The Origin and Evolution of Shell Beds in Ordovician Shales of Southwestern Pennsylvania (Point Pleasant and Associated Units) and Their Implications for the Preservation of Organic Carbon

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ABSTRACT

Shell beds in black shales have been interpreted as sediments transported from shallower carbonate shelf environments rather than as autochthonous deposits. If the shells were deposited in place, these intervals would indicate water column oxygenation. Defining bottom water redox better constrains models of total organic carbon (TOC) accumulation, which may provide essential nanoporosity. We investigated this possibility by examining the textures and compositions of shell beds in a core from southwestern Pennsylvania, where the Point Pleasant comprises a lower shell bed interval (~2% TOC), a middle shell bed free interval (~4% TOC) and an upper shell bed interval (~3% TOC). The upper shell bed interval consists of numerous thin shell beds one or two shells thick, dominated by dalmanellid brachiopods and thin shelled-trilobites, similar to other Ordovician black shales. The delicate shells are typically flat lying pavements with mud matrix and show little or no breakage. The thicker shell beds of the lower interval are more species diverse. They show varying degrees of breakage, less flat, more random orientations of platy fragments, a range of limestone textures, and phosphorus enrichment. Our observations support the hypothesis that shell beds formed in place. The morphology of pavements in the upper unit suggests brief periods of oxygenation with minimal penetration of oxygen to underlying mud. Thicker shell beds of the lower unit are also compatible with growth in place where higher diversities are consistent with more oxygen. Phosphorus enrichment suggests longer periods of accumulation under fluctuating interstitial redox conditions caused by reworking events that also generated chaotic textures and breakage. Preliminary correlations (isotopes pending) suggest thin shell beds in this interval are laterally extensive, covering an area from southwest Pennsylvania to western Ohio and central Kentucky that is difficult to reconcile with a model of downslope transport. While highest TOC values occur in the shell-free interval, some black shale organics were preserved through periods of water-column oxygenation. During the longer periods it took to accumulate thicker shell beds, oxygenation of accumulating shell gravels would have consumed organics as they formed but did not strongly affect previously buried carbon. The preservation of organics in this relatively quiet basin may have depended on rapid pulses of burial rather than a low oxygen water column.