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Shale Resources: An Emerging Exploration Concept In Kuwait

George Gega*, Abdulaziz Al-Fares*, Fida Hussain*, Awatif Al-Khamis*, Patrick Clews**
*Kuwait Oil Company
**Core Laboratories, Abu Dhabi
ggega@kockw.com

Summary

Over the past decade organic shale has become an increasingly important source of natural gas. The key to this success was primarily based on field experience while geological studies into the nature of the shales lagged behind.

During this time, a set of factors such as price and technology (hydraulic fracturing and horizontal drilling) converged to kick off the last decade's boom. However many questions still rise.

1. What makes a shale prospective? Simply said: "What is a shale"?
2. Is it worth the risk to explore for shale gas without conducting scientific studies?

Scientific studies paved the way for rapid progress in understanding the unique and very intricate properties of shales at all scales (from nano- to macro-scale) questioning even the meaning of the term "shale". The study of three key elements namely TOC, Thickness, and Maturity turns out to be of primary importance for defining shale resource systems and exploration success.

Objective

Our intent here is to compare these observable geological features of the potential gas shales of the Najmah and Makhul formations, with other shale formations in Kuwait (e.g. the Ratawi shale); and with the vast experience gained in North America. Defining the potential plays characterized by the above parameters falling within the assumed cut off limits (best experience) – form the high priority target from the exploration point of view.

Shale Characteristics

Properties such as brittleness, organic matter content, thermal maturity, presence of significant "organo-porosity" within kerogen (porous floccules, porous fecal pellets, fractures, etc.) are key factors controlling gas flow rates. It is well known that shales not only have the capacity to *generate* hydrocarbons but also to possess retentive and self-created *storage capacity*.

Processes and Composition affecting Shale Properties

The Najmah and Makhul formations comprise bituminous and non-bituminous limestones, deposited during Oceanic Anoxic Events (the Late Callovian for Najmah formation and Berriasian for Makhul) within transgressive systems.

Petrography: Petrographic analyses document the detrital and authigenic mineralogy, texture, and controls on reservoir quality. *Organic matter*, black and amorphous, is dominant while hydrocarbons fill the micropores**.** *Matrix* comprises *c*ompacted faecal pellets. *Detrital clay* (mainly illite & kaolinite) is present mixed with disseminated calcite. *Authigenic mineralogy***:** calcite is present as early to late cement. *Dolomite and Pyrite* are present in small amounts.

Discussion: For the Najmah and Makhul formations, most of the organic-rich rock is composed of bitumen and these formations are major source rocks in the Northern Arabian Gulf. XRD analysis indicates that these organic-

rich shales contain approximately 60% calcite & 11% total clay. These shales when broken release quantities of gas. Tiny pores within the organic matter are filled with gas. *Fissility and Lamination*: are created by seasonal variations in deposition. Fissility is increased by the presence of bivalve shells & enhanced by the drilling process. The rock becomes more indurated with an increase in calcite. *Permeability:* is expected to be negligible under reservoir conditions and will only be enhanced by fracturing propping of lamination.

Conclusions

The organic-rich Najmah and Makhul shales, usually match the definition of the North American "gas shale" in that they contain sufficient organic material, are sometimes “laminated” and at the same time are producing intervals.

Carbonate minerals are dominant such that the rocks are best classified as organic-rich limestones.

Based on the occurrence of three key elements (TOC, thickness & maturity) the Najmah and Makhul shales are identified as potential resource systems.

Based on the above parameters falling within the assumed cut off limits (best experience) the Najmah shale should be a potential play all over Kuwait, while the Makhul forms a potential play in the northern part of Kuwait. They are high priority targets from the exploration point of view.

The Ratawi formation has a typical shale composition with negligible organic matter. It is not classified as a Shale Resource System.

Emphasis has been on stratigraphic and structural framework. Conducting geochemical tests & mapping the thermal maturity of the formation is one of the key elements of success. The maturity seems to relate directly to the gas to oil ratio, and is one of the key factors controlling gas flow rates.

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