

Bring the Realities into Focus: New Integration Process for Geology, Engineering, Petrophysics, and Seismic for a CO₂ Flood

Jason Rush¹, John Doveton², and Lynn Watney²

¹Mina FazelAlavi

²Kansas Geological Survey

Abstract

An extensive multidisciplinary reservoir characterization project was undertaken to construct geologically accurate, 3D reservoir models of the Mississippian at Wellington Field (Sumner County, Kansas) for critical assessment of a pending pilotscale CO₂-EOR program. The BEREXCO-operated field, discovered in 1929, has cumulative production of 21 MMBO and is currently being produced using a 5-spot waterflood. As part of the CO₂-EOR assessment program, a new multicomponent 3D seismic survey was acquired over the 3.5- × 2.5-mile field and three new wells were drilled and logged near the proposed pilot area. Triple combo, full-wave sonic, nuclear magnetic resonance, elemental, and microresistivity imaging tools were run. New cores were acquired for facies description, stratigraphic analysis, diagenetic studies, routine core measurements, helical CT scanning, and SCAL. Depositional facies indentified from core are linked to seven petrophysically distinct rock fabrics having discrete water saturation and relative permeability functions.

Petrophysical analyses, PSDM seismic, borehole data, and observations were integrated into the modeling work flow, which broadly includes the following steps: 1) interpret bounding surfaces, stratal geometries, and faults from seismic; 2) describe the vertical succession of depositional facies; 3) link depositional facies (i.e., rock fabrics) to petrophysical properties and wireline log response, 4) distribute facies and rock fabrics within a predictive chronostratigraphic framework, and; 5) geostatistically collocate petrophysical properties to rock fabrics. Seismic interpretation reveals an approximately 250-ft thick, low-angle (<2°), dominantly westward prograding ramp system that thickens locally across rotated blocks bound by Chester-age syndepositional faults. High porosity and permeability values (0.045–194 mD; mean: 9.98 mD) are concentrated in 20–60-ft thick spiculite-bearing bioclastic packstones found along the topsets of individual progradational shingles, which form wedges that expand westward and pass downdip into low-permeability (0.001–1.37 mD; mean: 0.096 mD), microporous wackestones. Core-based permeability measurements are consistent with results from a step-rate test, which suggest an average permeability of 17.8 mD for the 60-ft interval above the FWL. The step-rate test also demonstrates that faulting has minimal impact on the effective (i.e., interwell-scale) reservoir properties within the pilot area. Modeling and simulation results indicate the optimum flood design for the pilot consists of a crestal CO₂ injector, a ring of producers, and a downdip ring of water injectors for pressure maintenance.