AAPG Datapages/Search and Discovery Article #90254 ©2016, GEO-2016, 12th Middle East Geosciences Conference & Exhibition, Manama, Bahrain, March 7-10, 2016

Comparison of Fracture Analysis Methods at Multiple Scales from Outcrop Analogues

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ABSTRACT

Good analogues for calibration of reservoir models should contain representative fracture properties across a wide range of scales. Capturing fracture data across multiple scales requires a range of different methods and appropriate technologies. In this study we illustrate a number of these methods, through field examples, comparing their advantages and disadvantages, and show how they are best when used in combination in order to extend the overall scale range of the analysis.

Direct methods of field measurement (e.g. along 1D transects) remain an essential way to study fracture characteristics such as aperture, fill, fracture morphology, mode, kinematics, and relative timing of fracture development. Relatively recent methods of digital acquisition, including terrestrial LiDAR and photogrammetry, are particularly adept at capturing detailed geometrical and geospatial attributes over wide areas, but should be considered as complimentary to traditional field methods, rather than replacements. Their main advantage is that they typically enable rapid acquisition of greater areas of coverage, resulting in multiple, longer 1D transects, and 2D or 3D surface datasets, including inaccessible areas of outcrops. This tends to give more robust datasets over a larger scale-range, particularly for fracture heights, lengths, spacing, clustering, termination and connectivity.

In order to be able to combine fracture properties derived using different acquisition methods into a single multi-scale dataset, it is necessary to calibrate the different technologies to ensure that the data will scale seamlessly. This is best achieved by analysing the same outcrop with different acquisition methods that at least partially overlap in their range of scales. Once this validation process is complete, the combined multi-scale fracture properties can be used to calibrate full-field fracture models for the target reservoir.

We illustrate these concepts with field examples analysed using three acquisition methods: traditional 1D transects, medium-range digital photogrammetry, and terrestrial lidar. Localities include outcrops of Cretaceous Wasia Gp. and Thamama Gp. (Ras Al-Khaimah, UAE), since these are regionally important reservoir units in the sub-surface. We also apply the same methods to the Jebel Hafeet anticline (Al-Ain, UAE). The combined datasets provide a much larger, multi-scale fracture model that is the basis for a full-field discrete fracture model.