Revisiting the Upper Cretaceous Niobrara Petroleum System in the Rocky Mountain Region

Mark W. Longman and Barbara A. Luneau, Denver, Colorado

Draft: February 19, 2019

ABSTRACT

In 1998 we co-authored a regional study of the Niobrara Formation in the Rocky Mountain area. The paper slightly preceded a burst of successful horizontal drilling in the Niobrara along with much additional research that resulted in new insights into Niobrara stratigraphy and depositional processes. With this presentation, we provide an update on which of our original ideas have endured, and one that we would like to improve upon to advance understanding of the Niobrara.

Although our alphanumeric terms for intervals within the Niobrara have been largely replaced by the “A”, “B”, and “C” terminology for the chalk-rich intervals, our isopach and facies maps as well as our depositional models for both the chalk and marl facies have proved valid and useful. However, we now feel we may have erred in attributing the chalk and marl benches principally to eustatic sea level changes. That model claims that the marls represent relative lowstand events whereas the chalks represent highstands during which the influx of detrital clay into the central part of the Western Interior Seaway was limited.

We now believe that the main factor controlling chalk vs. marl deposition was the direction of current flow through the long, relatively narrow (100s of miles), north-south trending seaway. When warmer waters from the incipient Gulf of Mexico flowed northward, they brought into the seaway the abundant coccoliths, copepods, and planktonic foraminifers that form the chalkier intervals. When cooler arctic waters flowed southward in the seaway, carbonate productivity was limited and marlier, more organic-rich facies were deposited. Changes in water depth had little to do with the resulting rock types.

Evidence supporting this interpretation is three-fold. First, past core descriptions and wireline logs largely focused on intervals many feet thick to define the chalk and marl facies. Closer examination of the cores on a <1-inch scale in combination with elemental data from X-ray fluorescence reveals interfingering of the chalk and marl facies on a scale far too small to be related to global sea level changes. Second, if changes in sea level controlled the chalk/marl lithofacies, their impact should have been much greater on the relatively shallow eastern and western shelves of the seaway where a 50-ft change in sea level could have had a profound impact on deposition. Instead, the open marine carbonate-rich facies so common on the eastern shelf show no evidence for significant changes in water depth. Third, the Fort Hays Member of the Niobrara with its thicker and more apparent interfingering of cyclical chalk and marl facies has long been interpreted as the product of Milankovitch (climate) cycles rather than sea level fluctuations. The cyclicity in the Smoky Hill Member may be too fine to be Milankovitch related, although this has been suggested. However, the internal Smoky Hill Member stratigraphy shows regional trends that are unlikely to be Milankovitch or sea-level related.