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# Predictive modelling of fault related fracturing in carbonate damage-zones: analytical and numerical models of field data (Central Apennines, Italy)

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Permeability in carbonates is strongly influenced by the presence of brittle deformation patterns, i.e pressure-solution surfaces, extensional fractures, and faults. Carbonate rocks achieve fracturing both during diagenesis and tectonic processes. Attitude, spatial distribution and connectivity of brittle deformation features rule the secondary permeability of carbonatic rocks and therefore the accumulation and the pathway of deep fluids (ground-water, hydrocarbon). This is particularly true in fault zones, where the damage zone and the fault core show different hydraulic properties from the pristine rock as well as between them.

To improve the knowledge of fault architecture and faults hydraulic properties we study the brittle deformation patterns related to fault kinematics in carbonate successions. In particular we focussed on the damage-zone fracturing evolution. Fieldwork was performed in Meso-Cenozoic carbonate units of the Latium-Abruzzi Platform, Central Apennines, Italy. These units represent field analogues of rock reservoir in the Southern Apennines. We combine the study of rock physical characteristics of 22 faults and quantitative analyses of brittle deformation for the same faults, including bedding attitudes, fracturing type, attitudes, and spatial intensity distribution by using the dimension/spacing ratio, namely H/S ratio where H is the dimension of the fracture and S is the spacing between two analogous fractures of the same set. Statistical analyses of structural data (stereonets, contouring and H/S transect) were performed to infer a focussed, general algorithm that describes the expected intensity of fracturing process. The analytical model was fit to field measurements by a Montecarlo-convergent approach. This method proved a useful tool to quantify complex relations with a high number of variables. It creates a large sequence of possible solution parameters and results are compared with field data. For each item an error mean value is computed (RMS), representing the effectiveness of the fit and so the validity of this analysis. Eventually, the method selects the set of parameters that produced the least values. The tested algorithm describes the expected H/S values as a function of the distance from the fault core (D), the clay content (S), and the fault throw (T). The preliminary results of the Montecarlo inversion show that the distance (D) has the most effective influence in the H/S spatial distribution and the H/S value decreases with the distance from the fault-core. The rheological parameter shows a value similar to the diagenetic H/S values (1-1.5). The resulting equation has a reasonable RMS value of 0.116.

The results of the Montecarlo models were finally implemented in FRAP, a fault environment modelling software. It is a true 4D tool that can predict stress conditions and permeability architecture associated to a given faults during single or multiple tectonic events. We present some models of fault-related fracturing among the studied faults performed by FRAP and we compare them with the field measurements, to test the validity of our methodology.