Deposition and Creation of the Upper Cretaceous Niobrara Petroleum System in the Western Interior Seaway of Colorado and Wyoming

Mark W. Longman
Consulting Geologist, Denver, Colorado

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ABSTRACT

Studies of Niobrara depositional environments done during the 1980s and 1990s relied on what was understood about the processes controlling deposition in ~300 ft (~100 m) water depth at that time. A common idea was that the chalkier beds formed as carbonate-rich marine "snow" settled slowly to the sea floor to form blanket-like deposits that could be easily correlated across tens to hundreds of miles. The dominant control on chalk vs. marl deposition was thought to be relative sea level with highstands favoring chalkier deposition versus lowstands that favored the influx of some clays resulting in deposition of more marly intervals.

Relatively recent studies of the deep-sea floor in some settings, however, have dramatically changed insights into deposition of the very fine grained (clay and silt-sized) hemipelagic deposits. Instead of a vertical rain of sediments, dynamic marine currents at depths of hundreds of feet (>100 m) can reign supreme and are now known to form scour and drift features that redistribute the sediments laterally into broadly lenticular sea-floor bars and channels that are themselves tens to hundreds of feet thick. The long (>3000 mi; 5000 km), relatively narrow (<800 mi; 1300 km), north-south trend of the Western Interior Seaway between adjacent land masses made it particularly susceptible to a complex set of marine currents during Niobrara deposition that redistributed both the chalkier reservoir and marlier source rock deposits.

Evidence for the importance of marine currents in the Seaway during Niobrara deposition versus the conventional idea of fluctuating sea level is six-fold: 1) well-documented interfingering of the chalk and marl facies on a scale of centimeters or less, which is far too thin to be controlled by sea-level fluctuations; 2) a lack of evidence for chalk-related highstands along the seaway's margins (e.g., in Utah and Kansas); 3) abrupt lateral changes in the thickness of chalkier deposits over distances of a mile (<2 km) or less; 4) thin (<2-inch [5 cm]) organic-rich (>15 weight % TOC) marly "kerogenites" within the clean chalk benches that are too thin to be the product of sea-level changes; 5) color-filled gamma-ray cross sections built with relatively closely spaced wells that clearly show the large-scale scour and drift features; and 6) study of modern ocean current flow patterns on deep-water hemipelagic deposits off New Zealand's South Island and in the Mediterranean that have yielded bedforms seen on high-resolution seismic lines similar to those seen on color-filled gamma-ray cross sections of the Niobrara in the Denver Basin. Furthermore, subtle topographic features on the sea floor such as the paleo-Hartville Uplift apparently influenced current flow patterns and impacted deposition.

Biosketch for Mark Longman

Mark received a B.A. degree from Albion College in Michigan in 1972 followed by a Ph.D. in Geology from the University of Texas at Austin in 1976. He then joined the research lab of Cities Service Company in Tulsa, Oklahoma for 5 years before moving to Denver in 1981 to work for Coastal Oil and Gas Company as an exploration geologist mainly in the Williston Basin. From 1984 to 2006, he was a consulting geologist and then joined QEP Resources, where he worked as their "Rock Expert" until 2018 when QEP restructured and no longer needed his skills as a sedimentologist and petrographer. Mark has worked extensively with cores, cuttings, and petrographic thin sections with a focus on integrating sedimentology and petrology with reservoir studies and petrophysics. He has worked extensively on the Cretaceous rocks and reservoirs in the Rocky Mountain region and has particularly enjoyed understanding and interpreting the regional controls on hydrocarbon reservoirs such as those in the Niobrara Formation and Codell Sandstone.

Mark is currently a Research Associate at the Denver Museum of Nature and Science and a part-time consulting geologist. He has published more than 40 papers in journals ranging from RMAG's ***The Mountain Geologist*** to the ***AAPG Bulletin*** and in 2014 co-edited AAPG Memoir 107 on the giant Pinedale gas field in Wyoming. In 2016 he received AAPG's Distinguished Service Award.

Mark Longman Photo below: