A Paradigm Shift in Understanding Fracture Origin and Fracture Influence on Deep Carbonate Reservoir Performance: A Study of Onshore Permo-Triassic Deep Reservoirs in Saudi Arabia*

Mohammed S. Ameen[1]

*Abstract from 2010-2011 AAPG Foundation Distinguished Lecture presentation.

[1]The Structural Geology & Rock Mechanics Group, Saudi Aramco, Dhahran, Saudi Arabia (mohammed.ameen@aramco.com)

Characterizing fractures and their geomechanical impact on reservoir performance is the ultimate objective of fracture and in-situ stress characterization. This presentation provides evidence contrary to the common perception of the major role played by fractures in the production performance of deep carbonate reservoirs. It is based on a recent study by Saudi Aramco in Saudi Arabia.

The highly variable performance of the Permo–Triassic reservoirs in onshore giant fields in Saudi Arabia has been attributed to the presence of natural fractures. Similar preproduction pressure profiles and hydrocarbons in the different reservoir units have been attributed to vertical communication through large faults. To validate these assumptions, we studied the static and dynamic data from the reservoirs. We identified two distinctive fracture domains based on fracture orientation and density. Fracture evolution is mainly controlled by extensional and consequent compressional plate tectonics instead of local structures. In-situ stresses in the study area are dominated by the Zagros plate tectonics and affect fracture aperture differently in the two fracture domains. The impact of fractures on reservoir performance is mostly subtle because of the nature and distribution of the fractures. Fracture-enhanced productivity occurs locally in some of the producing wells, and results from high-density fracture clusters (including mesoscopic faults) with channel-type apertures. The reservoir performance is mainly controlled by the matrix porosity and permeability that were preserved by early hydrocarbon placement.

The following findings challenge the common views on the influence of fractures in the reservoir performance: (1) individual fractures are dominantly tensile and small (mesoscopic and microscopic); (2) individual faults are small and not readily resolvable at seismic scale; (3) the depth and carbonate nature of the reservoir make the fractures highly susceptible to fast healing unless preserved within the hydrocarbon column; (4) initial vertical pressure gradient changes with production indicate a lack of present-day communication across the anhydrite sealing layers between the different reservoir units; (5) horizontal well direction does not generally have an impact on productivity; and (6) sustained and heavy losses of circulation are rarely encountered in the reservoir wells.