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How fracture systems control fluid transport in shallow-water carbonate rocks: an example from the Gargano Peninsula, Italy

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The hydromechanical properties of carbonate rocks are very variable. This is partly because carbonate rocks have different depositional patterns. Partly, however, the variability in properties is due to the rocks having undergone extensive alteration after deposition which may have changed their original matrix porosity and permeability. In a subsurface reservoir of relatively low porosity-related permeability, fractures (joints and faults) are commonly the main paths for fluid transport. Detailed studies of fracture patterns in outcrop analogues of such reservoirs may thus improve our understanding of fracture-controlled permeability in carbonate reservoirs.

Several factors control the fracture distribution in a carbonate reservoir. These factors include rock lithology and diagenesis (e.g. stylolites), mechanical layering, and the local stress fields, both the earlier ones as well as the present-day field. There are also many factors that affect fracture-related permeability in a reservoir, but perhaps the most important is fracture connectivity, namely how and to what degree individual fractures link up to form a continuous network. In turn, fracture connectivity is controlled by fracture attitude, size, and aperture distribution. When the percolation threshold is reached, that is, when a set of fractures forms an interconnected network, the permeability of a reservoir may increase by many orders of magnitude.

We have measured various fracture-related parameters in carbonate rocks of Lower Cretaceous age in the Apricena quarry located on the Gargano Peninsula in Italy. Approximately 1500 fractures and faults were measured along several vertical and horizontal scan lines. Preliminary results show that there are a number of fracture sets in the quarry, but the dominant strike is E-W to ESE-WNW. About 1000 fracture-spacing measurements along the scan lines indicate log-normal spacing distributions, with an arithmetic mean fracture spacing of 0.42 m and a median of 0.28 m. Plotting mean spacing against mean mechanical layer thickness indicates a crudely inverse linear relationship between spacing and thickness; that is, spacing decreases with increasing layer thickness. The average coefficient of variation, C_v, is defined as standard deviation divided by the mean. The minimum C_v is 0.76 while the maximum $C_v$is 1.31. Fracture aperture (opening) data (n=324) show a log-normal size distribution, with a mean opening of 10 cm and median of 2.9 cm. The larger apertures, however, are affected by dissolution, resulting in too high mean values. Many fractures are arrested or offset at layer contacts, indicating strong effects of the local stress fields on fracture propagation and the potential interconnectivity and permeability in the quarry. In many layers, however, there are fractures with various attitudes indicating that many fractures intersect and, for non-stratabound fractures, are likely to have reached the percolation threshold.