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The role of fault surface geometry in the evolution of the fault deformation zone: comparing modeling with field example from the Vignanotica normal fault (Gargano, Southern Italy).

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Faults have a (brittle) deformation zone that can be described as the presence of two distintive zones: an internal Fault core (FC) and an external Fault Damage Zone (FDZ).
The FC is characterized by grinding processes that comminute the rock grains to a final grain-size distribution characterized by the prevalence of smaller grains over larger, represented by high fractal dimensions (up to 3.4).
On the other hand, the FDZ is characterized by a network of fracture sets with characteristic attitudes (i.e. Riedel cleavages).
This deformation pattern has important consequences on rock permeability. FC often represents hydraulic barriers, while FDZ, with its fracture connection, represents zones of higher permability.
The observation of faults revealed that dimension and characteristics of FC and FDZ varies both in intensity and dimensions along them. One of the controlling factor in FC and FDZ development is the fault plane geometry. By changing its attitude, fault plane geometry locally alter the stress component produced by the fault kinematics and its combination with the bulk boundary conditions (regional stress field, fluid pressure, rocks rheology) is responsible for the development of zones of higher and lower fracture intensity with variable extension along the fault planes.
Furthermore, the displacement along faults provides a cumulative deformation pattern that varies through time. The modeling of the fault evolution through time (4D modeling) is therefore required to fully describe the fracturing and therefore permeability.
In this presentation we show a methodology developed to predict distribution of fracture intensity integrating seismic data and numerical modeling.
Fault geometry is carefully reconstructed by interpolating stick lines from interpreted seismic sections converted to depth.
The modeling is based on a mixed numerical/analytical method. Fault surface is discretized into cells with their geometric and rheological characteristics. For each cell, the acting stress and strength are computed by analytical laws (Coulomb failure). Total brittle deformation for each cell is then computed by cumulating the brittle failure values along the path of each cell belonging to one side onto the facing one. The brittle failure value is provided by the DF function, that is the difference between the computed shear and the strength of the cell at each step along its path by using the Frap in-house developed software. The width of the FC and the FDZ are computed as a function of the DF distribution and displacement around the fault.

This methodology has been successfully applied to model the brittle deformation pattern of the Vignanotica normal fault (Gargano, Southern Italy) where fracture intensity is expressed by the dimensionless H/S ratio representing the ratio between the dimension and the spacing of homologous fracture sets (i.e. group of parallel fractures that can be ascribed to the same event/stage/stress field).