Tectonism, Estimated Water Depths, and the Accumulation of Organic Matter in the Devonian - Mississippian Black Shales of the Northern Appalachian Basin

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Water depths during deposition of the Devonian-Mississippian black shales of eastern North America have been estimated at anywhere from “knee-deep” to thousands of meters, but both end-member estimates are probably incorrect. Similarly, physical, paleontological, and geochemical bathymetric indicators suggest overall deepening with time, but offer little evidence of the depths involved. Nonetheless, occurrence of the blackshale sequence in the northern Appalachian Basin as alternating units of black shale and intervening coarser clastic wedges not only reflects the cyclic nature of Acadian tectonism in adjacent orogenic source areas, but also provides a means for approximating water depths during blackshale deposition. These black shales clearly accumulated in a forelandbasin setting in which each black-shale unit represents an episode of rapid, foreland, tectonic subsidence below the pycnocline (anaerobic conditions) and subsequent infilling of the basin with shales and coarser clastics into higher, dysaerobic and aerobic parts of the water column. Due to the largely, one-time nature of any subsidence event, measuring the thickness of a clastic wedge from the top of the basinal black shale to a sea-level datum in the overlying coarser-clastic counterpart provides an approximation of absolute depth. Because some basins were underfilled and because the varying effects of compaction cannot be easily considered, the estimates are minimal at best. Nonetheless, the exercise provides order-of-magnitude estimates and reflects depths ranging from 80 to 310 m during deposition of Lower Devonian- through-Lower Mississippian black shales in the northern Appalachian Basin. The estimates not only show a general deepening with time, but also reflect shallowing-upward, third-order cycles that coincide with the timing of unconformity-bound sequences containing one or more, black shaleclastic wedge cycles. To confirm the origin of the cycles, the distribution of black shales in each cycle was mapped in space and time, which showed that black-shale units clearly tracked the progress of Acadian tectonism as predicted by flexural models. Increasing depths over time probably in large part reflect the cumulative effects of tectonic loading, but the Devonian was also a time of eustatic sea-level rise, and this, together with a unique paleogeographic setting, probably ensured large areas of enhanced organic productivity and the deep, stratified waters necessary to preserve it. It is probably no accident that the youngest — and deepest — of the black shales contains the highest amounts of organic matter. Hence, attention to estimated depths, combined with the extent of respective black-shale basins, may provide information about the likelihood and location of the most organic-rich source rocks.