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From outcrop analogue to full-field fracture model: the importance of multi-scale fracture size-intensity relationships

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ABSTRACT

We present new datasets from fractured carbonates measured across multiple scales, acquired using a combination of different methods, from surface outcrops of Cenozoic and Mesozoic reservoir units from the Kurdistan Region of Iraq. We use these data to illustrate the importance of characterising the scaling relationship of fracture size vs. fracture intensity, in order to be able to upscale fracture network parameters to derive full-field fracture models.

A combination of traditional fieldwork, geospatial technologies, and analysis of satellite imagery can allow fracture data across at least seven orders of magnitude to be acquired from suitable areas of surface exposure. Direct methods of field measurement (e.g. analysis along 1D transects) remain an essential way to study fracture characteristics such as aperture, fill, morphology, kinematics, and relative timing of fracture development. Newer methods of digital acquisition are particularly adept at capturing detailed geometrical and geospatial attributes over wide areas. Key technologies include terrestrial lidar and photogrammetry (ground-based or from unmanned aerial vehicles; i.e. 'UAVs' or 'drones'), and are complimentary to traditional field methods.

When measuring fracture characteristics at only a single scale (such as at outcrop scale), it is often difficult to ensure that an adequately large area (or volume) of rock is sampled to be sufficiently representative of the entire fracture network. An illustration of this is that fracture size-intensity relationships from individual outcrops often show apparently exponential distributions. However, when larger areas of the same outcrops are acquired with lidar or photogrammetry, there is an increased tendency for power-law relationships. When additional size-intensity data are added based on fractures characterised from satellite imagery, the combined plots suggest power-law scaling from sub-outcrop to full-field scales.

Integration of data acquired at different scales and resolutions, with different methods, requires validation to ensure that they can be combined seamlessly, and the effects of varying styles of interpretation within a team of geologists need to be mitigated.