



Comprehensive characterization of natural fracture networks of the Zubair Formation in North Rumaila oilfield

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ARTICLE INFO

Keywords:

Natural fractures
Borehole image logs
Zubair formation
North Rumaila oilfield
Secondary porosity
Reservoir characterization

ABSTRACT

The Zubair Formation serves as a crucial clastic sedimentary reservoir in southern Iraq, greatly contributing to hydrocarbon exploitation. Natural fractures affect fluid movement and reservoir efficiency, even though the reservoir is highly productive. This is the first multiscale characterization of fractures in the Zubair clastic reservoir. This study comprehensively analyzes natural fractures in the Zubair Formation using data from 15 wells. To classify fracture types, determine fracture orientations, and enable fracture diagnosis in non-imaging wells through log calibration, the methodology integrates core and thin-section samples, borehole image logs, and conventional well logs. Results showed that open fractures account for 44.25% of all natural fractures, and fracture permeability (Kf) varied from 52.75 to 303.84 Darcy, indicating a highly conductive fracture network. These fractures create channels within the upper shale and upper sand zones, enhancing oil flow and reservoir productivity. Fractures primarily extend from the northwest to the southeast, while their predominantly vertical to sub-vertical geometry favors horizontal hydraulic communication. Secondary porosity index (SPI) values exceeding 0.75 in many fractured intervals demonstrate that fracturing significantly contributes to secondary porosity and reservoir quality. Fractured intervals consistently exhibit increased gamma-ray values, decreased bulk density, increased neutron porosity and acoustic transmission time, and positive resistivity separation, enabling reliable fracture identification in wells without image logs. Integrating fracture characterization with dynamic reservoir data, stress analyses, and advanced fluid flow modeling will improve understanding of fracture-controlled reservoir behavior.

1. Introduction

Accurate reservoir characterization and improved development strategies rely on natural fracture characterization (Nelson, 2001). Natural fractures markedly influence fluid flow, permeability, and the efficiency of hydrocarbon recovery in petroleum reservoirs (Narr et al., 2006). The presence of fractures in low-permeability reservoirs facilitates fluid migration, whereas fractures in high-permeability reservoirs induce permeability anisotropy (Laubach et al., 2019). Traditional diagnostic techniques exhibit notable limitations despite their importance: core examination, while providing direct visual evidence, is constrained by limited area coverage, high cost, and partial recovery, especially within fractured intervals (Kulander et al., 1990; Lorenz and Cooper, 2017). Although thin-section petrography yields microscopic information on fracture-filling minerals and diagnostic relationships, it is restricted to small sample sets (Anders et al., 2014). Conventional well

logs (density, gamma ray, resistivity, acoustic, and neutron) lack sufficient resolution to quantify specific fracture characteristics, though they can aid in identifying fractured zones by their characteristic responses (Tiab and Donaldson, 2015). Understanding fluid flow in fractured reservoirs requires the exact determination of fracture parameters including dip, azimuth, density, and aperture using image logs (such as FMI and UBI) (Luthi, 2001; Lai et al., 2018). However, to evaluate the petrophysical impact of fractures on reservoir parameters, image logs alone are insufficient (Aghli et al., 2020). Most wells are unable to provide imaging logs because of their high operational expenses and technical risks (Luthi, 2001). Fracture networks and their reservoir properties can be thoroughly described by combining a range of data types, such as thin sections (microns), cores (centimeters), image logs (meters), and traditional logs (tens of meters) (Gauthier et al., 2002; Wennberg et al., 2016).

Recent studies show that well logs and geophysical data are

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<https://doi.org/10.1016/j.pce.2026.104718>

Received 15 April 2026; Received in revised form 29 July 2026; Accepted 3 August 2026

Available online 5 August 2026

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