Factors Controlling Natural Fracture Development in the Qusaiba Hot Shale, Northwest Saudi Arabia; Outcrop Approach

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Abstract

The Qusaiba Hot shale (QHS) with an average ~30 m thickness, crops out along the northeast margin of Tayma Graben, northwestern Saudi Arabia as hills facing the southwest direction. This graben is bounded by long normal faults oriented N 150o. Lithologically, the QHS consists mainly of dark grey to black organic-rich shale and muds with stingers of silt sediments. This study investigates the natural fracture network, the origin and evolution and the control on the fracture distribution and their effects on the potential reservoir quality QHS. Four hundred and sixty fractures (460) were described and measured in terms of their length, aperture, orientation, plunging angles and in-filling materials within 100 m2 of the cliff-face of the investigated QHS outcrop. Four fracture sets were identified based on plunging angles. These are (1) Vertical to sub-vertical fractures with plunging angle ranging from 80o to 90o, representing about 30% of the examined fractures. (2) High angle fractures with plunging angle ranges between 45o and 79o accounting for about 20 % of the fracture population. (3) Low-angle (10o to 44o) fractures is the most abundant fracture set representing~33 % in of the fracture counts (4) Parallel to subparallel bedding fractures (0o up to 9o) accounts for about 17% of the fracture. Four percent of the studied fractures was classified as open fractures while the partially open fractures represent about 38 %. The gypsum-sealed fractures constitute 58 % of the fracture populations. Gypsum is the main filling mineral in the studied section occurs along bedding planes and fracture surfaces. The fracture aperture ranges from less than 1 cm up to 10 cm with average 2 cm. The measured fracture height ranges from 7cm up to 820 cm although more than 42 % of these fractures has length between 10 to 30 cm. Lithological heterogeneity and organic matter richness control the development, propagation and distribution of the short fractures while the orientations of the long fractures were likely influenced by the regional tectonics. the natural fracture development. The intensity distribution of the natural fractures shows a wide variation from 7.7 fracture/ m2 at the base of the section to 2.8 fracture/m2. This variation could be related to the vertical distribution of organic matter from 6.1 wt % at the base to 1.8 wt % at the top of the investigated outcrop.