Stratigraphic and Sedimentologic Controls on Williston Basin Three Forks Oil Occurrence

John C. Hohman[1]

[1]Retired

Abstract

The Williston Basin Three Forks represents a prolific oil producer within the Bakken Petroleum System that is characterized by relatively low porosity dolo-mudstone with varying amounts of shale, conglomerate/breccia and anhydrite. Due to its overall low porosity, subtle variations in grain size within the dolo-mudstone, specifically dolo-siltite (silt-size grains) versus dolo-lutite (clay-size grains), along with the variable shale, conglomerate/breccia and anhydrite contents play key roles in governing reservoir quality and determining the distribution of hydrocarbons in the section. Importantly, these variations result from systematic changes in depositional facies within in an evolving Three Forks depositional setting. The most conspicuous change impacting reservoir quality is the cyclical nature of Three Forks deposition consisting of four stacked depositional sequences with each sequence further subdivided into lowstand and highstand system tracts producing an alternating succession of eight system tract deposits. It is critical to note that the deposits of the lower two sequences and their component system tracts are fundamentally different from the upper two sequences and system tracts. The lower two sequences reflect deposition in a hyper-saline salina/sabkha setting typified by anhydrite-infused, brecciated/conglomeratic dolo-mudstone sabkha lowstand deposits capped by anhydrite-infused, microbial dolo-mudstone salina highstand deposits characterizing early Three Forks deposition. Conversely, the upper two sequences reflect a change in depositional setting to a less-saline tidal flat/coastal plain setting typified by tidal flat dolo-mudstone of thinly interbedded dolo-siltite and dolo-lutite which comprise the highstand deposits capping brecciated/conglomeratic dolo-mudstone coastal plain lowstand deposits that characterize later Three Forks deposition. Reservoir quality closely follows this cyclical deposition within a changing depositional setting with the best reservoir concentrated in the highstand tidal flat deposits of the upper two sequences. The underlying lowstand coastal plain deposits are markedly poorer reservoirs than the respective highstand tidal flat deposits. The reservoir quality of both highstand and lowstand deposits of the salina/sabkha depositional setting is very poor, particularly the lowstand sabkha deposits. The highstand salina deposits are also very poor reservoirs, but with the exception of the uppermost highstand salina. This salina reflects a transition from highstand salinas below to highstand tidal flats above and contains interbedded tidal flat deposits with better reservoir quality. These Three Forks reservoir quality characteristics coupled with petroleum system limitations essentially precludes oil from essentially all the salina/sabkha deposits. Instead, oil is primarily focused in the tidal flat portion of the tidal flat/coastal plain deposits.