

Stratigraphic Details Illuminated Using Modern 3-D Seismic Techniques in Upper Cretaceous Lenticular Reservoirs, Optimizing EOR Production with CO₂

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The major Lower Tuscaloosa oil fields of SW Mississippi were developed on 40-acre spacing providing “apparent” abundant well control to delineate the reservoir limits. However, the abrupt reservoir variations in these stacked fluvial and transitional marine sand sequences readily revealed the limits of relying on “apparent” high density well control alone when implementing an EOR (tertiary) CO₂ project. Early recognition of flow units is critical to the success of a CO₂ flood because viscous fingering and gravity segregation can have an adverse effect on flood performance. This realization resulted in a proprietary 3D seismic plan in an effort to optimize well locations by accurately defining reservoir limits (edges) while imaging multiple channels. Denbury Resources Inc. began in 2001 to acquire proprietary 3D shoots for each of their five Lower Tuscaloosa CO₂ floods in SW Mississippi. The sequence of these 3D shoots over six years depict the acquisition and processing advances realized in less than a decade. Full utilization of the geological well data set combined with the latest 3D interpretation software provides a visualization method to spatially depict these complex reservoirs and the future opportunity to monitor CO₂ sweep efficiency via time lapse 4D seismic. Although each of Denbury’s 3D surveys has resolvability issues due to limited band width and frequency content, this does not impede channel detectability and relative reservoir thickness variations. Channel detectability is readily accomplished by seismically “picking” a regional conformable stratigraphic event below the Lower Tuscaloosa reservoirs, flattening on that picked event and then generating stratigraphically conformable (stratal) slices. These reservoir sands tune at certain frequencies which correspond to a temporal thickness that is related to actual sand thickness and fluid content. We have combined four seismic attributes including up to three frequency volumes to detect these changes in reservoir thickness and/or fluid content. This combined image simultaneously displays spec decomp attributes in 3D space and the interpreter can animate through the slices in subsampled time increments to reveal increased stratigraphic detail. Denbury Resources latest generation of reservoir maps incorporate the results of the 3D spectral decomposition interpretation and have significantly enhanced the understanding and management of the five Lower Tuscaloosa EOR CO₂ floods.