

# **3D Digital Outcrop Model-Based Fracture Analysis of Reservoir Outcrop Analogue (Arab-D Member, Saudi Arabia)**

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## **Abstract**

Fracture networks may significantly influence permeability in the subsurface reservoir, affecting both well productivity and recovery factor. Despite the considerable advances in defining geological characteristics at reservoir conditions, methods to describe subsurface fracture networks are still poor at the mesoscale (cm - 10's of m). In this context, outcrop analogues allow more extensive and laterally continuous measurements of reservoir properties, also covering interwell volumes. The objective of the work presented here is to measure fracture intensity (P21), length of fractures, Fisher dispersion coefficient, and attitude of fracture sets along an outcrop of the Late Jurassic Arab-D member along Wadi Daqlah, north of Riyadh, Saudi Arabia. Furthermore, we aim to compare the measured outcrop fracture geometries to published data on age-equivalent Arabian reservoirs to assess whether outcrop and subsurface sequences are comparable and whether a link exist with the structural history of the Arabian plate. A large 3D digital photogrammetry data set was used to build the Digital Outcrop Model (DOM) of the Arab-D member located along Wadi Daqlah. Using the DOM, the mapping of visible fractures along the outcrop was performed to define the main fracture sets and compute the fracture intensity (P21). The fracture intensity (P21), length of fractures (mean/standard deviation), fisher dispersion coefficient, and attitude of fracture sets have been determined to build a reservoir structural model. 2152 fractures were traced in the DOM, highlighting the presence of six different fracture sets exposed in the outcrop. The predominant sets have a general trend of NE-SW, NW-SE and E-W with the following attitudes: 325°N88°, 301°N78°, 172°N83°, 208°N44°, 271°N85°, and 247°N74°. Most of the fractures are sub-vertical and strata bound, with a mean length size of 0.29m, a max. length of 3.42m, min. length of 0.05m and a standard deviation of 0.27. The fracture intensity analysis (P21) was conducted using the entire fractures dataset along the outcrop in order to describe fracture intensity distribution and variability. The maximum P21 value observed in the outcrop is 4.017 m<sup>-1</sup>. The fracture sets defined and measured in the Arab-D outcrop match with the fracture sets defined using the same methodology for the Jubaila Formation outcrops in another study along Wadi Laban, in Riyadh. Furthermore, previous studies characterizing subsurface fractures in Arab-D reservoirs to the east of the outcrops had reported fracture sets with general trend of NE-SW, NW-SE and E-W, matching with the general trends defined for the fracture sets in this study. These results show that by extracting fracture data from outcrops it may be possible to describe fracture patterns in the subsurface usually not detected by conventional methods, improving the structural characterization of subsurface reservoirs.