

**An Eolian Dust Origin for Clastic Fines of Devono-Mississippian Mudrocks of the Greater  
North American Midcontinent - Discussion**

**By**

**Ryan D. Wilson and Juergen Schieber**

**Published in: Journal of Sedimentary Research, 2024, v. 94, p. 151-155**

**This discussion was written as a critique of the paper by McGlannan et al. 2022 (citation below), on supposed eolian contributions to Late Devonian black shales of North America:**

McGLANNAN, A.J., BONAR, A., PFEIFER, L., STEINIG, S., VALDES, P., ADAMS, S., DUARTE, D., MILAD, B., CULLEN, A., SOREGHAN, G.S., 2022, An eolian dust origin for clastic fines of Devono-Mississippian mudrocks of the greater North American midcontinent. Journal of Sedimentary Research, v. 92, p. 1186–1206.

**Whereas the official version of the manuscript can be accessed via the JSR web site (<https://doi.org/10.2110/jsr.2023.114>), We post here our final submission to Journal of Sedimentary Research (JSR), as printed in JSR v. 94, p. 151-155, with additional commentary for clarification (see below).**

**Due to JSR format requirements for disuccssions, our original title:**

**Eolian Input was not a Critical Factor for the Formation of Devonian Black Shales in North America. Critique of Paper by McGlannan et al.**

**Was changed to (as seen above):**

**An Eolian Dust Origin for Clastic Fines of Devono-Mississippian Mudrocks of the Greater  
North American Midcontinent – Discussion**

**Everything else shown below in black typeface is the original text as printed by JSR, as are the figures.**

**After reading the response to our critique by McGlannan et al., we concluded that several of the points we had raised would benefit from further clarification, so as to eliminate potential ambiguity about the facts on the ground and to benefit the scientific discussion.**

**This added commentary is in red type and in text boxes with light orange background so as to be clearly distinguishable from the text as published in JSR**

40 >>>>start of Discussion as published in JSR.

41 In a recently published paper, McGlannan et al. (2022) posit that the detrital silt  
42 component of Upper Devonian and Lower to Middle Mississippian shales of the North American  
43 Midcontinent region is of eolian origin and provided essential nutrients that stimulated the  
44 organic productivity that is recorded by these shales. Our initial concern with their study was the  
45 fact that McGlannan et al. (2022) studied a stratigraphic interval that spans approximately 20  
46 million years (Late Devonian to Early Mississippian), and applied conclusions reached for the  
47 Mississippian part of the succession to the underlying Devonian black shales. This was  
48 surprising because it is well known that a drastic sea-level fall occurred at the end of the  
49 Devonian and resulted in an unconformity over much of the North American craton (Frazier and  
50 Schwimmer, 1987; Over, 2021). As far as we understand from geologic literature, extrapolating  
51 the inferred sedimentary dynamics of one stratigraphic interval (Early Mississippian) across a  
52 sequence boundary to rocks that were deposited multiple millions of years earlier (Late  
53 Devonian) is neither recommended nor considered good practice.

54 McGlannan et al. find the preceding sentence “odd”, but we maintain that the way they  
55 applied (in their 2022 paper) textural observations made in overlying Mississippian shales  
56 (“no to minimal instances of quartz overgrowths”) to justify interpretations of Late  
57 Devonian black shales (across an unconformity) is poor science nonetheless. In particular,  
58 because the reader was given the impression that these textural features were shared by the  
59 substantially older Devonian black shales. Data and observations collected from the  
60 Mississippian should not be extrapolated to the underlying Late Devonian black shales as a  
61 major unconformity developed across Laurentia marks a significant drawdown of eustatic  
62 sea-level as a result of glaciation, representing vastly different depositional conditions.

63  
64 The aim of this discussion is not to disqualify eolian systems in general as a potential  
65 source of fines in shale successions. It is not implausible that there were times and places in the  
66 geologic past when they may have contributed to marine or lacustrine shale/mudstone  
67 successions. We are, however, firmly convinced that in the case of the Late Devonian of North

68 America, no compelling case can be made for a significant eolian clastic component to its widely  
69 distributed black-shale successions.

70           Whereas we disagree with the validity of the McClannan et al. (2022) study at several  
71 levels, three principal lines of reasoning stand out to demonstrate that their conclusions are  
72 flawed and inapplicable to the Late Devonian black shales of North America.

73           First, petrographic examination of the rocks in question, collected from the same location  
74 as samples used by the authors (Woodford samples from McAlister Quarry), as well as samples  
75 from the Woodford of the Central Basin Platform (Permian Basin, Texas, samples courtesy of  
76 Kitty Milliken) does not support their assumptions about these rocks. SEM analysis shows these  
77 samples to be strongly dominated by microcrystalline quartz (Fig. 1) and indicates that it is  
78 highly unlikely that the authors could have succeeded to extract detrital quartz grains from these  
79 rocks with the method described (McClannan et al. 2022), much less using them for grain-size  
80 analysis. The abundant early diagenetic silica cementation that fed on dissolution of radiolarian  
81 tests is so ubiquitous in these shales, generating silt- and even sand- size quartz particles (Blatt,  
82 1987; Schieber, 1996; Schieber et al, 2000) that upon crushing/processing it would inevitably  
83 have generated silt- and sand-sized quartz particles (Fig. 2). Petrographic constraints (Fig. 1),  
84 however, should readily disabuse a discerning observer from the notion that these particles are in  
85 any kind or form detrital in nature.

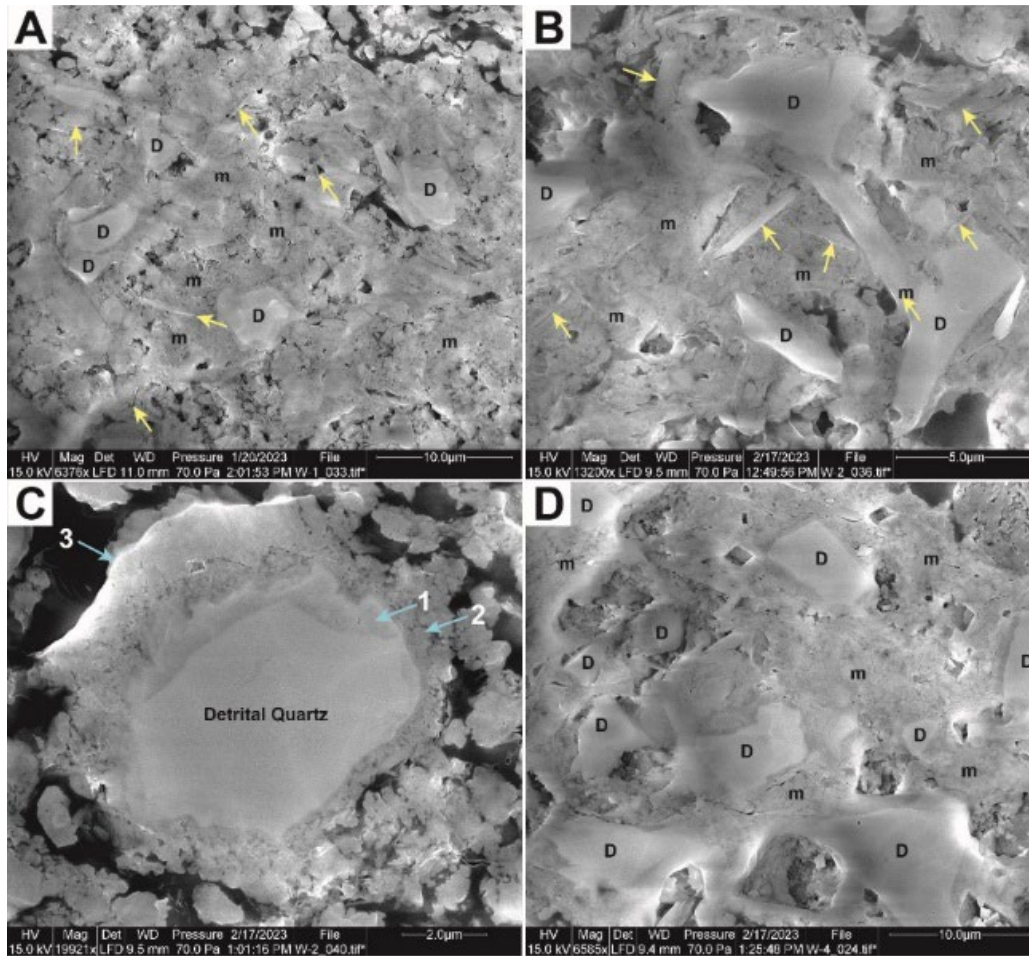
86

87

88

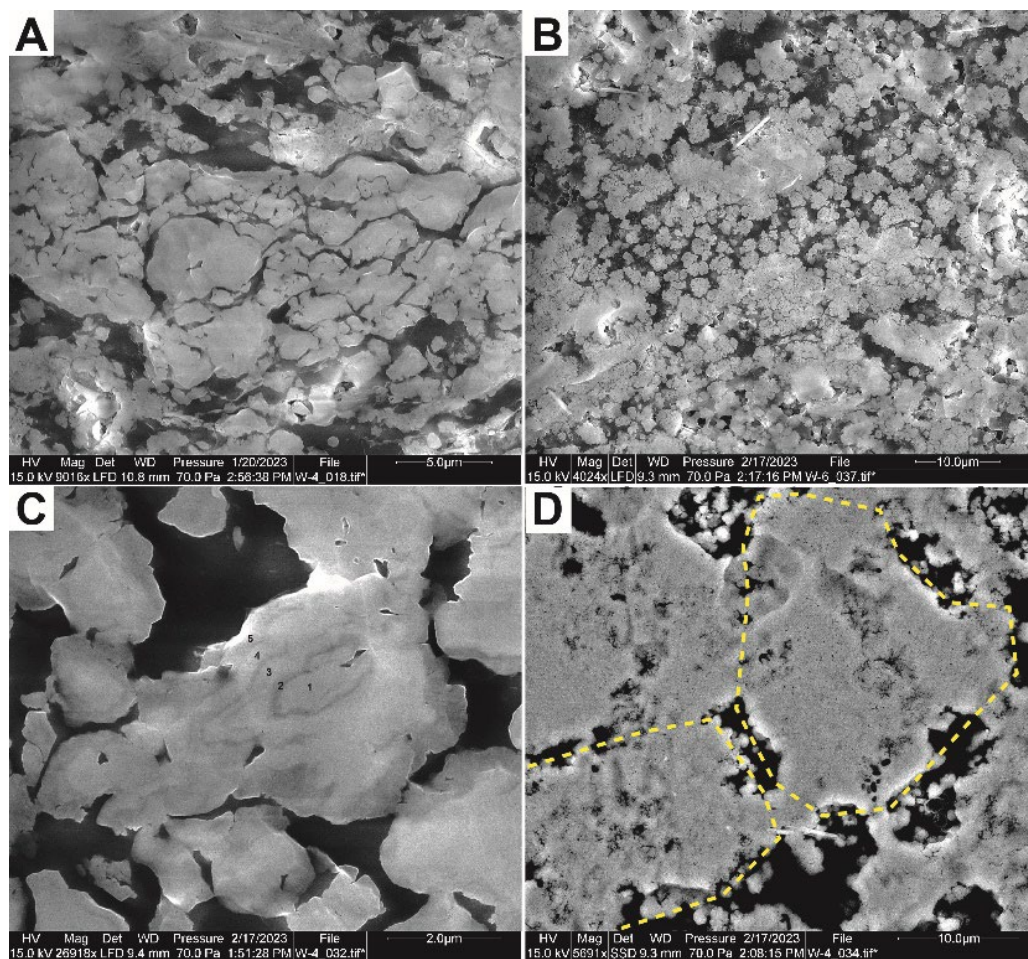
89

90



91  
 92 **Figure 1:** Examples of diagenetic quartz cementation in the Woodford Shale of the Arbuckle  
 93 Mountains of Oklahoma (secondary electron images). Only examples of fabric categories are  
 94 marked, the gray-scale contrast between particles and matrix is due to charge contrast because  
 95 the images were taken in low-vacuum mode. A) Typical appearance of silica cemented shale, a  
 96 mixture of detrital quartz (D), phyllosilicate flakes (yellow arrows), and fine crystalline matrix  
 97 (m). B) Comparable fabric in a different sample at higher magnification. Note that in both  
 98 parts, A and B, the mica and clay flakes show random orientation. C) Close-up view of a single  
 99 detrital quartz grain with three generations of silica overgrowth (numbered blue arrows). The  
 100 dark matter is kerogen. This image also shows the clumpy nature of the diagenetic silica,  
 101 comparable to what Milliken and Olsen (2017) and Longman et al. (2019) described as opal-CT  
 102 lepispheres that subsequently recrystallized to microquartz. D) Another example of the intimate  
 103 association of detrital quartz grains (D) and fine-grained siliceous matrix (m) containing

104 randomly oriented mica and clay flakes (not marked). Holes seen in these images are due to  
 105 oxidation of organic matter and dissolution of diagenetic pyrite and dolomite.



106  
 107 **Figure 2:** Clustering and clumping of early-diagenetic silica in the Woodford Shale, and  
 108 potential disaggregation sub-units (SEM images). A) Low-porosity quartz aggregates that range  
 109 in size from 1 to 8 microns, and are separated by kerogen (black). B) More porous aggregates  
 110 that range in size from 1 to 20 microns and are separated by kerogen (black). If such rock is  
 111 crushed, or if the organic matrix is digested chemically, quartz particles in the 1 to 20 micron  
 112 size range can be expected in the residue. C) Detail of low porosity aggregates that show well  
 113 developed cement zonation (1 through 5). D) Better cemented and partially fused aggregates of  
 114 the type shown in Part B. If crushed mechanically, fragments outlined by yellow dashed lines,  
 115 several ten microns in size, are likely to form.

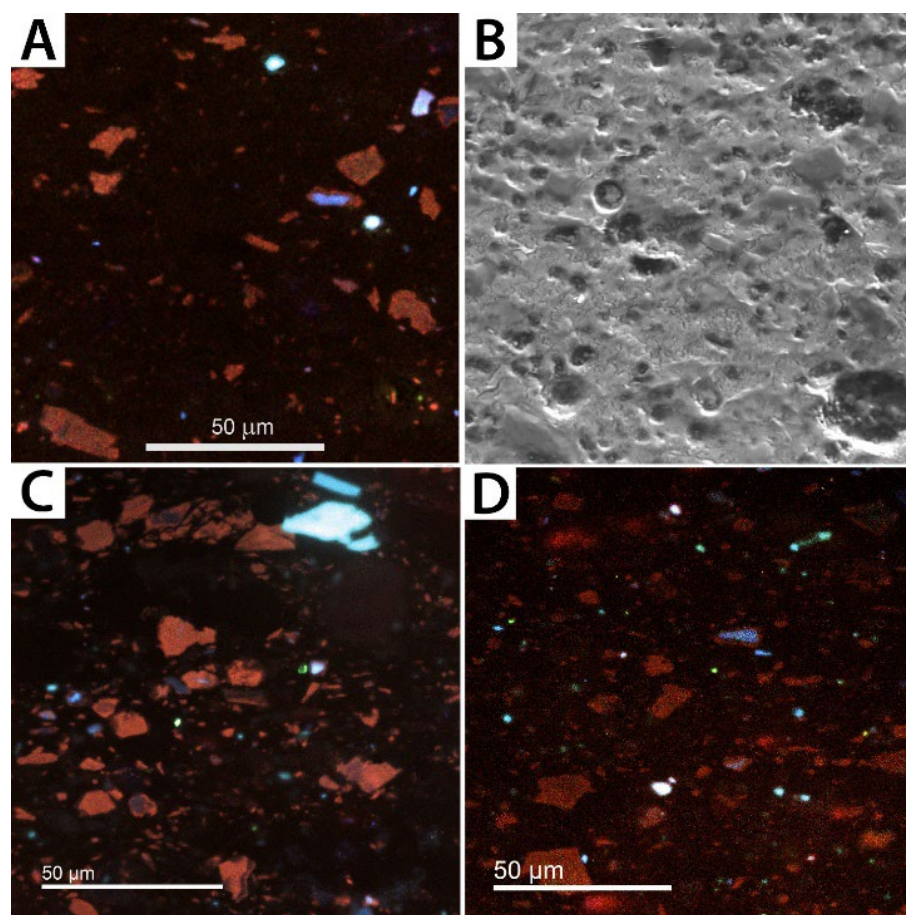
116 **Note that the quartz cement in Fig. 2 is not contiguous as it would be in a chert. It forms**  
 117 **subunits in the micron to tens of microns size range, separated by organic matter. That is the**  
 118 **reason why this material weathers recessive, and it is these recessive intervals of the**

119 Woodford that were sampled by McGlannan et al. 2022 and subsequently by us to make  
120 sure we don't engage into an "apples" vs "oranges" discussion.

121 In their reply, McGlannan et al. (2024) try to invalidate this point by stating that they  
122 "preferentially avoided silica-rich facies and predominantly sampled laminated shale  
123 facies", implying that we had not done so and that our observations regarding petrography in  
124 some way "missed the mark". We take exception to that, because we were very much  
125 cognizant of this issue and that is exactly why we went to the very outcrops that were  
126 sampled by McGlannan et al. (2022) and did indeed sample the softer intervals between  
127 chert ledges of the Woodford Shale. Although these recessive interbeds are softer than the  
128 chert beds, abundant diagenetic silica still dominates the fabric and detrital quartz grains  
129 invariably are overgrown by secondary quartz.

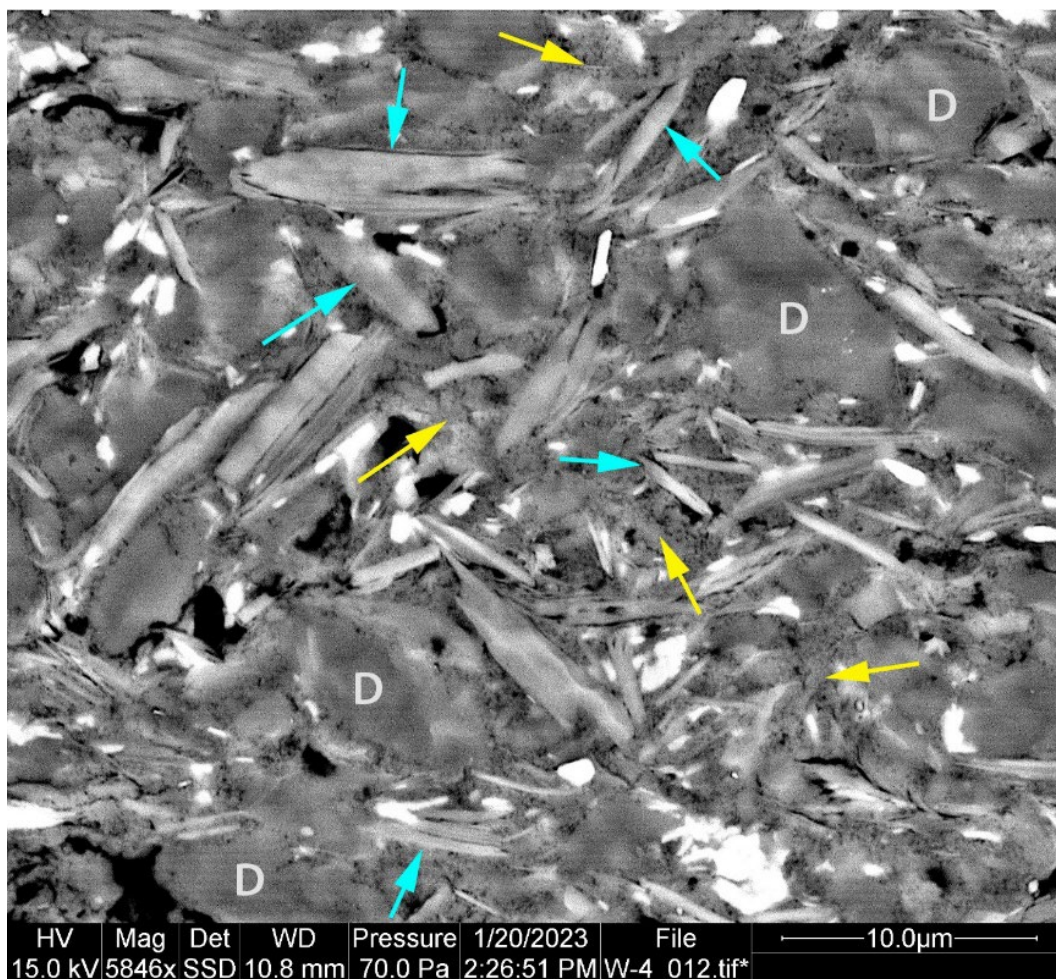
130  
131 In our extensive experience with mudstone petrography, the detrital vs. authigenic nature  
132 of silt-size quartz grains cannot be determined (as the authors did) via inspection of "smear slides  
133 of residues" with a petrographic microscope. To make that determination requires the resolution  
134 offered by scanning electron microscopes (SEM). Fig. 3 shows our Woodford samples from the  
135 perspective of scanned cathodoluminescence, illustrating the type and size range of detrital  
136 quartz. The dominant reddish-orange colors of quartz grains suggest derivation from the same  
137 low-grade metamorphic source, the Acadian orogeny, presumed for Late Devonian black shales  
138 farther east (Schieber, 2016). The general abundance and size range of detrital quartz from the  
139 Woodford is in essence the same as that observed in Upper Devonian black shales of the Illinois  
140 Basin ca. 500 km to the east, and in the Williston Basin ca. 900 km to the north (Fig. 3),  
141 plausibly suggesting that all three locales received clastics from the Acadian orogen in the east  
142 (Schieber, 2016). The lacking differences in size range and source characteristics of detrital  
143 quartz (Fig. 3) between samples from Oklahoma and those of time-equivalent Devonian black  
144 shales from the Illinois and Williston basins (both far offshore the Acadian source region)  
145 supports strong dilution of clastics by early diagenetic silica in the case of the Woodford  
146 samples. No principal difference is observed between these locales. The randomly oriented  
147 phyllosilicate platelets (cardhouse fabric) observed in these rocks (Figs. 1 and 4), shielded from

148 compaction by early diagenetic silica cements (Figs. 1 and 2), strongly suggests that the detrital  
 149 component of these shales arrived via bedload transport of flocculated muds, and is quite similar  
 150 to uncompacted fabrics seen in flume experiments that simulated accumulation of muds from  
 151 bottom current transported floccules (Schieber et al., 2007; Schieber, 2011). Settling of airborne  
 152 dust through the water column should produce an entirely different fabric with largely bedding-  
 153 aligned phyllosilicates (O'Brien and Slatt, 1990).



154  
 155 **Figure 3:** Scanned CL-appearance and size range of detrital quartz in the Woodford compared  
 156 with other Devonian black shales across the United States. A) Scanned cathodoluminescence  
 157 image where detrital quartz shows as reddish and reddish-blue particles (bright bluish-green  
 158 particles are K-feldspar), whereas the diagenetic matrix silica is largely non-luminescent. B)  
 159 The same field of view (secondary electron image), detrital quartz grains appear as medium-  
 160 gray objects, whereas the fine crystalline matrix quartz appears light gray and has a fine

161 granular texture. C) CL images of the New Albany Shale in the Illinois Basin, and D) of the  
 162 Bakken Shale of the Williston Basin for comparison. There is no significant difference in type  
 163 and size range of detrital quartz grains between the Woodford, New Albany, and Bakken. The  
 164 main difference is that the Woodford shows substantially more dilution by diagenetic silica. The  
 165 CL images were acquired several years apart with somewhat different instrument settings and  
 166 image resolution, but they are displayed at the same magnification. The image in Part C was  
 167 collected with substantially higher beam dwell time than images in Parts A and D, resulting in a  
 168 “crisper” looking image.



169  
 170 **Figure 4:** Shale fabric with randomly oriented clay and mica flakes (blue arrows), scattered  
 171 small detrital quartz grains (marked D), and a fine crystalline matrix of early diagenetic silica  
 172 (yellow arrows).



173 Second, when examined in detail, stratigraphic relationships in Devonian organic-rich  
174 mudstone successions show rapid shifts of depocenters in response to basin–dynamics (e.g.,  
175 basement fault reactivation; Jacobi and Fountain, 2002; Wilson et al., 2022) as well as  
176 accommodation change due to subsidence (tectonic) and sea-level fluctuations. In the Late  
177 Devonian, regional unconformities (sequence boundaries) and their correlative conformities have  
178 been recognized and correlated across the United States by various authors (Brett et al., 2011;  
179 Lazar and Schieber, 2022; Wilson et al., 2022). Yet, these erosional contacts (and implicit  
180 hiatuses) are absent from Fig. 2 of McGlannan et al. (2022), greatly oversimplifying the existing  
181 stratigraphic complexities. Stratigraphic analysis shows that in the Appalachian Basin (Smith et  
182 al., 2019; Wilson et al., 2022), the Illinois Basin (Lazar and Schieber, 2022), and in central  
183 Oklahoma (Infante Paez et al., 2017), Devonian black shale successions invariably onlap onto  
184 structural highs (Cincinnati Arch, Nemaha Ridge). Such distal responses to shoreline  
185 progradation and retrogradation imply lateral sediment supply (for example by wind-driven  
186 bottom current systems) from a distal source and require shoreline-attached sediment dispersal  
187 systems. Had eolian sediment dispersal indeed been the key control in the distal realm, stratal  
188 units should be expected to drape across positive elements, rather than terminate against them.

189 McGlannan’s reply is very supportive and aligned with a dynamic hydrodynamic system  
190 proposed by numerous authors cited in our text, however, this (now stated) sentiment is **not**  
191 **aligned with the original McGlannan article** wherein it is stated “we propose that eolian  
192 delivery is an additional and simpler explanation that avoids the need to call upon unknown  
193 and unusually powerful storms or tides, as well as flocculation, which is inconsistent with  
194 the minimal clay-mineral content of the study units.” As demonstrated in our discussion,  
195 sedimentary structures (including evidence for flocculation) that suggest significant lateral  
196 transport via bottom currents are abundantly observed in the Woodford.

198 The most pervasive chert deposits associated with Late Devonian black shales occur in  
199 southern Laurentia, where a proximity to deep ocean waters and a combination of SE tradewinds  
200 with the Ekman spiral provide ideal conditions for upwelling of nutrient-rich waters onto the

201 flooded North American craton (e.g., Parrish, 1982; Schopf, 1983; Parrish and Barron, 1986;  
202 Comer, 1991). Whereas the influence of this nutrient source likely diminishes away from the  
203 cratonic edge (Murphy et al., 2000a, 2000b), it is a highly plausible scenario for driving marine  
204 productivity in the Anadarko–Arkoma and Permian Basins and the Woodford Shale sections  
205 sampled by McGlannan et al. (2022).

206         Third, due to the Devonian-age colonization of land masses by trees and other land  
207 plants, nutrient supply to shelf and epicontinental seas increased so dramatically (Algeo et al.,  
208 1995; Algeo and Scheckler, 1998) that eolian sourced nutrients, had they existed, would not have  
209 made any difference with regard to the available nutrient supply. Also, as mentioned above, the  
210 very likely existence of upwelling of nutrient-rich deep-sea waters along the southern margin of  
211 the Late Devonian inland sea is a much more plausible nutrient source (rather than eolian input)  
212 for that part of the Late Devonian black-shale system. Fundamentally, there is no need, nor any  
213 justification, to call upon input of eolian clastics as a critical factor for the formation of any of  
214 the Late Devonian black-shale successions in North America. Several studies of geochemical  
215 proxies and organic petrography have shown marine-terrestrial co-dependencies linking rapid  
216 expansion of land plants, enhanced continental weathering, terrestrial runoff, and nutrient supply  
217 from the Acadian borderlands to enhanced primary productivity in the Devonian inland sea  
218 (Maynard, 1981; Algeo et al., 1995; Algeo and Scheckler, 1998; Berner, 2005; Wilson and  
219 Schieber, 2017; Song et al. 2021). Collectively these studies evoke a mental image of coastal  
220 plains with thriving forests, unlikely to have facilitated widespread deflation and lofting of  
221 siliciclastic fines as postulated by McGlannan et al. (2022). Furthermore, generating copious  
222 quantities of dust to fertilize the Devonian inland sea for several millions of years by way of  
223 deflation implies a commensurate concentration of sand and formation of eolian dunes (Kocurek,

224 1996). Yet, in spite of a long history of research into Devonian nearshore and onshore deposits  
225 of the Appalachian Basin (e.g., Bridge and Willis, 1991; 1994; Walker and Harms, 1975;  
226 Slingerland and Loule, 1988) no eolian deposits have ever been documented.

227 McGlannan et al., 2024, disagree with our argument on the requirement for “a  
228 commensurate concentration of sand and formation of eolian dunes” to generate “copious  
229 quantities of dust.” Yet, in our critique we do not assume (as McGlannan et al., 2024 imply)  
230 that dust is generated by “grinding down” sand grains. We operate from an understanding  
231 that fines (mud, silt) are the most abundant product of weathering, and that in order to  
232 generate large quantities of dust, a substantial pile of sand is being “left behind”. And it is  
233 that sand that concerns us, because we don’t see it in the Devonian rock record. The Copper  
234 River deltaic system is called upon as an analog by McGlannan et al., 2022, and it so  
235 happens that the Copper River delta shows abundant eolian sand dunes (longitudinal ridges  
236 as much as 150 feet high) nourished by sustained, unidirectional, high-velocity winds that  
237 blow down the Copper River Canyon. If we accept the Copper River Delta as an analog for  
238 dust sourcing to the Late Devonian mudstone-dominated depositional system of the North  
239 American craton, spanning 10’s of millions of years of (supposedly) eolian dust generation,  
240 we would expect to see ample evidence of eolian dunes (the sand that was left behind)  
241 forming in coastal areas of this supposed source region of eolian dust, especially given the  
242 vast expanse of Late Devonian shales across Laurentia and the high volume of dust that  
243 would be required to form them.  
244

245 In summary, the confluence of petrographic constraints, stratigraphic relationships, and  
246 global controls thoroughly invalidates the premise of McGlannan et al. (2022). The considered  
247 evidence shows a striking mismatch between well documented geologic realities and the “eolian  
248 supply” vision proposed by McGlannan et al. (2022).

249

## 250 ACKNOWLEDGMENTS

251 The authors are indebted to João Trabucho-Alexandre, Joe Macquaker, and Kevin  
252 Bohacs for their helpful comments on the initial draft, as well as Kitty Milliken for her  
253 discussion points and providing samples of the Woodford from the Permian Basin. Helpful  
254 guidance and reviews provided by Peter Burgess and Kathie Marsaglia greatly improved the  
255 manuscript, as well as editorial comments provided by John Southard.

## REFERENCES

- 256
- 257 ALGEO, T.J., BERNER, R.A., MAYNARD, J.B., AND SCHECKLER, S.E., 1995, Late Devonian oceanic  
258 anoxic events and biotic crises: “Rooted” in the evolution of vascular land plants: *GSA*  
259 *Today*, v. 5, p. 45–66.
- 260 ALGEO, T.J., AND SCHECKLER, S.E., 1998, Terrestrial-marine teleconnections in the Devonian:  
261 Links between the evolution of land plants, weathering processes, and marine anoxic  
262 events: *Philosophical Transactions of the Royal Society of London, Series B, Biological*  
263 *Sciences*, v. 353, p. 113–130.
- 264 BERNER, R., 2005, The rise of trees and how they changed Paleozoic atmospheric CO<sub>2</sub>, climate,  
265 and geology, *in* Baldwin, I.T., Caldwell, M.M., Heldmaier, G., Jackson, R., Lange, O.L.,  
266 Mooney, H.A., Schulze, E.D., Sommer, U., Ehleringer, J., Denise Dearing, M., and  
267 Cerling, T., eds., *A History of Atmospheric CO<sub>2</sub> and Its Effects on Plants, Animals, and*  
268 *Ecosystems*: New York, Springer, v. 177, p. 1–7.
- 269 BLATT, H., 1987, Oxygen isotopes and the origin of quartz: *Journal of Sedimentary Petrology*, v.  
270 57, p. 373–377.
- 271 BRETT, C.E., BAIRD, G.C., Bartholomew, A.J., DeSantis, M.K., and Ver Straeten, C.A., 2011,  
272 Sequence stratigraphy and a revised sea-level curve for the Middle Devonian of eastern  
273 North America: *Palaeogeography, Palaeoclimatology, Palaeoecology*, v. 304, no. 1-2, p.  
274 21–53.
- 275 BRIDGE, J.S., AND WILLIS, B.J., 1991, Middle Devonian near-shore marine, coastal and alluvial  
276 deposits, Schoharie Valley, central New York State. *New York State Geological*  
277 *Association Guidebook* 63, p. 131–160.
- 278 BRIDGE, J.S., AND WILLIS, B.J., 1994, Marine transgressions and regressions recorded in Middle

- 279 Devonian shore-zone deposits of the Catskill clastic wedge: Geological Society of  
280 America Bulletin, v. 106, p. 1440–1458.
- 281 COMER, J.B., 1991, Stratigraphic Analysis of the Upper Devonian Woodford Formation, Permian  
282 Basin, West Texas and Southeastern New Mexico: The University of Texas at Austin,  
283 Bureau of Economic Geology, Report of Investigations 201, 63 p.
- 284 FRAZIER, W.J., AND SCHWIMMER, D.R., 1987, The Zuni Sequence: Middle Jurassic Upper  
285 Cretaceous: *in* Frazier, W.J., and Schwimmer, D.R. eds., Regional Stratigraphy of North  
286 America: Springer Plenum Press New York, p. 135–201.
- 287 INFANTE-PAEZ, L., CARDONA, L.F., MCCULLOUGH, B., AND SLATT, R., 2017, Seismic analysis of  
288 paleotopography and stratigraphic controls on total organic carbon: Rich sweet spot  
289 distribution in the Woodford Shale, Oklahoma, USA: Interpretation, v. 5, p. 33–47.
- 290 JACOBI, R.D., AND FOUNTAIN, J.C., 2002, The character and reactivation history of the southern  
291 extension of the seismically active Clarendon–Linden Fault System, western New York  
292 State: Tectonophysics, v. 353, p. 215–262.
- 293 KOCUREK, G.A., 1996, Desert aeolian systems, *in* Sedimentary Environments: Processes, Facies,  
294 and Stratigraphy, by Reading, H.G, 687 pp.
- 295 LAZAR, O.R., AND SCHIEBER, J., 2022, New Albany Shale, Illinois Basin, USA–Devonian  
296 Carbonaceous mudstone accumulation in an epicratonic sea: Stratigraphic insights from  
297 outcrop and subsurface data, *in* Bohacs, K.M. and Lazar, O.R., eds., Sequence  
298 stratigraphy: Applications to Fine-Grained Rocks: American Association of Petroleum  
299 Geologists Memoir 126, p. 249–294.
- 300 LONGMAN, M.W., DRAKE, W.R., MILLIKEN, K.L., AND OLSON, T.M., 2019, A comparison of  
301 silica diagenesis in the Devonian Woodford Shale (Central Basin Platform, West Texas)

- 302 and Cretaceous Mowry Shale (Powder River Basin, Wyoming), in Camp, W., Milliken,  
303 K., Taylor, K., Fishman, N., Hackley, P., eds.: *Mudstone Diagenesis: Research  
304 Perspectives for Shale Hydrocarbon Reservoirs, Seals, and Source Rocks: American  
305 Association of Petroleum Geologists Memoir 120*, p. 49–68.
- 306 MAYNARD, J.B., 1981, Carbon isotopes as indicators of dispersal patterns in Devonian–  
307 Mississippian shales of the Appalachian Basin: *Geology*, v. 9, p. 262–265.
- 308 MCGLANNAN, A.J., BONAR, A., PFEIFER, L., STEINIG, S., VALDES, P., ADAMS, S., DUARTE, D.,  
309 MILAD, B., CULLEN, A., SOREGHAN, G.S., 2022, An eolian dust origin for clastic fines of  
310 Devono-Mississippian mudrocks of the greater North American midcontinent. *Journal of  
311 Sedimentary Research*, v. 92, p. 1186–1206.
- 312 MILLIKEN, K.L. AND OLSON, T., 2017, Silica Diagenesis, Porosity Evolution, and Mechanical  
313 Behavior In Siliceous Mudstones, Mowry Shale (Cretaceous), Rocky Mountains,  
314 U.S.A. *Journal of Sedimentary Research*, v. 87, p. 366–387.
- 315 MURPHY, A.E., SAGEMAN, B.B., AND HOLLANDER, D.J., 2000a, Eutrophication by decoupling of  
316 the marine biogeochemical cycles of C, N, and P: a mechanism for the Late Devonian  
317 mass extinction: *Geology*, v. 28, p. 427–430.
- 318 MURPHY, A.E., SAGEMAN, B.B., HOLLANDER, D.J., LYONS, T.W., AND BRETT, C.E., 2000b, Black  
319 shale deposition and faunal overturn in the Devonian Appalachian Basin: clastic  
320 starvation, seasonal water-column mixing, and efficient biolimiting nutrient recycling:  
321 *Paleoceanography*, v. 15, p. 280–291.
- 322 O'BRIEN, N.R. AND SLATT, R.M., 1990, *Argillaceous Rock Atlas*: New York, Springer-Verlag,  
323 337 p.

- 324 OVER, D.J., 2021, The Devonian-Carboniferous boundary in the United States:  
325 Palaeobiodiversity and Palaeoenvironments v. 101, p. 529–540.
- 326 PARRISH, J.T., 1982, Upwelling and Petroleum Source Beds, With Reference to Paleozoic.  
327 American Association of Petroleum Geologists Bulletin, v. 66, p. 750–774.
- 328 PARRISH, J.T., AND BARRON, E.J., 1986, Paleoclimates and economic geology: SEPM Lecture  
329 Notes for Short Course 18, 162 p.
- 330 SCHIEBER, J., 1996, Early diagenetic silica deposition in algal cysts and spores: A source of sand  
331 in black shales? Journal of Sedimentary Research, v. 66, p. 175–183.
- 332 SCHIEBER, J., 2011, Reverse engineering mother nature – Shale sedimentology from an  
333 experimental perspective: Sedimentary Geology, v. 238, no. 1–2, p. 1–22.
- 334 SCHIEBER, J., 2016, Mud-redistribution in epicontinental basins—exploring likely processes:  
335 Marine and Petroleum Geology, v. 71, p. 119–133.
- 336 SCHIEBER, J., KRINSLEY, D., AND RICIPUTI, L., 2000, Diagenetic origin of quartz silt in mudstones  
337 and implications for silica cycling: Nature, v. 31, p. 981–985.
- 338 SCHIEBER, J., SOUTHARD, J.B., AND THAISEN, K., 2007, Accretion of Mudstone Beds from  
339 Migrating Floccule Ripples: Science, v. 318, p. 1760–1763.
- 340 SCHOPF, T., 1983, Paleozoic black shales in relation to continental margin upwelling, *in* Suess,  
341 E., and Thiede, J., eds., Coastal Upwelling: Its Sediment Record. Part B: Sedimentary  
342 Records of Ancient Coastal Upwelling: New York, Plenum Press, p. 579–596.
- 343 SONG, Y., GILLEAUDEAU, G.J., ALGEO, T.J., OVER, D.J., LYONS, T.W., ANBAR, A.D., XIE, S.,  
344 2021, Biomarker evidence of algal–microbial community changes linked to redox and  
345 salinity variation, Upper Devonian Chattanooga Shale (Tennessee, USA). Geological  
346 Society of America Bulletin, v. 133, p. 409–424.

- 347 SLINGERLAND, R. AND LOULE, J.P., 1988. Wind/wave and tidal processes along the Upper  
348 Devonian Catskill shoreline in Pennsylvania, U.S.A., *in* McMillan, N.J., Embry, A.F.,  
349 and Glass, D.J., eds., *Devonian of the World*, Vol. 2. Canadian Society of Petroleum  
350 Geologists, Calgary, p. 125–138.
- 351 SMITH, L.B., SCHIEBER, J., WILSON, R.D., 2019. Shallow-water onlap model for the deposition of  
352 Devonian black shales in New York, USA: *Geology*, v. 47, p. 279–283.
- 353 WALKER, R.G., AND HARMS, J.C., 1971, The "Catskill Delta": A Prograding Muddy Shoreline in  
354 Central Pennsylvania. *The Journal of Geology*, v. 79, p. 381–399.
- 355 WILSON, R.D., AND SCHIEBER, J., 2017, Association between wave- and current-aided  
356 hyperpycnites and flooding surfaces in shelfal mudstones: an integrated sedimentologic,  
357 sequence stratigraphic, and geochemical approach: *Journal of Sedimentary Research*, v.  
358 87, p. 1143–1155.
- 359 WILSON, R.D., SCHIEBER, J., AND BOHACS, K.M., 2022, Sequence stratigraphic reconstruction of  
360 the late Middle Devonian Geneseo Formation of NY, USA: Developing a genetic model  
361 for “Upper Devonian” unconventional targets in the Northern Appalachian Basin. *Marine*  
362 *and Petroleum Geology*, v. 138, p. 1–23.