Stratigraphic and Structural Framework of Recent Ratcliffe (Mississippian, Charles Formation) Production in McKenzie County, North Dakota

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The recent development of the Foreman Butte Field in western North Dakota demonstrates that there is still considerable potential for new production from low-permeability carbonate reservoirs within the Madison Group using horizontal drilling methods. Between its discovery in late 2004 and the beginning of 2007, the Foreman Butte Field (T150N-R102W and R103W) has produced 1.8 million bbls of oil and 1.2 MMCF gas from some 36 wells drilled to a TVD of approximately 9300 feet. Initial production has been as high as 680 bbls oil per day. Production is obtained from horizontal laterals that tap an oolitic/pisolitic shoal island complex within the Alexander and Flat Lake subintervals of the Ratcliffe. This reservoir typically has porosities in the range of 5 to 10 percent with total reservoir thicknesses that are less than 20 feet.

The Forman Butte Field lies on the west flank of the Williston Basin within a broad homoclinal flexure that probably produces no more than 10 feet of structural closure within the field. Production extends well beyond the limits of this structure thereby suggesting that closure alone is not a prerequisite for production.

The Alexander and Flat Lake subintervals are shallowing-upward, peritidal, shoal island complexes consisting of restricted subtidal to supratidal limestones, partially dolomitized limestones and anhydrite. The productive oolitic /pisolitic shoal facies contains significant primary intergranlar, fenestral porosity and local solution-enhanced secondary porosity. In general, porosity has been significantly reduced by compaction and multiple episodes of cementation. Even though the porosities are low and the productive interval is thin, the distribution of lateral porosity is extensive within the shoal facies. Cross-sections illustrate that the porous zones within the shoal complexes grade rapidly into anhydritic carbonates and anhydrites. In several instances, an anhydrite signature on porosity logs mark the edge of production or a significant decrease in production. Apparently, this happens when porous peritidal shoal facies change into nonproductive sabkha facies dominated by impermeable anhydrites, anhydritic limestone or dolostone. The geographic distribution of anhydrite within the Alexander/Flat Lake subintervals suggest that coalesced shoal island complexes form an anhydrite "free" limestone corridor. This corridor is locally more than 6 miles across and extends north-south along depositional strike for more than 60 miles. The carbonates of the Alexander/Flat Lake subintervals pinch out into thick massive anhydrite to the east and presumably landward of the shoal complex. West of the shoal complex, thinner anhydrites are locally present possibly reflecting inter-island playa deposits formed during minor drops in sea-level. These "playa" anhydrites lie updip of the shoal complexes and may therefore play important roles in the formation of individual traps.

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