Impact of multiphase fracture sequence in folded carbonates on the evolution of naturally fractured reservoir types. An outcrop case study from Mirabeau Anticline (SE France)

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Fractures in rocks are sensitive cursers that may enhance porosity and permeability. This is particularly true in carbonates because background fractures might be ubiquitous after embrittlement at early burial (Lavenu & Lamarche, 2018). Barren fractures at depth are susceptible to chemical reactions with underground fluids and cementation that might totally or partially reduce porosity and permeability (Laubach et al., 2019; Aubert et al., 2019). Hence, early background fractures with long lasting tectonic history and structural diagenesis, in addition to fractures neo-formed at any time during burial, tectonic inversion and folding join the game of matrix/fracture permeability and porosity modification. To predict the fractures contribution to flow in Naturally Fractured Reservoirs, it is fundamental to know the fracture sequence and geometry resulting from the geological history in folded carbonates, from the host-rock embrittlement to the present-day situation. At any step, we intent quantifying the fracture geometry and estimating their contribution to the host reservoir properties.

The study is performed in Upper Jurassic to Lower Cretaceous carbonates (Oxfordian, Tithonian, Berriasian) formed in the South-Provençal Basin. From deposition to present-day, the platform carbonates underwent alternating subsidence, uplift, erosion and folding. We sampled a scan-line along a horizontal path across both flanks of the Mirabeau Anticline (SE France). We measured all tectonic and stratigraphic features crossed by the line, checked their nature and position. We deciphered their chronological relationships with respect to each other and to the bed tilting. We compiled all cross-cutting relationships into a coherent sequence of deformation of pre-, syn- and post-fold structures and correlated it to burial, uplift and folding of the host rock. At each brittle stage, the fracture pattern was characterized in terms of architecture, mechanical stratigraphy and reservoir properties in order to draw a time-path in a matrix versus fracture permeability and porosity table (Nelson Reservoir types) during 150My. After embrittlement, the host-rocks bear fractures, pressure-solution, faulting, folding and erosion. If it was a reservoir, its Nelson type would have evolved from IV to III during the burial and initial brittle deformation. The tectonic inversion and onset of multiple-scale brittle structures would have increased and decreased the
fracture and matrix contribution respectively and the reservoir evolved to types II and I. During the 150My history, fracture porosity and permeability depends on their geometry (veins versus tension gashes) and cementation. This results in several switches from type II to I as a function of the fracture timing, geometry, connectivity and diagenesis.

Aubert I. et al. (2019). Imbricated structure and hydraulic path induced by strike-slip reactivation of a normal fault in carbonates. Fifth International Conference on Fault and Top Seals, 8-12 September 2019, Palermo, Italy.


Lavenu A.P.C., Lamarche J. (2018) What controls diffuse fractures in platform carbonates? Insights from Provence (France) and Apulia (Italy), JSG 108, p. 94-107