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Fluid-flow model of high-porosity carbonates crosscut by a strike-slip fault system, Favignana Island (southern Italy)

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This contribution integrates structural analysis and numerical modelling to build up, from outcrop data, a 3D Discrete Fracture Network (DFN) model, and then to run fluid flow simulations of a porous carbonate reservoir. A semi-automated process of lineament analysis, followed by the use of power law distributions to model sub-seismic scale features, is here proposed as a workflow for reservoir-scale assessment of the control exerted by structural features on the bulk permeability in porous carbonate reservoirs.

In Favignana Island (southern Italy), several quarries provide an excellent 3D view of Lower-Pleistocene grainstones crosscut by a strike-slip fault system. This fault system is made up of two main conjugate sets of strike-slip structural features such as Compactive Shear Bands (CSB), Zones of compactive shear Bands (ZB) and faults. The multi-scale properties of the aforementioned elements, distinguished for individual sets, have been previously assessed by mean of detailed scan-line and scan-area measurements. The DFN model was built using the Fracture Modelling module within the MOVE software package from Midland Valley. Analysis of an aerial photo was performed to identify the major faults. The intensity of CSBs and ZBs was computed after a preliminary outcrop analysis. We used the variation in intensity to build a DFN that reflects a pattern of deformation similar to the natural structural framework.

It is well known that both CSBs and ZBs reduce permeability, whilst slip surfaces present within faults enhance fault-parallel fluid flow. The obtained DFN was used, hence, to model the effect of deformation on host rock permeability by imposing a reduced porosity of the CSBs and ZBs relative to both host rock and slip surfaces. By taking advantage of the computed distribution of both porosity and permeability within the modelled rock volume, fluid flow simulations have been carried out by solving the flow and transport equations with finite elements. In this approach, the properties of the CSBs, ZBs and faults are coupled with the properties of the surrounding, pristine carbonate matrix. This method allows to evaluate the effects of both geometry and thickness of CSBs, ZBs and fault on the bulk permeability of grid blocks with different dimensions, and assess their effect as barriers or buffers for fluid circulation.