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Fracture analysis of an Eocene reservoir in Eastern Tunisia by coupling Terrestrial Laser Scanning with GigaPan Technology and seismic attribute

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It is usually not possible to study in situ fractures and faults of oil reservoirs. Then outcropping reservoir analogues are used instead. For this purpose, Terrestrial Laser Scanning (TLS) has been increasingly used for some years in the petroleum sector.
The formations El Garia and Reineche make the Eocene oil reservoir of Eastern Tunisia. The fracturing of these formations has been analyzed on the surface by TLS on a reservoir analogue outcrop and in the depth by 3D seismic data. TLS datasets provide clear information on fracture geometry distribution (spacing and persistence), connectivity and joint orientation. These results were then compared to structures observed in depth with seismic data.
The reservoir analogues are the Ousselat cliff (formation El Garia) and the Damous quarry (formation Reineche). Those two sites are made of marine limestone rich in large foraminifers, gastropods and nummulites.
Fieldwork, TLS acquisitions and high-resolution GigaPan panoramas were put together to create digital outcrop models. A total of 9 scans at 3 different survey positions were carried out. Firstly, the data processing (cleaning, alignment and georeferencing of the raw point clouds) was carried out using the Polyworks software. Secondly, we draped Gigapixel pictures on the triangular mesh generated with 3DReshaper to produce relief shading. This process produces a photorealistic model that gives a 3D representation of the outcrop. Finally, Coltop3D was used to identify the different sets of discontinuities and to measure their orientations. Furthermore, we used some 3D seismic attribute data to interpret approximately 60 fractures and faults at the top of the Eocene reservoir.
The Coltop3D analysis of the Ousselat cliff shows 5 sets of joints and fractures, with different dips and dip directions. They all strike in directions NW-SE, NNE-SSW, NE-SW and ENE-WSW. Using the photorealistic model, we measured approximately 120 fracture spacings ranging from 1.75m to 10m.
For Reineche formation outcrop, the structural analog indicates 8 sets of joints and fractures. In Total, we measured 150 fracture spacings. The most part of fracture spacings range from 0.05m to 1m. The results show that many joints of the quarry rocks are interconnected with other small-scale fractures.
The comparison between the stereonets obtained by Coltop3D and the seismic attributes indicated that fractures striking NW-SE to NNW-SSE and NE-SW to NNE-SSW are represented in all surveys position. The majority of the faults and fractures observed in TLS data and 3D seismic data can be explained by a combination of extension and shear. Moreover, in this study, we found that there is no correlation between fractures density or fracture distribution and lithology. Finally, the density and the geometry of the fractures have been also interpreted at the outcrop level and in depth, this comparison allows to better characterize the relationship between permeability, secondary porosity and fracture density of the Eocene reservoir.