**, 711–720 (2007)

Altermann, W. The oldest fossils of Africa – a brief reappraisal of reports from the Archean. *Journal of African Earth Sciences* **33**, 427–436 (2001)

Watkins, R. & Kuglitsch, J. Lower Silurian (Aeronian) megafaunal and conodont biofacies of the northwestern Michigan Basin. *Canadian Journal of Earth Sciences* **34**, 753–764 (1997)

Semikhatov, M., Gebelein, C., Cloud, P., Awramik, S. & Benmore, W. Stromatolite morphogenesis—progress and problems. *Canadian Journal of Earth Sciences* **16**, 992–1015 (1979)

Park, J. & Jefferson, C. Magnetic and tectonic history of the Late proterozoic upper little dal and coates lake groups of northwestern Canada. *Precambrian Research* **52**, 1–35 (1991)

Brett, C., Tepper, D., Goodman, W., LoDuca, S. & Eckert, B. Revised stratigraphy and correlations of the Niagaran provincial series (Medina, Clinton, and Lockport groups) in the type area of western New York. Tech. Rep., USGS (1995)

Harrison, R., Orndorff, R., Weems, R., Albertson, P., Mienert, D. & Butler, G. Geology of the Fort Leonard Wood Military Reservation and adjacent areas, south-central Missouri. Tech. Rep., USGS (1996)

Johnson, M. & Jia-yu, R. Middle to Late Ordovician rocky bottoms and rocky shores from the Manitoulin Island area, Ontario. *Canadian Journal of Earth Sciences* **26**, 642–653 (1989)

Dover, J. Geology of east-central Alaska. Tech. Rep., USGS (1990)

Claire, M., Catling, D. & Zahnle, K. Biogeochemical modelling of the rise in atmospheric oxygen. *Geobiology* **4**, 239–269 (2006)

Armstrong, A. & MacKevett, E. Stratigraphy and diagenetic history of the lower part of the Triassic Chitistone Limestone, Alaska. Tech. Rep., USGS (1982)

Hunter, D. Developments and interactions of the Precambrian atmosphere, lithosphere and biosphere. Developments in Precambrian geology, 7 edited by B. Nagy, R. Weber, J.C. Guerrero and M. Schidlowski. Elsevier, Amsterdam, 1983. xii + 476 pp. Price: U.S. $89.25 (U.S.A. and Canada)/Dfl. 210.00 (rest of world). Hardback. *Lithos,* 65–66 (1985)

Martin, W. The Petrology of a Composite Vertical Section of Cincinnatian Series Limestones (Upper Ordovician) of Southwestern Ohio, Southeastern Indiana, and Northern Kentucky. *SEPM Journal of Sedimentary Research* **Vol. 45** (1975)

Gutstadt, A. Pseudo- and Dubiofossils from the Newland Limestone (Belt Supergroup, Late Precambrian), Montana. *SEPM Journal of Sedimentary Research* **Vol. 45** (1975)

Strand, K. Global and continental-scale glaciations on the Precambrian earth. *Marine and Petroleum Geology* **33**, 69–79 (2012)

Richard, A., Boulvais, P., Mercadier, J., Boiron, M., Cathelineau, M., Cuney, M. & France-Lanord, C. From evaporated seawater to uranium-mineralizing brines: Isotopic and trace element study of quartz–dolomite veins in the Athabasca system. *Geochimica et Cosmochimica Acta,* 38–59 (2013)

Seong-Joo, L. & Golubic, S. Microfossil populations in the context of synsedimentary micrite deposition and acicular carbonate precipitation: Mesoproterozoic Gaoyuzhuang Formation, China. *Precambrian Research* **96**, 183–208 (1999)

Harwood, C. & Sumner, D. Microbialites of the Neoproterozoic Beck Spring Dolomite, Southern California. *Sedimentology* **58**, 1648–1673 (2011)

edited by Martin, J. & Pratt, W. Geology and mineral-resource assessment of the Springfield 1 degree x 2 degrees quadrangle, Missouri, as appraised in September 1985. Tech. Rep., USGS (1991)

Hofmann, H. & Grotzinger, J. Shelf-facies microbiotas from the Odjick and Rocknest formations (Epworth Group; 1.89 Ga), northwestern Canada. *Canadian Journal of Earth Sciences* **22**, 1781–1792 (1985)

Cailteux, J., Kampunzu, A., Lerouge, C., Kaputo, A. & Milesi, J. Genesis of sediment-hosted stratiform copper–cobalt deposits, central African Copperbelt. *Journal of African Earth Sciences* **42**, 134–158 (2005)

Banks, N. & Krieger, M. Geologic map of the Hayden quadrangle, Pinal and Gila Counties, Arizona. Tech. Rep., USGS (1977)

Horodyski, R. Paleontology of proterozoic shales and mudstones: examples from the Belt supergroup, Chuar group and Pahrump group, western USA. *Precambrian Research* **61**, 241–278 (1993)

Nehza, O. & Woo, K. The effect of subaerial exposure on the morphology and microstructure of stromatolites in the Cretaceous Sinyangdong Formation, Gyeongsang Supergroup, Korea1. *Sedimentology* **53**, 1121–1133 (2006)

Sachse, V., Littke, R., Jabour, H., Schümann, T. & Kluth, O. Late Cretaceous (Late Turonian, Coniacian and Santonian) petroleum source rocks as part of an OAE, Tarfaya Basin, Morocco. *Marine and Petroleum Geology* **29**, 35–49 (2012)

Vrazo, M., Brett, C. & Ciurca, S. Buried or brined? Eurypterids and evaporites in the Silurian Appalachian basin. *Palaeogeography, Palaeoclimatology, Palaeoecology,* 48–59 (2016)

Kampunzu, A., Cailteux, J., Moine, B. & Loris, H. Geochemical characterisation, provenance, source and depositional environment of 'Roches Argilo-Talqueuses' (RAT) and Mines Subgroups sedimentary rocks in the Neoproterozoic Katangan Belt (Congo): Lithostratigraphic implications. *Journal of African Earth Sciences* **42**, 119–133 (2005)

Toomey, D. An Unhurried Look at a Lower Ordovician Mound Horizon, Southern Franklin Mountains, West Texas. *SEPM Journal of Sedimentary Research* **Vol. 40** (1970)

Cónsole-Gonella, C. & Marquillas, R. Bioclaustration trace fossils in epeiric shallow marine stromatolites: the Cretaceous-Palaeogene Yacoraite Formation, Northwestern Argentina. *Lethaia* **47**, 107–119 (2014)

Planavsky, N. & Grey, K. Stromatolite branching in the Neoproterozoic of the Centralian Superbasin, Australia: an investigation into sedimentary and microbial control of stromatolite morphology. *Geobiology* **0**, 070816220552001–??? (2007)

Kröger, B. & Landing, E. Early Ordovician community evolution with eustatic change through the middle Beekmantown Group, northeast Laurentia. *Palaeogeography, Palaeoclimatology, Palaeoecology* **294**, 174–188 (2010)

Elison, M. & Speed, R. Triassic flysch of the Fencemaker allochthon, East Range, Nevada: Fan facies and provenance. *Geological Society of America Bulletin* **100**, 185–199 (1988)

Tucker, M. Diagenesis, Geochemistry, and Origin of a Precambrian Dolomite: the Beck Spring Dolomite of Eastern California. *SEPM Journal of Sedimentary Research* **Vol. 53** (1983)

Pratt, B. Epiphyton and Renalcis–Diagenetic Microfossils from Calcification of Coccoid Blue-Green Algae. *SEPM Journal of Sedimentary Research* **Vol. 54** (1984)

Multer, H. & Hoffmeister, J. Subaerial Laminated Crusts of the Florida Keys. *Geol Soc America Bull* **79**, 183 (1968)

Unrug, R., Ausich, W., Bednarczyk, J., Cuffey, R., Mamet, B., Palmes, S. & Unrug, S. Paleozoic age of the Walden Creek Group, Ocoee Supergroup, in the western Blue Ridge, southern Appalachians: Implications for evolution of the Appalachian margin of Laurentia. *Geological Society of America Bulletin* **112**, 982–996 (2000)

Domack, E. & Hoffman, P. An ice grounding-line wedge from the Ghaub glaciation (635 Ma) on the distal foreslope of the Otavi carbonate platform, Namibia, and its bearing on the snowball Earth hypothesis. *Geological Society of America Bulletin* **123**, 1448–1477 (2011)

Cailteux, J. Lithostratigraphy of the Neoproterozoic Shaba-type (Zaire) Roan Supergroup and metallogenesis of associated stratiform mineralization. *Journal of African Earth Sciences* **19**, 279–301 (1994)

Marshall, D. & Anglin, C. CO2-clathrate destabilization: a new model of formation for molar tooth structures. *Precambrian Research* **129**, 325–341 (2004)

Westrop, S. Temporal persistence and stability of Cambrian biofacies: Sunwaptan (Upper Cambrian) trilobite faunas of North America. *Palaeogeography, Palaeoclimatology, Palaeoecology* **127**, 33–46 (1996)

Dallmeyer, R. & Nance, R. Tectonic implications of 40 Ar/ 39 Ar mineral ages from late Precambrian – Cambrian plutons, Avalon composite terrane, southern New Brunswick, Canada. *Canadian Journal of Earth Sciences* **29**, 2445–2462 (1992)

Geldon, A. Geology of Paleozoic Rocks in the Upper Colorado River Basin in Arizona, Colorado, New Mexico, Utah, and Wyoming, Excluding the San Juan Basin. Tech. Rep., USGS (2003)

Saltzman, M. Organic Carbon Burial and Phosphogenesis in the Antler Foreland Basin: An Out-of-Phase Relationship During the Lower Mississippian. *Journal of Sedimentary Research* **73**, 844–855 (2003)

Spencer, A. Mechanisms and environments of deposition of late precambrian geosynclinal tillites: Scotland and East Greenland. *Palaeogeography, Palaeoclimatology, Palaeoecology* **51**, 143–157 (1985)

Turner, E., Narbonne, G. & James, N. Neoproterozoic reef microstructures from the Little Dal Group, northwestern Canada. *Geol* **21**, 259 (1993)

Westrop, S. Taphonomic versus ecologic controls on taxonomic relative abundance patterns in tempestites. *Lethaia* **19**, 123–132 (1986)

Sekine, Y., Tajika, E., Ohkouchi, N., Ogawa, N., Goto, K., Tada, R., Yamamoto, S. & Kirschvink, J. Anomalous negative excursion of carbon isotope in organic carbon after the last Paleoproterozoic glaciation in North America. *Geochemistry, Geophysics, Geosystems* **11**, n/a–n/a (2010)

Gregg, J. Regional epigenetic dolomitization in the Bonneterre Dolomite (Cambrian), southeastern Missouri. *Geol* **13**, 503 (1985)

Bekker, A., Karhu, J. & Kaufman, A. Carbon isotope record for the onset of the Lomagundi carbon isotope excursion in the Great Lakes area, North America. *Precambrian Research* **148**, 145–180 (2006)

Ojakangas, R. & Dickas, A. The 1.1-Ga Midcontinent Rift System, central North America: sedimentology of two deep boreholes, Lake Superior region. *Sedimentary Geology* **147**, 13–36 (2002)

Simonson, B., Schubel, K. & Hassler, S. Carbonate sedimentology of the early Precambrian Hamersley Group of Western Australia. *Precambrian Research* **60**, 287–335 (1993)

Hobbs, S., Griggs, A., Wallace, R. & Campbell, A. Geology of the Coeur d'Alene district, Shoshone County, Idaho. Tech. Rep., USGS (1965)

Condon, S. Geology of pre-Pennsylvanian rocks in the Paradox Basin and adjacent areas, southeastern Utah and southwestern Colorado. Tech. Rep., USGS (1995)

Schmidt, R., Loen, J., Wallace, C. & Mehnert, H. Geology of the Elliston region, Powell and Lewis and Clark counties, Montana. Tech. Rep., USGS (1994)

Hasson, K. & Haase, C. Lithofacies and paleogeography of the Conasauga Group, (Middle and Late Cambrian) in the Valley and Ridge province of east Tennessee. *Geological Society of America Bulletin* **100**, 234–246 (1988)

Sando, W. & Sandberg, C. New interpretations of Paleozoic stratigraphy and history in the northern Laramie Range and vicinity, Southeast Wyoming. Tech. Rep., USGS (1987)

Gair, J. & Thaden, R. Geology of the Marquette and Sands quadrangles, Marquette County, Michigan. Tech. Rep., USGS (1968)

Corsetti, F. & Kaufman, A. The relationship between the Neoproterozoic Noonday Dolomite and the Ibex Formation: New observations and their bearing on 'snowball Earth'. *Earth-Science Reviews* **1-4**, 63–78 (2005)

Mitchell, C. & Sweet, W. Upper Ordovician conodonts, brachiopods, and chronostratigraphy of the Whittaker Formation, southwestern District of Mackenzie, N.W.T., Canada. *Canadian Journal of Earth Sciences* **26**, 74–87 (1989)

Mackey, T., Sumner, D., Hawes, I., Jungblut, A. & Andersen, D. Growth of modern branched columnar stromatolites in Lake Joyce, Antarctica. *Geobiology* **13**, 373–390 (2015)

Park, L. & Gierlowski-Kordesch, E. Paleozoic lake faunas: Establishing aquatic life on land. *Palaeogeography, Palaeoclimatology, Palaeoecology* **1-2**, 160–179 (2007)

Birnbaum, S. & Wireman, J. Sulfate-reducing bacteria and silica solubility: a possible mechanism for evaporite diagenesis and silica precipitation in banded iron formations. *Canadian Journal of Earth Sciences* **22**, 1904–1909 (1985)

Hofmann, H., Pearson, D. & Wilson, B. Stromatolites and fenestral fabric in Early Proterozoic Huronian Supergroup, Ontario. *Canadian Journal of Earth Sciences* **17**, 1351–1357 (1980)

Pope, M., Grotzinger, J. & Schreiber, B. Evaporitic Subtidal Stromatolites Produced by in situ Precipitation: Textures, Facies Associations, and Temporal Significance. *Journal of Sedimentary Research* **70**, 1139–1151 (2000)

Brookins, D. Helium isotopes in nature. Developments in geochemistry, 3 by B.A. Mamyrin and I.N. Tolstikhin, Elsevier, Amsterdam, 1984. xiv + 273 pp. Price: U.S. $53.75 (U.S.A. and Canada)/Dfl. 140.00 (rest of world). Hardback. *Lithos,* 66–67 (1985)

Mazzullo, S. & Friedman, G. Competitive Algal Colonization of Peritidal Flats in a Schizohaline Environment: The Lower Ordovician of New York. *SEPM Journal of Sedimentary Research* **Vol. 47** (1977)

Raha, P. & Sastry, M. Stromatolites and Precambrian stratigraphy in India. *Precambrian Research* **18**, 293–318 (1982)

Pratt, B. Molar-tooth structure in Proterozoic carbonate rocks: Origin from synsedimentary earthquakes, and implications for the nature and evolution of basins and marine sediment. *Geological Society of America Bulletin* **110**, 1028–1045 (1998)

Roy, S. Manganese metallogenesis: A review. *Ore Geology Reviews* **4**, 155–170 (1988)

Bosak, T., Liang, B., Wu, T., Templer, S., Evans, A., Vali, H., Guerquin-Kern, J., Klepac-Ceraj, V., Sim, M. & Mui, J. Cyanobacterial diversity and activity in modern conical microbialites. *Geobiology* **10**, 384–401 (2012)

Chauhan, D. Phosphate-bearing stromatolites of the Precambrian Aravalli phosphorite deposits of the Udaipur region, their environmental significance and genesis of phosphorite. *Precambrian Research* **8**, 95–126 (1979)

Schelble, R., Westall, F. & Allen, C. ∼1.8 Ga iron-mineralized microbiota from the Gunflint Iron Formation, Ontario, Canada: implications for Mars. *Advances in Space Research* **33**, 1268–1273 (2004)

Gregg, J., Laudon, P., Woody, R. & Shelton, K. Porosity evolution of the Cambrian Bonneterre Dolomite, south-eastern Missouri, USA. *Sedimentology* **40**, 1153–1169 (1993)

Runnegar, B. Precambrian oxygen levels estimated from the biochemistry and physiology of early eukaryotes. *Global and Planetary Change* **5**, 97–111 (1991)

Barroso-Barcenilla, F., Cambra-Moo, O., Escaso, F., Ortega, F., Pascual, A., Pérez-García, A., Rodríguez-Lázaro, J., Sanz, J., Segura, M. & Torices, A. New and exceptional discovery in the Upper Cretaceous of the Iberian Peninsula: the palaeontological site of “Lo Hueco”, Cuenca, Spain. *Cretaceous Research* **30**, 1268–1278 (2009)

Kalliokoski, J. & Welch, E. Keweenawan-age caliche paleosol in the lower part of the Calumet and Hecla Conglomerate, Centennial Mine, Calumet, Michigan. *Geol Soc America Bull* **96**, 1188 (1985)

Bartley, J., Kah, L., McWilliams, J. & Stagner, A. Carbon isotope chemostratigraphy of the Middle Riphean type section (Avzyan Formation, Southern Urals, Russia): Signal recovery in a fold-and-thrust belt. *Chemical Geology* **237**, 211–232 (2007)

Druschke, P., Jiang, G., Anderson, T. & Hanson, A. Stromatolites in the Late Ordovician Eureka Quartzite: implications for microbial growth and preservation in siliciclastic settings. *Sedimentology* **56**, 1275–1291 (2009)

Armstrong, A. & Mamet, B. Biostratigraphy and regional relations of the Mississippian Leadville limestone in the San Juan Mountains, southwestern Colorado. Tech. Rep., USGS (1976)

Chafetz, H. Paragenesis of the Morgan Creek Limestone, Late Cambrian, central Texas: Constraints on the formation of glauconite. *Deep Sea Research Part II: Topical Studies in Oceanography* **54**, 1350–1363 (2007)

McMechan, M. & Price, R. Transverse folding and superposed deformation, Mount Fisher area, southern Canadian Rocky Mountain thrust and fold belt. *Canadian Journal of Earth Sciences* **19**, 1011–1024 (1982)

Osleger, D. & Read, J. Relation of Eustasy to Stacking Patterns of Meter-Scale Carbonate Cycles, Late Cambrian, U.S.A. *SEPM Journal of Sedimentary Research* **Vol. 61** (1991)

Bekker, A. & Eriksson, K. A Paleoproterozoic drowned carbonate platform on the southeastern margin of the Wyoming Craton: a record of the Kenorland breakup. *Precambrian Research* **120**, 327–364 (2003)

Pratt, B. Stromatolitic Framework of Carbonate Mud-Mounds. *SEPM Journal of Sedimentary Research* **Vol. 52** (1982)

Payne, M. & Allison, C. Paleozoic continental-margin sedimentation in east-central Alaska. *Geol* **9**, 274 (1981)

Borch, C., Bolton, B. & Warren, J. Environmental setting and microstructure of subfossil lithified stromatolites associated with evaporites, Marion Lake, South Australia. *Sedimentology* **24**, 693–708 (1977)

Anand, R. Regolith-landform processes and geochemical exploration for base metal deposits in regolith-dominated terrains of the Mt Isa region, northwest Queensland, Australia. *Ore Geology Reviews* (2015)

Williams, G., Jenkins, R. & Walter, M. No heliotropism in Neoproterozoic columnar stromatolite growth, Amadeus Basin, central Australia: Geophysical implications. *Palaeogeography, Palaeoclimatology, Palaeoecology* **1-2**, 80–89 (2007)

Schenk, P. The Macumber Formation of the Maritime Provinces, Canada–A Mississippian Analogue to Recent Strand-Line Carbonates of the Persian Gulf. *SEPM Journal of Sedimentary Research* **Vol. 37** (1967)

Day, E., James, N., Narbonne, G. & Dalrymple, R. A sedimentary prelude to Marinoan glaciation, Cryogenian (Middle Neoproterozoic) Keele Formation, Mackenzie Mountains, northwestern Canada. *Precambrian Research* **133**, 223–247 (2004)

Strong, D., O'Brien, S., Taylor, S., Strong, P. & Wilton, D. Aborted Proterozoic rifting in eastern Newfoundland. *Canadian Journal of Earth Sciences* **15**, 117–131 (1978)

Barley, M., Bekker, A. & Krapež, B. Late Archean to Early Paleoproterozoic global tectonics, environmental change and the rise of atmospheric oxygen. *Earth and Planetary Science Letters* **1-2**, 156–171 (2005)

Shelton, K., Bauer, R. & Gregg, J. Fluid-inclusion studies of regionally extensive epigenetic dolomites, Bonneterre Dolomite (Cambrian), southeast Missouri: Evidence of multiple fluids during dolomitization and lead-zinc mineralization. *Geological Society of America Bulletin* **104**, 675–683 (1992)

Pufahl, P., Anderson, S. & Hiatt, E. Dynamic sedimentation of Paleoproterozoic continental margin iron formation, Labrador Trough, Canada: Paleoenvironments and sequence stratigraphy. *Sedimentary Geology,* 48–65 (2014)

Read, J. & (2), R. Fabrics of Allochthonous Reefal Blocks, Shady Dolomite (Lower to Middle Cambrian), Virginia Appalachians. *SEPM Journal of Sedimentary Research* **Vol. 53** (1983)

van Acken, D., Thomson, D., Rainbird, R. & Creaser, R. Constraining the depositional history of the Neoproterozoic Shaler Supergroup, Amundsen Basin, NW Canada: Rhenium-osmium dating of black shales from the Wynniatt and Boot Inlet Formations. *Precambrian Research,* 124–131 (2013)

Gao, G. & Land, L. Nodular chert from the Arbuckle Group, Slick Hills, SW Oklahoma: a combined field, petrographic and isotopic study. *Sedimentology* **38**, 857–870 (1991)

Edwards, C., Pufahl, P., Hiatt, E. & Kyser, T. Paleoenvironmental and taphonomic controls on the occurrence of Paleoproterozoic microbial communities in the 1.88Ga Ferriman Group, Labrador Trough, Canada. *Precambrian Research,* 91–106 (2012)

Pratt, B., Winston, D., Rittel, J. & Furniss, G. Gas bubble and expansion crack origin of molar-tooth calcite structures in the middle Proterozoic Belt Supergroup, western Montana; discussion and reply. *Journal of Sedimentary Research* **69**, 1136–1145 (1999)

Simonson, B. Sedimentological constraints on the origins of Precambrian iron-formations. *Geol Soc America Bull* **96**, 244 (1985)

Schoenborn, W. & Fedo, C. Provenance and paleoweathering reconstruction of the Neoproterozoic Johnnie Formation, southeastern California. *Chemical Geology* **1-4**, 231–255 (2011)

Obermajer, M., Dewing, K. & Fowler, M. Geochemistry of crude oil from Bent Horn field (Canadian Arctic Archipelago) and its possible Paleozoic origin. *Organic Geochemistry* **41**, 986–996 (2010)

Henderson, J. Archean Stromatolites in the Northern Slave Province, Northwest Territories, Canada. *Canadian Journal of Earth Sciences* **12**, 1619–1630 (1975)

Taylor, M. & Halley, R. Systematics, environment, and biogeography of some Late Cambrian and Early Ordovician trilobites from eastern New York State. Tech. Rep., USGS (1974)

Miller, R. & Falcon-Lang, H. Stonehammer Geopark, New Brunswick, Canada. *Geology Today* **28**, 110–118 (2012)

Stewart, J. Eolian deposits in the Neoproterozoic Big Bear Group, San Bernardino Mountains, California, USA. *Earth-Science Reviews* **1-4**, 47–62 (2005)

Beeunas, M. & Knauth, L. Preserved stable isotopic signature of subaerial diagenesis in the 1.2-b.y. Mescal Limestone, central Arizona: Implications for the timing and development of a terrestrial plant cover. *Geol Soc America Bull* **96**, 737 (1985)

Lehnert, O., Miller, J. & Repetski, J. Paleogeographic significance of Clavohamulus hintzei Miller (Conodonta) and other Ibexian conodonts in an early Paleozoic carbonate platform facies of the Argentine Precordillera. *Geological Society of America Bulletin* **109**, 429–443 (1997)

Edited by Cobb, E. The United States Geological Survey in Alaska; accomplishments during 1975. Tech. Rep., USGS (1976)

Fåhræus, L. Depositional Environments and Conodont-Based Correlation of the Long Point Formation (Middle Ordovician), Western Newfoundland. *Canadian Journal of Earth Sciences* **10**, 1822–1833 (1973)

Samson, S., Barr, S. & White, C. Nd isotopic characteristics of terranes within the Avalon Zone, southern New Brunswick. *Canadian Journal of Earth Sciences* **37**, 1039–1052 (2000)

(*), L. Paleozoic Carbonate Facies of the Central Appalachian Shelf. *SEPM Journal of Sedimentary Research* **Vol. 41** (1971)

Fahrig, W. & Chown, E. The Paleomagnetism of the Otish Gabbro from North of the Grenville Front, Quebec. *Canadian Journal of Earth Sciences* **10**, 1556–1564 (1973)

Kennedy, M., Christie-Blick, N. & Sohl, L. Reply. *Geol* **30**, 287 (2002)

Hahn, K., Turner, E., Babechuk, M. & Kamber, B. Deep-water seep-related carbonate mounds in a Mesoproterozoic alkaline lake, Borden Basin (Nunavut, Canada). *Precambrian Research,* 173–197 (2015)

Awramik, S. & Semikhatov, M. The relationship between morphology, microstructure, and microbiota in three vertically intergrading stromatolites from the Gunflint Iron Formation. *Canadian Journal of Earth Sciences* **16**, 484–495 (1979)

Chown, E. & Caty, J. Diagenesis of the Aphebian Mistassini regolith, Quebec, Canada. *Precambrian Research* **19**, 285–299 (1983)

Budai, J., Lohmann, K. & R, R. Burial Dedolomite in the Mississippian Madison Limestone, Wyoming and Utah Thrust Belt. *SEPM Journal of Sedimentary Research* **Vol. 54** (1984)

Grey, K. & Corkeron, M. Late Neoproterozoic stromatolites in glacigenic successions of the Kimberley region, Western Australia: evidence for a younger Marinoan glaciation. *Precambrian Research* **92**, 65–87 (1998)

Soria, J., Caracuel, J., Corbí, H., Dinarès-Turell, J., Lancis, C., Tent-Manclús, J., Viseras, C. & Yébenes, A. The Messinian–early Pliocene stratigraphic record in the southern Bajo Segura Basin (Betic Cordillera, Spain): Implications for the Mediterranean salinity crisis. *Sedimentary Geology* **203**, 267–288 (2008)

Salama, W., Gazley, M. & Bonnett, L. Geochemical exploration for supergene copper oxide deposits, Mount Isa Inlier, NW Queensland, Australia. *Journal of Geochemical Exploration* (2016)

Fowler, M., Stasiuk, L., Hearn, M. & Obermajer, M. Evidence for Gloeocapsomorpha prisca in Late Devonian source rocks from Southern Alberta, Canada. *Organic Geochemistry* **35**, 425–441 (2004)

Hagadorn, J. & Bottjer, D. Restriction of a Late Neoproterozoic Biotope: Suspect-Microbial Structures and Trace Fossils at the Vendian-Cambrian Transition. *Palaios* **14**, 73 (1999)

Caplan, M. & Marc Bustin, R. Palaeoenvironmental and palaeoceanographic controls on black, laminated mudrock deposition: example from Devonian–Carboniferous strata, Alberta, Canada. *Sedimentary Geology* **145**, 45–72 (2001)

Lesser Himalaya Zone. *Physics and Chemistry of the Earth,* 53–105 (1992)

Greenough, J., McCutcheon, S. & Papezik, V. Petrology and geochemistry of Cambrian volcanic rocks from the Avalon Zone in New Brunswick. *Canadian Journal of Earth Sciences* **22**, 881–892 (1985)

McCormick, D. & Grotzinger, J. Evolution and significance of an overfilled alluvial foreland basin: Burnside Formation (1.9 Ga), Kilohigok Basin, N.W.T., Canada. *Basin Research* **4**, 253–278 (1992)

Sarg, J. The sequence stratigraphy, sedimentology, and economic importance of evaporite–carbonate transitions: a review. *Sedimentary Geology* **140**, 9–34 (2001)

Dubiel, R., Ridgley, J., Armstrong, A. & Holcomb, L. Depositional environments of the Upper Triassic Chinle Formation in the eastern San Juan Basin and vicinity, New Mexico. Trace fossils and mollusks from the upper member of the Wanakah Formation, Chama Basin, New Mexico; evidence for a lacustrine origin. Stratigraphy, facies, and paleotectonic history of Mississippian rocks in the San Juan Basin of northwestern New Mexico and adjacent areas. Tech. Rep., USGS (1989)

Richard, A., Kendrick, M. & Cathelineau, M. Noble gases (Ar, Kr, Xe) and halogens (Cl, Br, I) in fluid inclusions from the Athabasca Basin (Canada): Implications for unconformity-related U deposits. *Precambrian Research,* 110–125 (2014)

Lanier, W. Interstitial and peloid microfossils from the 2.0 Ga Gunflint Formation: Implications for the paleoecology of the Gunflint Stromatolites. *Precambrian Research* **45**, 291–318 (1989)

Carr, W. Geology of the Devils Hole area, Nevada. Tech. Rep., USGS (1988)

Aspler, L., Wisotzek, I., Chiarenzelli, J., Losonczy, M., Cousens, B., McNicoll, V. & Davis, W. Paleoproterozoic intracratonic basin processes, from breakup of Kenorland to assembly of Laurentia: Hurwitz Basin, Nunavut, Canada. *Sedimentary Geology,* 287–318 (2001)

Soja, C., White, B., Antoshkina, A., Joyce, S., Mayhew, L., Flynn, B. & Gleason, A. Development and Decline of a Silurian Stromatolite Reef Complex, Glacier Bay National Park, Alaska. *Palaios* **15**, 273–292 (2000)

Collins, D. & Bohm, R. Description of insoluble residues from the T.P. Russell No. 1 drill hole and other drill holes in southeastern Missouri. Tech. Rep., USGS (1993)

Feltrin, L. Predictive modelling of prospectivity for Pb–Zn deposits in the Lawn Hill Region, Queensland, Australia. *Ore Geology Reviews* **34**, 399–427 (2008)

Mukherjee, D., Khan, S. & Sullivan, C. Upper Albian rudist buildups of the Edwards Formation in central Texas: A GPR-assisted reservoir analog study. *Sedimentary Geology,* 71–81 (2012)

Marenco, P., Martin, K., Marenco, K. & Barber, D. Increasing global ocean oxygenation and the Ordovician Radiation: Insights from Th/U of carbonates from the Ordovician of western Utah. *Palaeogeography, Palaeoclimatology, Palaeoecology* (2016)

Johnson, E. Depositional history of Triassic rocks in the area of the Powder River basin, northeastern Wyoming and southeastern Montana. Tech. Rep., USGS (1993)

Landing, E. & Kröger, B. Cephalopod ancestry and ecology of the hyolith "Allatheca" degeeri s.l. in the Cambrian Evolutionary Radiation. *Palaeogeography, Palaeoclimatology, Palaeoecology,* 21–30 (2012)

Choubert, G. & Faure-Muret, A. 3. The newfoundland avalonides — a comparison with the anti-atlas. *Earth-Science Reviews,* 126–139 (1980)

Read, C., Mamay, S. & Keroher, G. Upper Paleozoic floral zones and floral provinces of the United States, with a glossary of stratigraphic terms. Tech. Rep., USGS (1964)

Rast, N. & Skehan, J. Changing tectonic environments of the Avalon superterrane and the Nashoba terrane in Massachusetts. *Journal of Geodynamics* **17**, 1–20 (1993)

Barnaby, R. & Read, J. Carbonate ramp to rimmed shelf evolution: Lower to Middle Cambrian continental margin, Virginia Appalachians. *Geological Society of America Bulletin* **102**, 391–404 (1990)

Kidder, D. Syntectonic sedimentation in the Proterozoic upper Belt Supergroup, northwestern Montana. *Geol* **16**, 658 (1988)

Webb, G. Was Phanerozoic reef history controlled by the distribution of non-enzymatically secreted reef carbonates (microbial carbonate and biologically induced cement)? *Sedimentology* **43**, 947–971 (1996)

Childers, M. Structure and Stratigraphy of the Southwest Marias Pass Area, Flathead County, Montana. *Geol Soc America Bull* **74**, 141 (1963)

Pratt, B. & James, N. The St George Group (Lower Ordovician) of western Newfoundland: tidal flat island model for carbonate sedimentation in shallow epeiric seas. *Sedimentology* **33**, 313–343 (1986)

(2), J. Petrology of the Carbonate-evaporite Facies Transition of the Seven Rivers Formation (Guadalupian, Permian), Southeast New Mexico. *SEPM Journal of Sedimentary Research* **Vol. 51** (1981)

Tohver, E., Holm, D., van der Pluijm, B., Essene, E. & Cambray, F. Late Paleoproterozoic (geon 18 and 17) reactivation of the Neoarchean Great Lakes Tectonic Zone, northern Michigan, USA: Evidence from kinematic analysis, thermobarometry and 40Ar/39Ar geochronology. *Precambrian Research* **157**, 144–168 (2007)

Carrara, P. Late quaternary glacial and vegetative history of the Glacier National Park region, Montana. Tech. Rep., USGS (1989)

Draganits, E. & Noffke, N. Siliciclastic Stromatolites and Other Microbially Induced Sedimentary Structures in an Early Devonian Barrier-Island Environment (Muth Formation, NW Himalayas). *Journal of Sedimentary Research* **74**, 191–202 (2004)

Miall, A. Continental marine transition in the Devonian of Prince of Wales Island, Northwest Territories. *Canadian Journal of Earth Sciences* **7**, 125–144 (1970)

Robertson, W. Pole Position from Thermally Cleaned Sibley Group Sediments and its Relevance to Proterozoic Magnetic Stratigraphy. *Canadian Journal of Earth Sciences* **10**, 180–193 (1973)

Hoffman, P. & Li, Z. A palaeogeographic context for Neoproterozoic glaciation. *Palaeogeography, Palaeoclimatology, Palaeoecology* **277**, 158–172 (2009)

Bryan, J. A Paleocene coral—algal—sponge reef from southwestern Alabama and the ecology of Early Tertiary reefs. *Lethaia* **24**, 423–438 (1991)

Moore, T., Wallace, W., Bird, K., Karl, S., Mull, C. & Dillon, J. Stratigraphy, structure, and geologic synthesis of northern Alaska. Tech. Rep., USGS (1992)

Ross, J., Hintze, L., Ethington, R., Miller, J., Taylor, M., Repetski, J., Sprinkle, J. & Guensburg, T. The Ibexian Series (Lower Ordovician), a replacement for "Canadian Series" in North American chronostratigraphy. Tech. Rep., USGS (1993)

Ghazban, F., Schwarcz, H. & Ford, D. Multistage dolomitization in the Society Cliffs Formation, northern Baffin Island, Northwest Territories, Canada. *Canadian Journal of Earth Sciences* **29**, 1459–1473 (1992)

Lacelle, D., Pellerin, A., Clark, I., Lauriol, B. & Fortin, D. (Micro)morphological, inorganic–organic isotope geochemisty and microbial populations in endostromatolites (cf. fissure calcretes), Haughton impact structure, Devon Island, Canada: The influence of geochemical pathways on the preservation of isotope biomarkers. *Earth and Planetary Science Letters* **281**, 202–214 (2009)

Barbieri, R., Ori, G. & Cavalazzi, B. A Silurian Cold-Seep Ecosystem From the Middle Atlas, Morocco. *Palaios* **19**, 527–542 (2004)

Allison, C. Paleontology of late Proterozoic and Early Cambrian rocks of east-central Alaska. Tech. Rep., USGS (1988)

Chafetz, H. & Reid, A. Syndepositional shallow-water precipitation of glauconitic minerals. *Sedimentary Geology* **136**, 29–42 (2000)

Hackley, P. & Karlsen, A. Geologic assessment of undiscovered oil and gas resources in Aptian carbonates, onshore northern Gulf of Mexico Basin, United States. *Cretaceous Research,* 225–234 (2014)

Soja, C. & Antoshkina, A. Coeval development of Silurian stromatolite reefs in Alaska and the Ural Mountains: Implications for paleogeography of the Alexander terrane. *Geol* **25**, 539 (1997)

Sherman, A., Narbonne, G. & James, N. Anatomy of a cyclically packaged Mesoproterozoic carbonate ramp in northern Canada. *Sedimentary Geology* **139**, 171–203 (2001)

(2), R. & Read, J. Cambrian Carbonate Platform Margin Facies, Shady Dolomite, Southwestern Virginia, U.S.A. *SEPM Journal of Sedimentary Research* **Vol. 50** (1980)

Saltzman, M. & Sedlacek, A. Chemostratigraphy indicates a relatively complete Late Permian to Early Triassic sequence in the western United States. *Geology* **41**, 399–402 (2013)

Medig, K., Thorkelson, D., Davis, W., Rainbird, R., Gibson, H., Turner, E. & Marshall, D. Pinning northeastern Australia to northwestern Laurentia in the Mesoproterozoic. *Precambrian Research,* 88–99 (2014)

Stewart, J., McMenamin, M. & Morales-Ramirez, J. Upper Proterozoic and Cambrian rocks in the Caborca region, Sonora, Mexico; physical stratigraphy, biostratigraphy, paleocurrent studies, and regional relations. Tech. Rep., USGS (1984)

Joeckel, R. & Korus, J. Bayhead delta interpretation of an Upper Pennsylvanian sheet-like sandbody and the broader understanding of transgressive deposits in cyclothems. *Sedimentary Geology,* 22–37 (2012)

Wilmeth, D., Dornbos, S., Isbell, J. & Czaja, A. Putative domal microbial structures in fluvial siliciclastic facies of the Mesoproterozoic (1.09 Ga) Copper Harbor Conglomerate, Upper Peninsula of Michigan, USA. *Geobiology* **12**, 99–108 (2014)

Abbott, P. Calcitization of Edwards Group Dolomites in the Balcones Fault Zone Aquifer, South-Central Texas. *Geol* **2**, 359 (1974)

Gatrall, M., Jenkyns, H. & Parsons, C. Limonitic Concretions From The European Jurassic, With Particular Reference To The Snuff-boxes Of Southern England. *Sedimentology* **18**, 79–103 (1972)

Macnaughton, R., Dalrymple, R. & Narbonne, G. Early Cambrian braid-delta deposits, MacKenzie Mountains, north-western Canada. *Sedimentology* **44**, 587–609 (1997)

Collins, D., Taylor, M., Repetski, J. & Palmer, A. New sedimentologic and paleontologic data for the Dow Chemical #1 B. L. Garrigan drill hole, Mississippi County, Arkansas. Tech. Rep., USGS (1992)

Unrug, R., Ausich, W., Bednarczyk, J., Cuffey, R., Mamet, B., Palmes, S. & Unrug, S. Paleozoic age of the Walden Creek Group, Ocoee Supergroup, in the western Blue Ridge, southern Appalachians: Implications for evolution of the Appalachian margin of Laurentia. *Geological Society of America Bulletin* **112**, 982–996 (2000)

Greggs, R. & Greggs, D. Fault-block Tectonism In The Devonian Subsurface, Western Canada Basin. *Journal of Petroleum Geology* **12**, 377–404 (1989)

Copper, P. The cyanophyte Wetheredella in Ordovician reefs and off-reef sediments. *Lethaia* **9**, 273–281 (1976)

Morey, G. & Van Schmus, W. Correlation of Precambrian rocks of the Lake Superior region, United States. Tech. Rep., USGS (1988)

Petterson, R., Prave, A., Wernicke, B. & Fallick, A. The Neoproterozoic Noonday Formation, Death Valley region, California. *Geological Society of America Bulletin* **123**, 1317–1336 (2011)

Fedo, C., Young, G. & Nesbitt, H. Paleoclimatic control on the composition of the Paleoproterozoic Serpent Formation, Huronian Supergroup, Canada: a greenhouse to icehouse transition. *Precambrian Research* **86**, 201–223 (1997)

Demicco, R. & Bridge, J. A Unique Freshwater Carbonate from the Upper Devonian Catskill Magnafacies of New York State. *SEPM Journal of Sedimentary Research* **Vol. 57** (1987)

Paul, J. & Peryt, T. Kalkowsky's stromatolites revisited (Lower Triassic Buntsandstein, Harz Mountains, Germany). *Palaeogeography, Palaeoclimatology, Palaeoecology* **161**, 435–458 (2000)

Webb, G. Late Mississippian thrombolite bioherms from the Pitkin Formation of northern Arkansas. *Geol Soc America Bull* **99**, 686 (1987)

Long, D. Tomographic study of Paleoproterozoic carbonates as key to understanding the formation of molar-tooth structure. *Gondwana Research* **12**, 566–570 (2007)

Grimwood, J., Coniglio, M. & Armstrong, D. Blackriveran carbonates from the subsurface of the Lake Simcoe area, southern Ontario: stratigraphy and sedimentology of a low-energy carbonate ramp. *Canadian Journal of Earth Sciences* **36**, 871–889 (1999)

Ruppel, S. & Walker, K. Petrology and depositional history of a Middle Ordovician carbonate platform: Chickamauga Group, northeastern Tennessee. *Geol Soc America Bull* **95**, 568 (1984)

Brannon, J., Podosek, F., Viets, J., Leach, D., Goldhabe, M. & Rowan, E. Strontium isotopic constraints on the origin of ore-forming fluids of the Viburnum Trend, southeast Missouri. *Geochimica et Cosmochimica Acta* **55**, 1407–1419 (1991)

Kennedy, M., Christie-Blick, N. & Prave, A. Carbon isotopic composition of Neoproterozoic glacial carbonates as a test of paleoceanographic models for snowball Earth phenomena. *Geol* **29**, 1135 (2001)

Hofmann, H. & Jackson, G. Precambrian (Aphebian) microfossils from Belcher Islands, Hudson Bay. *Canadian Journal of Earth Sciences* **6**, 1137–1144 (1969)

Brett, C., Allison, P., DeSantis, M., Liddell, W. & Kramer, A. Sequence stratigraphy, cyclic facies, and lagerstätten in the Middle Cambrian Wheeler and Marjum Formations, Great Basin, Utah. *Palaeogeography, Palaeoclimatology, Palaeoecology* **277**, 9–33 (2009)

Batten Hender, K. & Dix, G. Facies, geometry and geological significance of Late Ordovician (early Caradocian) coral bioherms: Lourdes Formation, western Newfoundland. *Sedimentology* **53**, 1361–1379 (2006)

Merrill, M., Drake II, R., Buursink, M., Craddock, W., East, J., Slucher, E., Warwick, P., Brennan, S., Blondes, M., Freeman, P., Cahan, S., DeVera, C. & Lohr, C. Geologic framework for the national assessment of carbon dioxide storage resources—Southern Rocky Mountain Basins: Chapter M in Geologic framework for the national assessment of carbon dioxide storage resources. Tech. Rep., USGS (2016)

Dimroth, E. & Kimberley, M. Precambrian atmospheric oxygen: evidence in the sedimentary distributions of carbon, sulfur, uranium, and iron. *Canadian Journal of Earth Sciences* **13**, 1161–1185 (1976)

Casey, G. Hydrogeology of the Silurian and Devonian carbonate-rock aquifer system in the Midwestern Basins and Arches Region of Indiana, Ohio, Michigan, and Illinois. Tech. Rep., USGS (1994)

Dehler, C., Elrick, M., Karlstrom, K., Smith, G., Crossey, L. & Timmons, J. Neoproterozoic Chuar Group (∼800–742Ma), Grand Canyon: a record of cyclic marine deposition during global cooling and supercontinent rifting. *Sedimentary Geology,* 465–499 (2001)

Luo, M., Chen, Z., Zhao, L., Kershaw, S., Huang, J., Wu, L., Yang, H., Fang, Y., Huang, Y., Zhang, Q., Hu, S., Zhou, C., Wen, W. & Jia, Z. Early Middle Triassic stromatolites from the Luoping area, Yunnan Province, Southwest China: Geobiologic features and environmental implications. *Palaeogeography, Palaeoclimatology, Palaeoecology,* 124–140 (2014)

Furniss, G., Rittel, J. & Winston, D. Gas bubble and expansion crack origin of molar-tooth calcite structures in the middle Proterozoic Belt Supergroup, western Montana. *Journal of Sedimentary Research* **68**, 104–114 (1998)

Scholle, P. & Halley, R. Upper Paleozoic depositional and diagenetic facies in a mature petroleum province (a field guide to the Guadalupe and Sacramento mountains). Tech. Rep., USGS (1980)

Tipping, R., Runkel, A., Alexander, E., Alexander, S. & Green, J. Evidence for hydraulic heterogeneity and anisotropy in the mostly carbonate Prairie du Chien Group, southeastern Minnesota, USA. *Sedimentary Geology* **184**, 305–330 (2006)

Baird, G., Zambito, J. & Brett, C. Genesis of unusual lithologies associated with the Late Middle Devonian Taghanic biocrisis in the type Taghanic succession of New York State and Pennsylvania. *Palaeogeography, Palaeoclimatology, Palaeoecology,* 121–136 (2012)

de Wet, C., Frey, H., Gaswirth, S., Mora, C., Rahnis, M. & Bruno, C. Origin of Meter-Scale Submarine Cavities and Herringbone Calcite Cement in a Cambrian Microbial Reef, Ledger Formation (U.S.A.). *Journal of Sedimentary Research* **74**, 914–923 (2004)

Soares, J., Nogueira, A., Domingos, F. & Riccomini, C. Synsedimentary deformation and the paleoseismic record in Marinoan cap carbonate of the southern Amazon Craton, Brazil. *Journal of South American Earth Sciences,* 58–72 (2013)

Thorman, C., Ketner, K., Miller, D. & Taylor, M. Field guide, roadlog, and comments on the geology from Wendover, Utah, to Wells, Nevada; for the Geological Society of America Penrose Conference. Tech. Rep., USGS (1987)

Bickford, M., Soegaard, K., Nielsen, K. & McLelland, J. Geology and geochronology of Grenville-age rocks in the Van Horn and Franklin Mountains area, west Texas: Implications for the tectonic evolution of Laurentia during the Grenville. *Geological Society of America Bulletin* **112**, 1134–1148 (2000)

Woods, A. & Baud, A. Anachronistic facies from a drowned Lower Triassic carbonate platform: Lower member of the Alwa Formation (Ba'id Exotic), Oman Mountains. *Sedimentary Geology* **209**, 1–14 (2008)

McDowell, R. & Schultz, A. Structural and stratigraphic framework of the Giles County area, a part of the Appalachian Basin of Virginia and West Virginia. Tech. Rep., USGS (1989)