Predicting and characterizing fractures in dolomite reservoirs: using the link between diagenesis and fracturing

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Dolomite reservoirs are important sources of hydrocarbons, and fluid flow within them is commonly influenced by fractures. Understanding of fundamental processes that govern properties of such reservoirs, namely precipitation of authigenic dolomite and fracturing, has remained elusive, making prediction and characterization challenging.

Studies of fractured dolomites show that progress in extending fracture attribute predictions into nonsampled areas requires understanding of the diagenetic history of the rock and the way diagenesis interacts with fracture growth. Mechanical rock properties, which affect fracture architecture, change with diagenesis, and mineral fill within fractures depends on cementation and dissolution processes. Opening-mode fractures can form throughout burial and exhumation under a wide spectrum of loading conditions, partly because rocks have low tensile strength. Fracture architecture depends on rock properties at the time of fracturing (particularly subcritical crack index), and thus on prefracturing diagenetic processes. Preservation of fracture void space depends in part on cement precipitation synchronous with fracture opening. Typically these cements obey systematic patterns throughout a fracture set and dominantly seal microfractures having apertures smaller than 0.1 mm, reflecting rock-dominated geochemical processes. Later cements have the greatest effect on sealing large fractures and commonly have highly heterogeneous distributions. A structural-diagenetic sequence may be established by analyzing details of the timing of diagenetic events relative to fracturing. A tool that has proven powerful for this purpose is SEM-based cathodoluminescence. Once the structural diagenetic sequence is known, rock properties at the time of fracturing can be estimated.

Problems related to scale of observation in wellbores and cores can be overcome by using microstructural observations to predict macrofracture attributes. Opening-mode fracture sets have power-law aperture size distributions, and core samples may yield a large population of microfractures, apertures at the submillimeter scale being orders of magnitude more abundant than those at the centimeter scale. Cores from Lower Ordovician Ellenburger and Permian Clear Fork Formations in West Texas, Lower Ordovician Knox Formation in Mississippi, and outcrops of Cretaceous dolomites from the Sierra Madre Oriental, Mexico, have been studied using this approach. Orientation, population systematics, and openness of macrofracture sets have been accurately predicted using microstructures.

In the case of dolomites, complexity of diagenetic processes might seem to be a hindrance to fracture prediction, but the reverse is true. A complex diagenetic signal can help resolve fracture events that are otherwise marked by nearly indistinguishable opening-mode fractures. Moreover, fracture events punctuate and may help us unravel diagenetic history. A combination of structural and diagenetic work is likely to be beneficial for both disciplines and to overall understanding of fractured dolomite reservoirs.