Silurian Qusaiba Shale Play: Distribution and Characteristics

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The organic-rich shale of the Lower Silurian Qusaiba Member of the Qalibah Formation is one of the most prolific source rocks in the Arabian Peninsula. More than 90% of the Paleozoic light oil and gas accumulations are known to be sourced by this unit. The extensive regional presence of this unit is a major factor for the significant Paleozoic oil and gas reserves that have been discovered in the region. It is now under investigation as a potential shale gas play in several basins in Saudi Arabia. It contains up to 8% of total organic content (Jones and Stump, 1999).

The Lower Qusaiba shale member was developed due to the global sea level rise at the base of the Silurian. This major transgression was recognized by Al-Laboun (1988) and others in the Middle East and North Africa. This event was recognized basin wide from Oman in the south to Turkey in the north and from Iran in the east to Morocco in the west. The Qusaiba member consists of a thin hot shale at the base overlain by thick lean shale, ranges its thickness from 250m at the outcrop to over 1000m in the basin. The extensive regional presence of the hot shale across most of the Arabian plate suggests a flat basin coupled with a very rapid rise in the sea level. This setting is reflected by the consistent development of the hot shale over all parts of the basin.

The subsequent Hercynian deformation controlled the distribution of the Qusaiba source rocks across the Arabian Plate basins. This deformation eroded the Silurian source rocks from large areas over the Levant, Al-Batin, and Oman-Hadhramaut arches. This erosion is illustrated by the truncation of the base Qusaiba seismic reflector along the flanks of these arches. The widespread erosion of the Silurian source rocks over these arches limits the Paleozoic hydrocarbon potential to the margins of Hercynian Basins. The deep burial of the Silurian source rocks in the Hercynian basins has extended maturation of these rocks into the wet and dry gas windows.

The hot shale is characterized by distinctive response on wire line logs with increased gamma-ray and resistivity responses and an increase in sonic transit times. Increases in gamma-ray values often indicate elevated amounts of TOC where non-detrital uranium is associated with organic matter (Stocks and Lawrence, 1990).

The basal Silurian hot shale produces a strong seismic reflector due to the sharp velocity contrast with the underlying and overlying sediments. Regional amplitude mapping of the reflector can be used to differentiate between areas where the hot shale is present and those where it is absent.

The Lower Qusaiba Hot shale is Type II, and appears as oil prone kerogen at the early stage of maturation. With increasing maturity, the generated gas was stored in a “sorbed” state as well as in a “free” state in interstitial pore in the low clay and brittle intervals. Gas yields are expected to be high and consistent with organic richness and original hydrocarbon generation potential. Some gas and light oil has been lost from the Qusaiba system through late stage expulsion but a high percentage remains in the Qusaiba itself as indicated by high mud gas readings measured in many wells that were drilled through it. Recent kinetic data and modeling indicated that the Qusaiba hot shale is more gas prone than typical type II marine kerogen. The richness and maturity of the Qusaiba hot shale offers favorable conditions for shale gas prospectively in the Arabian Peninsula particularly in the northwestern territory of the Kingdom of Saudi Arabia. In addition to the hot shale, the overlying thick lean shale can be a good potential for shale gas, which contains less clay, high quartz and maturity in the range of wet to dry gas. Overpressure conditions may occur where the bounding formations form a seal against hydrocarbon migration and gas generation continues within the shale. All these properties play an important role in making it as a prospective shale-gas play. The adsorption capacity of these shales is not very well understood and it needs more work. In addition, the desorption of gas might have occurred due to the uplift in the areas where Qusaiba had reached the gas window prior to the Hercynian uplift.

References

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