

Natural Fractures and In-Situ Stresses in the Naturally Fractured Najmah Reservoirs in Kuwait – Exploration Implications

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ABSTRACT

The Najmah Formation of Callovian to Oxfordian age comprises mainly calcareous mudstone with rare wackestone and minor calcareous shale interbeds. The formation is broadly divisible into three units-Lower Najmah Limestone (packstone-wackestone), Lower Najmah Shale (bituminous calcareous mudstone) and Upper Najmah Limestone (packstone).

The lower Najmah Shale consists of kerogen rich mudstones deposited in outer ramp to basinal setting and is the target for shale oil and gas exploration in Kuwait. Matrix porosity of the unit varies between 2% to 3% and permeability ranges from less than 0.01 to 1.5 millidarcy.

The core and borehole image data is analyzed in terms of size, opening, orientation, and cementation of natural fractures. In most of the wells, short hairline fractures are common. Most of the fractures are open or partially open. At places, some of these are sealed with calcite. The fracture aperture is 0.1 -0.2 mm. The fractures are invariably steep (60- 80). Two dominant fracture sets are present – north-northeast and west-northwest. However these trends show variations in line with structural disposition. High fracture density and good production potential within the formation have been observed in wells located close to the fault. Country-scale in-situ stress studies suggest that the direction of principal horizontal compressive stress is NE-SW. Natural fractures that strike in this direction appear to be critically stressed. These fractures may also act as plane of weakness during hydraulic fracturing. The fracture and in-situ stress data can be gainfully employed in deciding well-bore trajectories and stimulation design for exploratory drilling program.

The unit along with underlying Sargelu Formation is under active exploration and production. However, there is need for paradigm shift in exploration concepts (layer specific shale versus tight gas) and drilling, completion and testing practices of these plays.