

The Muddy Sandstone Giant Accumulation at Bell Creek Field, Montana: A Consequence of Hydrodynamics, Stratigraphic-Unconformity Trapping, and Primary, Secondary and Tertiary Recovery Programs

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Abstract

Bell Creek Field is an example of a CCUS project involving both utilization and storage of CO₂. The field is currently operated by Denbury Resources. The field produces from the Muddy Sandstone and was discovered in 1967 by Exeter Drilling and Sam Gary. The productive Muddy Sandstone is known as the Bell Creek Sandstone. Average reservoir depth is 4,500 ft; reservoir porosity ranges from 17 to 35%, permeabilities range from 425 to 1,175 md, and gross sand thickness is 25 ft. Bell Creek is a giant accumulation which has seen water flooding, micellar-polymer flooding, and CO₂ flooding. The field covers an area of 21,770 acres (15 mi long and up to 3 mi wide). Original-oil-in-place (OOIP) was estimated to be 353 MMBO. Cumulative production is 147 MMBO. Estimated ultimate recovery should be 180 to 200 MMBO (~50% of the OOIP). Ultimate primary recovery was estimated to be approximately 48 million barrels of oil (solution-gas drive). Water flooding in the field commenced in 1970 in six units (A-F). Micellar-polymer pilots were installed in a small part of Unit A in 1975 and 1981. CO₂ flooding (with continued water injection) commenced in 2013. Continuous CO₂ injection occurred initially followed by followed by water alternating gas (WAG) cycles thereafter. Cumulative production prior to the CO₂ flood was 133 MMBO. The CO₂ WAG flood potential is estimated to be 40-50 million barrels oil (Denbury). The field is currently separated into nine producing units. Up to 50 to 60% of the injected CO₂ is sequestered in the reservoir. All produced gas is reinjected. The Muddy at Bell Creek consists of an older regressive sandstone named the Bell Creek Sandstone and a younger valley-fill system. The two units are separated by a low-stand surface of erosion (LSE). All the production from the field comes from the Bell Creek Sandstone. The sandstone is interpreted to be a barrier bar sand and is compartmentalized by the erosional valleys. Hydrodynamic flow data for the Muddy Sandstone was compiled and reviewed for Bell Creek. Bell Creek occurs in a potentiometric low area. Hydrodynamic flow is downdip in the Bell Creek area. The oil accumulation is 6× what would be expected by simple capillary trapping alone. The trap is regarded as a hydrodynamic, sub-unconformity stratigraphic trap.