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Multiscale characterization of fracturing in folded platform carbonates: the case study of the Island of Pag, External Dinarides of Croatia

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Fractures are a primary factor controlling the fluid storage and transport properties of hydrocarbon reservoirs. The quantitative characterization of fractures in outcrop analogues allows a better understanding of natural fracture systems, to extrapolate predictive laws useful for integrating the limited data available for buried reservoirs. Here we present the methodological workflow we are applying for a multiscale characterization of fracturing in a folded Cretaceous carbonate platform in the Island of Pag, in the External Dinarides of Croatia, along with our preliminary results.

The External Dinarides are a fold and thrust belt developed between the Paleogene to Miocene, characterized by general SW vergence. The Pag anticline involves about 1 km of Cenomanian-Santonian rudist-bearing limestones overlain, through an unconformity, with transgressive Foraminiferal limestones of Eocene age. The outcrops are almost free of vegetation and display nice pavement and cross sectional exposures, although strongly affected by karst dissolution. The exceptional exposure conditions allowed us integrating remote sensing techniques with drone and ground-based photogrammetric surveys for characterizing the fracture network at multiple scales. For the analysis of digital outcrop models we developed a semi-automatic fracture detection method, combined with the 3D analysis tools available in Gocad. Traditional geological surveys and structural stations served for determining the crosscutting relations between multiple fractures and stylolites sets.

At the km-scale, the fold shows a high along-axis continuity for ca. 30km between the NW and SE periclinal terminations. In cross section, it has a box geometry, with sub-vertical to overturned limbs and a gently undulating hinge zone. The gently NE-dipping hinge zone is overthrusted over the NE limb through a sub-horizontal thrust fault. The fold is crosscut by other minor thrust faults verging both to NE and SW, and by sub-vertical strike-slip faults striking either NS or EW. Thrust and strike-slip faults determine an increase in fracture intensity clearly visible in drone imagery. At the outcrop scale, fractures and stylolites occur in both systematic and non-systematic arrays. Non-systematic, locally very intense fracturing is mostly found in thick mudstone-wackestone banks, while in packstone-grainstone dominated intervals fractures are more systematic and evenly spaced.

Our preliminary data suggest that the observed kilometer-scale tight folding of the Cretaceous platform is associated with multiple thrusts and back-thrusts at the decametric to hectometric scale. The organization and distribution of fractures is primary controlled by sedimentary facies, being more intense in mudstone-wackestone, and by the vicinity of thrust or strike-slip faults.