Integration of 3-D Ground Penetrating Radar and Outcrop Analysis for Characterizing Solution Enhanced Fractures in Cretaceous Carbonates, Cassis, France

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Conventional outcrop-based fracture analysis captures the two dimensional properties of the fractures. 3D Ground Penetrating Radar (GPR) images fracture geometry and distribution in three dimensions. In this study, 3D GPR and outcrop analyses are compared to test the resolution potential of GPR and its capability to enhance the fracture network characterization in three dimensions.

A conventional fracture analysis in a large quarry in Barremian rudist bearing strata in Cassis, France, using the scanline method identified about 500 fractures (mostly extensional fractures), where about half of them are solution enhanced. Several fracture patterns occur: (1) large fractures (length >10m) distributed along corridors; (2) small fractures (length 1-4m) in en échelon arrays; (3) scarce fractures abutting against layer boundaries; and, (4) scarce faults with displacement. The outcrop analysis recognizes 3 fracture families based on their orientation: N-S, E-W, and NW-SE oriented fractures. The distribution of the solution enhanced fractures is not uniform and cavities appear or disappear within a few meters along the fractures. They are mostly flat and thin (1cm to 20cm void), and rarely rounded and small (length <1.5m). Where large fractures (length >10m) dominate, the cavities form along fractures planes that cut through bedding boundaries. In others the stratigraphic horizons act as vertical boundaries for the solution while some dissolution continues laterally.

The three 3D GPR cubes acquired with two different frequencies (100MHz and 200MHz) add the third dimension to the fractures and solution cavities. In addition, 3D GPR images one more fracture family. It is a NE-SW oriented fracture family that runs parallel to the quarry wall and is not captured using the scanline method. The geometry, termination and the cross cutting relationship of the fractures are clearly visible in 3D GPR data, as well as the distribution of the solution-enhanced fractures. Thus, 3D GPR adds important information for the 3D geometry and distribution of the fractures, which are difficult to capture using only conventional outrop data.