Integrated Geological, Engineering and Laboratory Study for Improved Characterization and 3-D-Reservoir Modeling for Pilot Design of CO2-EOR and Carbon Storage in a Mature Oilfield From India

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Abstract

A comprehensive geological interpretation, laboratory study, production-injection analysis, 3D static modeling, and simulation study helped to significantly improve characterization of a mature sandstone reservoir from India toward the design of a CO2-EOR (enhanced oil recovery) pilot project. The reservoir is composed of fluvio-deltaic fine grained sandstone of Oligocene-Miocene age, bounded by faults in three directions (NW, N and E). However, the main trapping mechanism is a two-way closure against the two bounding faults to the NW and N. Distinct channel and flood plain facies were identified which generally trends NE-SW. Core analysis showed average porosity and permeability to be ~18% and 80 md, respectively. Rock typing was performed integrating sedimentary texture (photomicrograph), mineralogy, capillary pressure data, and poro-perm relationships from core data. A fine scale geological model was built for entire reservoir containing 30 wells. Facies and rock type distribution in the 3D model were constrained by variograms based on depositional trends (e.g., channel direction and dimension maps). Besides facies and petrophysical property models, the geomodel incorporated perforation depths, fluid properties and contacts. Integrating production and injection analysis helped to constrain the stratigraphic and structural complexity of the reservoir, which was further validated by history matching during dynamic simulation. History matching of 51-year field production and pressure data was completed

for the whole reservoir and various development scenarios were investigated. PVT lab studies indicated that CO2 injection could achieve miscibility with oil under reservoir conditions. Based on the results from CO2-EOR simulation study, a pilot pattern area of ~60 acres with one injector and four producers, was identified at the flank of the two way closure. CO2 was injected at 150 metric ton/day for 5 years with cumulative injection volume 15.4 BCF. Then the well was switched back to water injection. ~1 MMSTB incremental oil recovery was obtained in ~10 years, corresponding to 11% of original oil in place in the pattern area. The CO2 utilization ratio is approximately 6 MCF/BBL. It is expected that CO2 flooding will yield a pre-tax net cash flow of US $9.4 MM.The results of this project, based on a solid, integrated geological interpretation and engineering study, incorporating both analytical approach and numerical modeling, highlighted a great socio-economic development opportunity for India through enhanced domestic oil recovery, increased production and reduced carbon footprint.