Depositional and Diagenetic Factors Influencing CO2-Enhanced Oil Recovery in Estuarine Sandstone Facies of the Donovan Sand (Lower Cretaceous), Citronelle Field, Southwest Alabama

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Citronelle Field is a classic Gulf Coast oil field that is developed in a simple domal structure. The field has produced more than 169 MMbbl of 42-46° API gravity oil from the Lower Cretaceous Donovan Sand and is a strong candidate for CO2-enhanced oil recovery (EOR). However, the Donovan Sand is stratigraphically much more complex than other Gulf Coast reservoirs undergoing EOR. Field tests designed to determine the feasibility of EOR in the northeastern part of the oil field have included detailed characterization of multistory sandstone reservoirs and intervening mudstone baffles and seals. The test area constitutes a 5-spot well pattern that is developed in the upper Donovan 14-1 and 16-2 sandstone units. Predictions of EOR performance are informed by geologic models of reservoir heterogeneity based on integrated stratigraphic, sedimentologic, and petrologic analysis.

Stratigraphic data indicate that the upper Donovan was deposited as part of a retrogradational sequence set. Vertic paleosols and erosional surfaces mark the boundaries of high-frequency (~100 ky) depositional sequences between 5 and 10 m thick. Reservoir sandstone and conglomerate are concentrated in the lower parts of paleovalley fills. Sedimentary structures and fossil assemblages indicate transgressive sedimentation in estuarine settings. The upper parts of the valley fills are dominated by marginal-marine mudstone, and marine limestone beds are preserved above some major flooding surfaces. Recognizable highstand deposits are few. Indeed, much of the Donovan section has been altered within ancient soil profiles.

Donovan reservoirs are mainly in very fine- to fine-grained arkosic sandstone. The pore system consists mainly of secondary pores generated by feldspar dissolution and of primary interparticle pores. Many pores are completely or partly occluded by illuvial and authigenic clay, syntaxial quartz overgrowths, carbonate cement, and pyrobitumen. Petrologic analysis indicates that diagenesis and compaction are fundamental controls on reservoir quality and that pay is concentrated in sandstone that remained below the water table during early burial. Here, the pore system was protected from plugging with illuvial clay, and porosity was enhanced by feldspar dissolution. Hence, paleohydrology and diagenesis played a critical role in determining the distribution of reservoir sandstone in Citronelle Field and are vital considerations for designing EOR programs.