Advanced Characterization of Clay Mineralogy in the Organic-Bearing Ra'an Shale, Northwest Saudi Arabia, for Unconventional Oil/Gas Exploration and Development

Tawfik Al-Ghamdi[1], Abeer Al-Abdullatif[1], Septriandi Chan[2], Mohamed O. Abouelresh[2], Lameed Babalola[2], and Hicham El Hajj[1]

[1]Halliburton, Dhahran, Saudi Arabia.
[2]KFUPM university, Dhahran, Saudi Arabia.

ABSTRACT

The main objective of this paper is to accurately determine the occurrence, type, and characteristics of clay minerals in the organic-bearing mudstone of the Ra'an member, Qasim formation, which outcrops in the Tabuk basin, northwest Saudi Arabia. The mineral composition of the studied Ra'an shale samples show significant similarities to the Barnett shale, one of the most productive shale gas reservoirs in North America. The abundance of brittle minerals and low clay content in the investigated samples positively contributed to the development of microfractures in the outcrop. Thus, the Ra'an shale is a good candidate for unconventional oil/gas exploration and development. Approximately 80 outcrop shale samples were collected and processed for analyses. The samples were composed of light to dark gray, fissile, slightly calcreous, finely laminated mudstone and siltstone, fissile, and cross-bedded friable to highly lithified, cruziana-bearing micaceous siltstone to very fine calcareous sandstone. X-ray diffraction (XRD), X-ray fluorescence (XRF), cations exchange capacity (CEC), capillary suction time (CST), acid solubility, and linear swelling meter (LSM) tests were used to achieve a comprehensive characterization of this formation. XRD analysis showed that the Ra'an shale is primarily composed of quartz (~50%) and feldspar (~27%). Clay minerals (mainly kaolinite) content ranges from 3 to 20% (average: 11.2%), which was confirmed by CEC tests. LSM tests indicated that the clay fraction in the studied samples is characterized by low swelling (1 to 8.5%). Among the various mineral groups constituting organic-bearing rock, clay minerals are significant for understanding the deposition, evolution, and hydrocarbon potential of these shales. In addition, clay minerals in unconventional resources can affect both reservoir capacity and production. It is important to measure and validate the type and abundance of clay minerals to better understand the petrophysical properties of shale and consequently avoid exploration failure by choosing compatible drilling hydraulic fluids.