Fractured Carbonate Reservoirs Part 2: High-Resolution Mechanical Stratigraphy Derived from Kilometre-Scale Outcrop Analogues

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One of the main challenges in carbonate reservoirs is to develop a predictive understanding of the relationship between natural fractures, matrix properties, diagenesis and structural position. In order to achieve this goal, systematic study of multilayered carbonate reservoir facies has been made in spectacular kilometer-scale exposures in the Middle East, combining extensive geological fieldwork and innovative remote sensing technologies. In this contribution, the results of an integrated detailed study that evaluated the relationships between carbonate multilayer and fracture network geometry and connectivity is presented.

The multilayered reservoir section ranges from basin, slope, shoal and lagoonal facies and from little to completely dolomitized. The mechanical stratigraphy of the reservoir interval was characterized through extensive fieldwork (systematic fracture and facies analysis) and interpretation of surface and subsurface (2 tunnels crossing the area of study) 3D virtual outcrops: orthorectified QuickBird imagery combined with satellite-derived digital elevation models (0.70 m image resolution) and LiDAR-derived photorealistic models (up to 0.05 m resolution).

Fieldwork and remote sensing data reveal complex fracture geometry and evolving mechanical stratigraphy of the multilayer through time. Fractures show a pre- to post-folding timing. Early pre-folding mode I fractures are generally stratabound and cemented. Folding and post-folding deformations mostly reactivate pre-existing fractures generating open to partly cemented non-stratabound thoroughgoing fractures. Distribution and geometry of the different fracture sets are intimately correlated to matrix property distribution, diagenetic imprint, structural position and tectonic evolution of the area.

Systematic fieldwork analysis and interpretation of high resolution 3D virtual outcrops allowed detailed quantitative and qualitative parameterization of fracture distribution across the Cretaceous carbonate multilayer and provided essential inputs for the construction of an integrated reservoir model. The research provides important insights for better understanding and prediction of fracturing in important carbonate reservoir facies.