The anatomy of a fractured reef from Cyprus: a possible analogue for the Eastern Mediterranean carbonate reservoirs

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The core of the island of Cyprus hosts the inverted Troodos ophiolitic zone, whose flanks are overlain by autochthonous sedimentary rocks, mostly comprising Cenozoic-age carbonate shelf units. Some of these units are likely analogous to the Miocene part of the Levantine Basin “Zohr-like” carbonate buildup reservoirs, which are playing a dominant role in the present-day gas prospectivity and long-term potential for CO₂ carbon capture and storage in the Eastern Mediterranean.

The study location hosts a steep sided carbonate hill (c. 90 m elevation and about 0.35 km² total area. This hill corresponds to a lower Miocene shallow-water Terra Member carbonate buildup (Pakhna Formation), inclusive of a well-developed reefal biothermal fossil community at the summit. The buildup can be subdivided into four main depositional sub-units (informally called ‘beds’). Each of these approximately horizontal “beds” is about 5-20 m thick and hosts a number of near-vertical open fracture and minor fault sets, further enlarged by meteoric diagenesis. The lack of vegetation makes this a world-class example of shallow-water buildup available for geological analyses.

In this work, we have focused on the reservoir-scale physical properties and stratigraphic architecture of the reef outcrop, and in particular on the impact that the fracture and karst networks can be expected to play on the porosity and permeability properties of these rocks. We have utilized 133 drone photographs, subsequently “patched” together in a 3D Digital Terrain Model (DTM) using CMD-MVS; this software takes a series of pictures and creates a 3D point cloud from them thereby solving the problem of structure from motion (SFM). Several photographs have been additionally georeferenced and the visible fracture networks mapped in GIS. Furthermore, fieldwork analyses have been carried out and the following fracture properties measured at several representative locations utilizing linear scanline sampling and circular scanline methods: fracture orientation, aperture, spacing, length, intensity. Finally, representative samples have been collected from the field in order to measure their porosity and permeability properties.

Our analysis suggests the presence of a dominant fracture and fault set, striking approximately NE-SW to ESE-WNW. Additional relatively randomly-oriented, minor fracture sets are also present. Fracture intensity from the linear scanline method varies from 3 fractures per meter to the north-east to 6 fractures per meter to the south-west. The fracture aperture ranges from 0.01 to 1
meter. The studied shallow-water carbonate is characterized by high permeability and moderate porosity, with likely anisotropic flow properties along the main fracture sets. The presence of fractures enlarged by subaerial dissolutions is likely the key property controlling the reservoir parameters of these rocks, although further analyses are needed to find out whether such dissolution is associated with the present-day outcrop exposure to meteoric leaching, or was developed earlier on and can be reasonably expected in the subsurface.