Shallow Seasonal Anoxia Model for Organic-Rich Mudrocks: An Alternative Hypothesis

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Abstract

Organic-rich marine mudrocks are commonly interpreted to have been deposited in deep, quiet, permanently anoxic basins. While this appears to the case in some modern and ancient examples, field relations, regional correlations and sedimentological observations show that at least some widespread organic-rich may instead have been deposited in relatively shallow (<50 meters), moving water that at times had enough oxygen to support at least some life on the sea floor.

The examples presented will be from the Ordovician Utica and Devonian Marcellus and Upper Devonian black shales of the Northern Appalachian Basin, but many other organic-rich units have similar characteristics. These organic-rich shales were deposited in relatively shallow water on the cratonward side of foreland basins, not in the deepest part where organic-poor turbidites and gray shale were deposited. The organic-rich units commonly overlie and are time-equivalent to unconformities farther cratonward, some of which are demonstrably subaerial in origin. These field relations suggest that the water depth was likely no more than 50 meters and probably less than 30 meters.

Abundant scour surfaces and fining upward laminations in these black shales were produced by storm-generated moving traction currents rather than variations in suspended load in still water. Burrows and benthic fossils such as brachiopods occur in thin beds or laminations within organic-rich strata, which suggests that at least episodically bottom waters had enough oxygen to support life on the sea floor.

These observations and literature review have led to development of a shallow seasonal anoxia model for the deposition of these and some other organic-rich marine mudrocks. Algal blooms in the spring lead to temporary anoxia as the algae dies and falls to the shallow sea floor. Winter storms rework the sediments and produce scour surfaces and laminations. Although much of the organic-rich sediment may be oxidized during these storms, over time enough is preserved to make a viable source rock or unconventional reservoir.