Integrated Stratigraphic and Geochemical Analysis of a Shallow Drill Core of the Maastrichtian Lewis Shale in the Eastern Washakie Basin, Wyoming

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Abstract

The U.S. Geological Survey collected a 601-foot, continuous core of the Maastrichtian Lewis Shale in 2022. The Cow Creek 1-21 core was drilled to assess the source rock potential of multiple, organic-rich flooding surfaces within the Lewis. The core is in the eastern Washakie Basin, ~60 miles southwest of Rawlins, WY. The Lewis, which produces abundant natural gas in Wyoming, was deposited in a regional embayment during the last transgressive/regressive cycle of the Cretaceous Western Interior Seaway (KWIS). The core in this study is unique in that it penetrated 7 organic-rich flooding intervals (F1–F7) and a regional, high gamma ray condensed section at the base of the Lewis, informally known as the Asquith marker. In addition to stratigraphic analysis, a robust geochemical and mineralogical data suite was collected. The core is ~85% siltstone and organic-rich mudstone, 15% sandstone, and is highly laminated. There is little bioturbation but abundant foraminifera, shell fragments, and fish scales. Regional cross-sections and isopach maps indicate at least two sediment sources were active during deposition. The lower portions of the core record deposition from a southern source, whereas the upper portions primarily record deposition from a northern source. The Asquith marker in the core averages 3.2 % TOC and is the most oil-prone of the flooding surfaces based on pyrolysis data. F1–F7 average 1.8 % TOC and contain mixed oil/gas-prone and gas-prone organic matter. Overall, from the base to top of the core, flooding zones become more gas-prone and have lower petroleum potential as the KWIS is regressing. ICP-OES/MS results show that the Asquith marker and F1–F7 are relatively enriched in the major elements Ca, P, and S, and are relatively depleted in Al, Si, and Ti compared to the non-organic intervals. Additionally, the Asquith and F1–F7 are enriched in the trace elements Cu, Cd, Mo, Re, Sb, Se, Tl, and U compared to average values in shales. Enrichment in these major and trace elements are interpreted to reflect changes in both sediment source and redox conditions. Vitrinite reflectance values suggest thermally immature conditions, which aligns with low Tmax values (<435ºC). Petrographic observations also reveal that the organic matter assemblage generally comprises ~85% marine biolaminae and ~10% terrigenous fragments. The mix of organic matter indicates that the core location was predominately deposited in a marine environment but was still receiving sediment from terrestrial sources. The Lewis Shale in the Cow Creek 1-21 core provides a rare window into the Late Cretaceous in southwestern Wyoming during the final transgression of the KWIS. The data presented here show that fourth-order condensed sections have minimal petroleum potential in a regressive system close to the sediment source. Additionally, multiple sediment sources are indicated by both regional stratigraphic correlation and core geochemistry.