Fracture Intensity and Associated Variability: Insights from Jurassic Arab Formation Outcrop Analogues, Saudi Arabia

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Abstract

Objectives
Fracture networks significantly influence permeability of subsurface reservoirs, affecting both well productivity and recovery factor. Despite recent improvements, characterization and prediction of subsurface fracture networks at centimeter to 1 Os of meters resolution are still limited. In contrast, outcrop analogues allow extensive and laterally continuous measurement of reservoir properties for interwell volumes. The research presented here measures fracture intensity (P21), fracture geometry, and fracture set attitude in outcrops of the Late Jurassic Arab Formation in Wadi Daqlah, Saudi Arabia. Outcrops provide robust datasets and models of fracture sets, which reduce uncertainty in the characterization and prediction of subsurface reservoir quality. We investigate whether fracture propagation in the study area is linked to different structural phases that affected the Arabian Plate.

Procedures and Results
Six 3D digital photogrammetry data sets were used to build Digital Outcrop Models (DOM) of the Arab Formation in Wadi Daqlah, Saudi Arabia. Then, the mapping of visible fractures in the DOMs was performed to define the main fracture sets and to compute the aerial fracture intensity (P21). A total number of 11,950 fractures were traced on the DOMs, which show the presence of three predominant fracture sets across the entire study area. They display NE-SW, NW-SE, and N-S trends. The vast majority of visible fractures are subvertical and stratabound. The P21 analysis used the entire fracture dataset along the outcrop to describe lateral distribution and variability. The mean P21 value observed in the outcrops is 0.341 m-1, the minimum 0.001 m-1, and the maximum 4.998 m-1.

Conclusions
The fracture sets defined and measured in the Arab Formation outcrops match those analyzed with the same methodology in the Hanifa and Jubaila Formation outcrops. Furthermore, previous studies characterizing subsurface fractures in the Arab Formation had also reported fracture sets with NE-SW and NW-SE trends, i.e. matching the trend of fracture sets identified in this outcrop-based study. The detailed P21 results show that fracture data from outcrops (this study) are relevant to improve the understanding of subsurface fracture patterns. Considering that P21 data are usually not detected in subsurface investigations, DOM data can improve the structural understanding and calibration of subsurface reservoirs.