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3D modelling of fracture networks from DOM: variability of density and topology in fracture corridors

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Many studies were devoted to model diffuse fractures in 3D but few ones were focused on modelling the spatial organization of fractures in fracture corridors. Fracture corridors are particular geological structures within which the fracture density is particularly high. Recently, it was that the internal architecture of fracture corridors is more complex than expected. It is not only characterized by high fracture density, for instance: 1) the fracture density may vary within the fracture corridors, horizontally and vertically; 2) other geological structures such as breccia are also encountered; 3) lenses or zones of diffuse fractures may occur within the fracture corridor boundaries.
Fracture corridors have major impacts on fluid flow in carbonate reservoirs. However, fractures are only observed along well data, i.e. 1D data. The 3D modelling of the fracture networks within fracture corridors is then of paramount importance to fill the gap between the 3D nature of these objects and the 1D available observations. The 3D models of fracture corridors can also serve as support for flow simulation in order to understand their impact on fluid flow behavior, while drilling.
In this study, 3D Digital Outcrop Models (DOM) were acquired from outcrops in the South-East of France. These numerical data were used as a support for interpreting and modelling fracture networks in order to study the fracture patterns in fracture corridors. Semi-automated techniques were used to extract fracture planes and traces Indeed, two cases exist: 1) the fracture planes belong to the outcrop surface geometry; 2) the fracture planes intersect the outcrop surface and draw a gutter or a line along the outcrop. In the first case, the objective is to extract the surface patch where the fracture plane is merged with the outcrop surface. In the second case, the aim is to extract the line corresponding to the fracture trace along the outcrop surface.
This automatic procedure combined with field validation and common geomodelling approach allows accurate 3D models of fracture networks within a zone including diffuse fractures and fracture corridors. Then, it was possible to study the variability of the fracture density, the lacunarity and other topological indices of the network, inside and outside the fracture networks. The 3D models serves also as support for analyzing the 1D density (P10) in different locations in order to study its variability. This last analysis aims at filling the gap between well data and the 3D structure of the fracture corridors.