The Value of Digital Photogrammetry for 3D Fracture Network Characterization in Late Jurassic Outcrops Analogues, Saudi Arabia

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Abstract

We investigate outcrops in Central Saudi Arabia exposing late Jurassic sequences namely the Hanifa, the Jubaila, and the Arab formations. These outcrops are adequate analogues for their subsurface reservoir intervals in Saudi Arabia's Eastern Province and enable us to study natural fracture networks at the mesoscale (10s meters) that highly impact in situ permeability, productivity, and recovery factor. While current techniques to properly characterize natural fracture systems at this scale in the subsurface are limited, the use of digital photogrammetry on outcrop analogues has proved to be a powerful tool to improve our understanding - in particular fracture characterization in 3D space, fracture sizes, persistence, as well as their dips and dip directions. For each formations we follow the same approach: first, we use digital photogrammetry to reconstruct the 3D Digital Outcrop Model (DOM). Then we map fractures along their visible exposure on the DOM with 3D dense cloud and texturized mesh in order to make quantitative measurements. In all three study areas we observed three fracture sets that are in agreement with previous studies conducted on the Arabian Peninsula. There are roughly oriented NNE-SSW, NW-SE and E-W. These sets can be associated with different tectonic phases that had a marked structural effect on the area, Jurassic rifting (NNE-SSW oriented), Alpine I (NW-SE oriented), and Alpine II (E-W oriented) respectively. Furthermore, we compute fracture intensity values for every investigated DOM and thus derive lateral and vertical fracture variability. We observe and describe the size and distribution of fractures corridors. Fracture intensity varies vertically as well and strongly correlates with matrix permeability (derived from log data in wells cored near the outcrops). Assuming a connection between subsurface and outcrops, this integration of well and outcrop data is valuable for reservoir modeling.