Petrographic Study of the Middle Devonian Portwood Member of the New Albany Shale: Implications for Depositional Processes and Paleoenvironment Interpretations

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9.29.2020 - 10.1.2020 – AAPG Annual Convention and Exhibition 2020, Online/Virtual

Abstract

The Portwood Member consists mainly of grey to black mudstones that were deposited in a shallow marine setting. These organic-, and silt-rich mudstones are time-equivalent to the Tully limestone interval further east in the Appalachian Basin. They overlie the middle Devonian Boyle Dolomite and show strong lateral thickness variation as they infilled relief generated by tectonic movements and intermittent erosion. In this study, the petrographic characteristics of the Portwood shale were studied in detail by outcrop, thin section and scanning electron microcopy (SEM) observations. Three lithofacies of carbonaceous mudstones were identified: silt-bearing clay-rich mudstone, silty mudstone, and clay-rich siltstone. Dolosiltite beds and laminae show knife-sharp scour bases as well as diffuse layer boundaries due to crypto-bioturbation. Vertical lithofacies stacking and an overall fining upward trend are considered a response to a combination of eustatic sea-level rise and storms. Mudstones are composed predominantly of detrital dolomite, clay minerals, quartz, and organic matter, along with minor amounts of feldspar, pyrite, marcasite and glauconite. Two types of detrital dolomite grains occur: 1) angular to well-rounded grains with euhedral dolomite overgrowth; 2) angular to subrounded dolomite grains with little or no dolomite overgrowth. Detrital dolomite grains were derived from erosion of carbonates exposed on emergent islands within a broader platform that underwent tectonic differentiation. Far-field tectonism is the underlying cause for local derivation of detrital dolomite and high lateral

variability of depositional environments, and is also responsible for soft-sediment deformation observed in multiple outcrops. Clay minerals occur incorporated into silt- and sand-sized fine grained aggregates (shale lithics, fecal pellets, rip-up clasts) as well as in likely mud floccules, both of which were transported as bedload by bottom currents. Together with abundant fish bone and shell fragments, broken and flattened Tasmanite cysts, as well as multiple erosion surfaces, these petrographic characteristics suggest that the Portwood interval was deposited in an energetic shallow-marine setting with intermittent extensive reworking of surface sediments. This perspective contrasts with past interpretations that assumed suspension settling in still water as a dominant depositional process. A dysoxic environment is indicated by common bioturbation (i.e., Planolites, Chondrites and Teichichnus) and benthic fauna (i.e., brachiopod and agglutinated foraminifera). Marcasite was observed replacing and overgrowing pyrite under SEM, suggesting that overlying waters contained oxygen. Results from this study can aid in developing alternative depositional interpretations and sequence stratigraphic frameworks in complex mudstone-dominated successions.