Forum Comment

https://doi.org/10.1130/G46928C.1

Shallow-water onlap model for the deposition of Devonian black shales in New York, USA

Charles Ver Straeten[1], Carlton Brett[2], Gordon Baird[3], Diana Boyer[4], Richard Lindemann[5], Linda Ivany[6], D. Jeffrey Over[7], and Brian Witzke[8]
[1]New York State Museum, Albany, New York 12230, USA
[2]University of Cincinnati, Cincinnati, Ohio 45221, USA
[3]SUNY-Fredonia, Fredonia, New York 14063, USA
[4]Winthrop University, Rock Hill, South Carolina 29733, USA
[5]Skidmore College, Saratoga Springs, New York 12866, USA
[6]Syracuse University, Syracuse New York 13244, USA
[7]SUNY-Geneseo, Geneseo, New York 14454, USA
[8]University of Iowa, Iowa City Iowa 52242, USA

Over the past century, debate about deeper versus shallower origins of widespread black shales has coalesced around a deeper-water (>50 m) interpretation. Smith et al. (2019) raised the issue again relative to Devonian black shales in New York State (NY) based on subsurface and sedimentological data. We recognize that epicontinental marine black shales can form in a range of settings from basinal to lagoonal. However, diverse lines of evidence from stratigraphic relations, sedimentology, geochemistry, and paleobiology within and beyond the Appalachian Foreland Basin (AB) argue that a shallow-water (“a few meters to a few tens of meters”) origin is difficult to apply to the widespread Devonian black/dark shales of NY.

Inconsistent with the Smith et al. model, the Geneseo and older AB black shales are concentrically bounded by lateral gradations to gray mudstone-siltstone facies containing increasingly diverse and hydrodynamic-adapted faunas, indicative of progressively shallower-water settings. If deposited in shallow marginal settings, black shales would be geographically localized, contain consistently high amounts of terrestrial plant material, and laterally shift to terrestrial facies, as seen in eastern NY. Plant fossils in western black shales, other than fine debris, consist of rare logs that may have traveled long distances from land before sinking. In addition, characteristic organic-walled microfossils in the black shales indicate deeper-water assemblages to the west and shallow-water assemblages to the east (Kelly et al., 2019).

In support of their argument, Smith et al. stress that the water column was not permanently anoxic. This point, already widely accepted, does not imply exceptionally shallow settings, as changes in redox conditions can occur at a variety of depths. OrgC $\delta^{13}C$ and $\delta^{15}N$ data that require the presence of a chemocline are inconsistent with pervasive whole-water-column mixing (Uveges et al., 2018). In shallow depths, water-column mixing and oxygenation via waves, storms, and currents would probably destroy much organic matter, preventing concentration, despite a lack of sediment dilution. While Smith et al. mention black shale shelly faunas, they omit the fact that most shales lack a benthic fauna. Those that do contain very low-diversity assemblages of dysoxic specialist brachiopods (e.g., the rhynchonellid *Eumatabolotoechia*) and small bivalves grade concentrically outward into progressively more diverse, fully oxic assemblages (Boyer and Droser, 2009). Micro-endolith borings in eumetabolotoechiid brachiopod shells are primarily fungal traces, with rare etchings of photosynthetic cyanobacteria (Vogel et al., 1987). These record taxa adapted to low light levels (lower euphotic to dysphotic) in deeper settings and are quite different from known shallow-water microendolith assemblages, modern and ancient.

In AB Devonian carbonate-dominated sequences, black shales occur at or near maximum flooding surfaces. This includes the Dublin Shale tongue in the lower Marcellus-equivalent Delaware Limestone in central Ohio, which rises onto the Findlay Arch on the western margin of the AB. Where black shales overlie limestones in the NY succession (e.g., Marcellus Shale over Onondaga Limestone, Geneseo Shale over Tully Limestone), there is no evidence of subaerial exposure (paleokarst, vadose cements), as implied by the Smith et al. model. The presence of all upper Onondaga Tioga “ash” layers A–F below the Marcellus across central to western NY further indicates no erosional truncation at the contact. Several subsurface Onondaga pinnacle reefs, surrounded by ~9-m-thick basinal Onondaga facies (southern NY, northern Pennsylvania), are 55–62 m thick and extend up to 55 m into post-Marcellus Skaneateles Formation strata. Mid-Marcellus Cherry Valley Limestone laps onto the lower part of the reefs. In cores, no vadose cements or karst have been observed in the reefal rocks (Coughlin, 1980).

Smith et al.’s analogy with shallow-water cratonic basin deposition is inadequate for the foredeep of an active retroarc foreland basin, where load-induced subsidence is dominantly orogenic, providing ample impetus for deepening. Furthermore, downcutting and vertical onlap relations in unconformity-bounded sequences in the stable interior Iowa Basin that correlate with the NY section demonstrate *minimum* Givetian-Famennian sea-level changes from 20 m to 90-145 m (Witzke, 2011), magnitudes that are difficult to reconcile with a shallow-water model.

Overall, Smith et al.’s interpretations and hypothesis are not fully grounded in the lithologic, sedimentological, geochemical, and paleontological context of these black shales or their regional to continent-scale context. Based on the above, and many additional points, we argue that the most parsimonious interpretation is that widespread Devonian black shales, and similar strata, represent the deepest end-members of cycles, on the order of 50–150 m deep.

REFERENCES CITED

Boyer, D.L., and Droser, M.L., 2009, Palaeoecological patterns within the dysaerobic biofacies: Examples from Devonian black shales of New York State: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 276, p. 206–216, https://doi.org/10.1016/j.palaeo.2009.03.014.

Coughlin, R.M., 1980, Reefs and associated facies of the Onondaga Limestone (Middle Devonian), West Central New York [M.A. thesis]: Binghamton, New York, SUNY at Binghamton, 194 p.

Kelly, A.A., Cohen, P.A., and Boyer, D.L., 2019, Tiny keys to unlocking the Kellwasser events: Detailed characterization of organic walled microfossils associated with extinction in western New York State: Palaios, v. 34, p. 96–104, https://doi.org/10.2110/palo.2018.063.

Smith, L.B., Schieber, J., and Wilson, R.D., 2019, Shallow-water onlap model for the deposition of Devonian black shales in New York, USA: Geology, v. 47, p. 279–283, https://doi.org/10.1130/G45569.1.

Uveges, B.T., Junium, C.K., Boyer, D.L., Cohen, P.A., and Day, J.E., 2018, Biogeochemical controls on black shale deposition during the Frasnian-Famennian biotic crisis in the Illinois and Appalachian Basins, USA, inferred from stable isotopes of nitrogen and carbon: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 531, p. 1–14, https://doi.org/10.1016/j.palaeo.2018.05.031.

Vogel, K., Golubic, S., and Brett, C.E., 1987, Endolith associations and their relation to facies distribution in the Middle Devonian of New York State, USA: Lethaia, v. 20, p. 263–290, https://doi.org/10.1111/j.1502-3931.1987.tb00787.x.

Witzke, B.J., 2011, Estimating magnitudes of sea-level changes associated with Middle and Upper Devonian sequences in the Iowa area: Geological Society of America Abstracts with Programs, v. 43, no. 1, p. 96.