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Fracture Attribute Characterization in Karstic Field Analogues by a Combined Field and High-Resolution Terrestrial Photogrammetry Approach: Application to the Tightly Folded, Shallow-Water Carbonate Platform Rocks in the Pag Island, External Dinarides of

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ABSTRACT

Rock fractures usually form patterns that reflect the tectonic and geologic history of an area. Different type of fractures, such as veins, joints, and faults, as well as stylolites, exert a first- order influence on the migration and accumulation of fluids in fractured carbonate reservoirs. Understanding the relationships between the origin of fractures and their 3D distribution is a fundamental ingredient for characterizing the porosity and permeability of fractured reservoirs. Quantitative studies of field analogues provide an essential tool for the implementation of fracture patterns in reservoir models to optimize fluid-flow predictions. In particular, field analogues provide the opportunity to obtain predictive laws of fracture attributes as a function of mechanical stratigraphy and the evolution of folding and/or faulting mechanisms. Here, we describe the results of a structural study carried out in the Island of Pag, External Dinarides (Croatia), where a Triassic to Eocene carbonate platform succession was affected by tight folding during Paleocene-Miocene Dinaridic tectonics. The exposed carbonate rocks consist of about 1 km thick Cenomanian to Senonian shallow-water rudist-bearing carbonates that pass upwards to about 650m thick Eocene-Oligocene nummulitic limestone. Fractures and stylolites occur in both systematic and non-systematic arrays. Pavements and cross-sectional exposures suitable for the acquisition of large fracture attribute datasets are lacking or strongly affected by karst dissolution. To overcome such a problem, we set up a multidisciplinary approach that combines field data acquisition in small circular and/or short linear scanlines integrated with very high resolution digital outcrop models (DOMs) from terrestrial photogrammetry of typically few meter-wide areas including the scanlines themselves. DOMs were used to obtain 3D actual fracture networks and then create virtual bedding-parallel and bedding-perpendicular planar sections suitable to guarantee acquisition of statistically robust datasets. Virtual scanline data were then integrated and validated with field data. Due to the high number of variably-oriented, small-size fractures, serial cross-sectioning of DOMs was used to quantify the 3D variability of fracture attributes. Our results suggest that the proposed working method provides reliable results to characterize complex fracture pattern attributes in intensely deformed rocks by overcoming the poor quality of exposures.