Hydrocarbon Seals in Kuwait – Variability and Impact on Hydrocarbon Accumulation and Reservoir Compartmentalization

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Abstract

The State of Kuwait is endowed with multiple petroleum systems straddling the Paleozoic to Cenozoic stratigraphy. The major petroleum systems are Qusaiba-Unayzah and Qusaiba-Khuff (Paleozoic); Jilh (Triassic), Najmah-Marrat, Najmah and Najmah-Gotnia (Jurassic); Najmah-Minagish, Najmah-Zubair, Najma-Burgan, Najmah-Mauddud etc. (Cretaceous); Makhul-Radhuma and Makhul-Lower Fars (Tertiary). Associated hydrocarbon accumulations are capped by regional as well as local vertical seals. Additionally majority of the reservoirs are laterally compartmentalized by faults. Vertical and lateral compartmentalization is suggested by variations in reservoir pressures, oil gravity, saturates and asphaltene percentages.

Three main regional seals the Upper Triassic Jilh, Upper Jurassic Hith-Gotnia and Lower Cretaceous Ratawi Shale are characterized by increased pore pressures. These seals along with the Upper Cretaceous Ahmadi Shale control the hydrocarbon distribution. The Jilh has a regional extent and isolates the underlying Sudair to Unayzah formations from overlying Jurassic. The Gotnia-Hith evaporites are highly overpressured and constitute a major barrier for the Jurassic fluids. The Ratawi Shale retains overpressures to the North and West of Burgan. The Ahmadi Shale controls the Cretaceous accumulations in Burgan. It is it is effected by the permeable faults to the north.

A number of local shale and carbonate seals effectively cap the accumulations at reservoir and field levels. The important intraformational local seals occur almost within all the reservoirs, the most notable being within Unayzah, Khuff, Marrat, Minagish, Zubair, Burgan and Mauddud reservoirs. Nature of these seals vary from area to area and they act as barriers and baffles for vertical compartmentalization. The all-encompassing unconventional reservoirs of Najmah, Gotnia and Makhul are self-sealing. Pre-Khuff and Khuff reservoirs are sealed by anhydrite rich section of Lower Khuff and Sudair. The intraformational halite and anhydrite can act as local seals for the Triassic. The Tertiary Lower Fars reservoirs are sealed by the Miocene Main Cap and Middle Shale.

A case study of Cretaceous reservoirs of North Kuwait shows significant variations in reservoir pressures and oil properties across the Younger cross faults. Significant lateral lithofacies and thickness variations are not seen occurring on the field scale, thus negating their major impact on lateral reservoir compartmentalization. Major NW-SE and NE-SW aligned faults have worked as barrier for re-migration and homogenization of oils.

These sealing surfaces have a clear impact on play and prospect risking, development planning and drilling designs and need to be analysed comprehensively for future exploration and development for reduction of risk and cost.