Fracture networks in a Late Jurassic Arab-D reservoir outcrop analogue, Upper Jubaila Formation, Saudi Arabia.

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Fracture networks are responsible for channeling flow in subsurface reservoirs (hydrocarbon or geothermal) and markedly impact well productivity and ultimate recovery. Yet, methods to provide fracture (network) distribution at sufficiently high resolution are still lacking – mainly because subsurface data do not adequately capture natural fractures at the mesoscale (cm to m in size) beyond the well bore. In this study we utilize an outcrop analogue to bridge this scale gap. Over the last decades 3D digital photogrammetry drastically improved in terms of measurement amount and quality enabling the collection of large data sets over wide outcrops. Such data provide critical insights on depositional and structural heterogeneities that may then be utilized for reservoir analogue simulations. Subject of this study is an outcrop in Wadi Laban located in SW Riyadh, Saudi Arabia, along the Mecca-Riyadh highway. We constructed a reliable 3D Digital Outcrop Model (DOMs) at high resolution of the Late Jurassic (Kimmeridgian) Upper Jubaila Formation following a ~800m long escarpment without any occlusion or bias. In particular we reconstruct a colorized dense point cloud using the high-quality setting of Agisoft Metashape© software. We investigated DOMs with CloudCompare© software (CloudCompare, 2021) to map the visible fractures 3D exposure and infer general fractures pattern. Four fracture sets are evident in the data: the predominant sets 1 and 2 are roughly E-W oriented, while sets 3 and 4 are roughly NNE-SSW oriented. Most fractures are strata bound and sub-vertical in nature. Fracture intensity (P21) analysis along the entire outcrop enables us to describe and quantify lateral and vertical variability. Laterally natural fractures are concentrated in corridors with a spacing of few tens of meters. Vertically, fracture intensity is heterogeneous. Furthermore, we found a strong correspondence between fracture intensity on the outcrop and a porosity log acquired on core samples from a well drilled only a few meters behind the outcrop. The outcome of this study provides a step forward for the comparison of outcrop and subsurface fractures, and expand the application of outcrop data to generate high resolution and fidelity reservoir analogue models.