Reservoir Characterization and Enhanced Oil Recovery from a Naturally Fractured Reservoir—Caguan Basin, Colombia

Juan Carlos Ramon, Maria Eugenia Bernal, and Xiuxia Tian
Emerald Energy
juan.ramon@emerald.com.co

Abstract

The Capella field in the Caguan Basin has 3 producing reservoir zones: Basal Tertiary sandstones, fractured "C" unit and fractured basement. This paper would review the reservoir properties and EOR production results from the naturally fractured "C" unit based in about 12 wells drilled and almost 600 feet of core recovered to date. The "C" reservoir is restricted to the central and north portion of the Capella structure. It is preserved as a series of semi-half grabens. Preliminary biostratigraphic data suggest these strata are Paleozoic in age. It is mostly composed of sandstones, matrix-supported conglomerates and siltstones. These strata are compositionally immature. Conglomeratic clasts consist of quartz, chert, metamorphic and igneous rocks. Clasts are very angular indicating short distance of sediment provenance. A conspicuous characteristic of sandstones and matrix-supported conglomerates is the strong silica cement. This diagenetic feature reduces dramatically the porosity but makes brittle these rocks and thus fracture-prone.

Core and log show porosity ranging between 6% and 15% that locally reach porosities up to 25%. Matrix permeability generally in lower than 10 miliDarcies. Dynamic and PBU data indicates permeabilities up to 10 D. This difference is explained but the presence of continuous fracture systems. Image logs (FMI) run in the wells support the presence of open fractures in almost every drilled well. Also strong mud (up to 1970 Bbls) and cement (up to 90 Bbls) losses are normally reported during drilling of this interval.

The historical oil production of wells completed in this reservoir support the lateral continuity of the naturally fracture system. Based on multi-scale fracture modelling 3 fracture-systems have been identified. Big scale faults from seismic, medium scale faults from seismic attributes and small scale fractures from well data. Big scale faults have 2 main orientations: NE-SW parallel to the main bounding Capella Fault. and a second fault system that is NW-SE oriented. Two main orientations of small scale fracture was identified by borehole image logs and multi-scale fracture modeling, the first one NE-SW and the second one NNW-SSE with two predominant dip families: the first one dips between 50°-60° and the second one dips 70-80°. Based on these fracture models productivity of the wells we believe the most prolific main fracture system that contribute to production is NE-SW about 45° NE average and horizontal wells have been designed perpendicular to this direction with navigation length between 400' and 895' in fracture zone.

The crude oil has a viscosity of about 2600 cP at reservoir conditions. As part of the full field development plans, we have done a couple of Steam injection pilots to define the viability of thermal enhanced oil recovery. The pilot test on this naturally fractured reservoir enhanced the daily oil production to 4 times relative to the cold production baseline. Fluid temperature and oil production decreased back to the cold

production levels after 180 days. These results indicate the steam EOR could be implemented for the long term development of the Capella field.