Fracture Development in Unconventional Reservoirs and Its Role in Hydrocarbon Migration and Expulsion

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Abstract

Organic-rich mudrocks are of great significance to the petroleum industry, potentially acting as source rocks, cap rocks or unconventional reservoirs. Several different factors control the development of fracture systems in such rocks. These include the physical/mechanical (low porosity and permeability, high young's modulus and low Poisson's ratio) and geochemical (high total organic carbon) properties. Consequently, fractures are most likely to develop in these fine-grained rocks under these conditions. Fractures, specifically natural fractures, are abundant in organic-rich shales, regardless of their mechanism/s of formation. They play an important role in both fluid storage and migration and are critical to hydrocarbon exploration and production. Natural fractures may act as either conduits or barrier for fluids migration. Fracture geometry and distribution are important factors that influence hydrocarbon migration, and in turn, influence hydrocarbon production. This work focuses on the study of fracture development in organic-rich shale reservoirs and their relationships to hydrocarbon migration and expulsion. The aim is to obtain an improved understanding of the development of natural fractures in fine-grained rocks, including their stratigraphic distribution, timing and formation mechanism/s. We studied fractures in different examples of unconventional plays with different maturity levels. In this study, we present examples of fracture development and distribution from Jordan (immature shale). The different features of natural fracture systems were investigated from the core. Fracture cement and host rock lithology were analysed for geochemical and petrographic characteristics. An experimental maturation of the immature Jordan Oil Shale was then done on the same rock samples to study the fracture development in an experimental scale under different experimental conditions. The Upper Cretaceous-Eocene Belqa Group of Jordan contains abundant natural fracture systems with varied types, geometries and distributions. Based on the geochemical, the rocks show high TOC (up to 30 wt %) and S content (up to 8 wt %) values and high Hydrogen Index (HI) values (up to 880 mg HC/g TOC). The core investigation exhibits that fracture formation and distribution is governed by the host lithology, which emphasises the role of mechanical serigraphy in fracture development. Mechanical stratigraphic controls on fracture distribution, as well as, the presence of solid bitumen within fractures as inclusions in fracture cement or as an entire filling, suggest that fracturing occurred due to different mechanisms and has different timings. Bitumen-bearing fractures provide an evidence hydraulic fracturing due to fluid overpressure. Experimentally, the rocks show almost a similar behaviour to what happens in the subsurface.

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