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Mechanical stratigraphy in carbonate rocks: examples from the Maiella Mountain (central Italy) and the Granada Basin (southern Spain)

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In the subsurface, the containment and migration capacity of geofluids within carbonate rocks is strongly influenced by the different types of structural discontinuities (joints, pressure solution seams, compaction/shear bands) they contain. Such structural discontinuities may be localized or distributed in rocks according to the stress state under which they formed. Considering only distributed fractures, in the last decades several works documented, at different scales, a positive correlation between bed thickness and both mode-I (joints) fracture spacing and fracture length in layered carbonates. Only a few papers, however, assessed the role played by the compositional, depositional and diagenetical rock properties on fracture distribution. In this present contribution, by combining an integrated stratigraphic-structural approach at both outcrop and microscopical scales, we aim to provide more insights on this issues by presenting the results of a study conducted in two key areas, which are respectively located in central Italy (Maiella Mountain) and southern Spain (Granada Basin). Due to the excellent outcrops of layered bioclast-supported to mud-supported carbonate rocks present in these areas, a detailed documentation of the 3D fracture distribution can be carried out.

The fieldwork focused on the geological mapping at a 1:10.000 scale of the different carbonates present in the two study areas, on their detailed stratigraphic characterization, on the acquisition of their mechanical properties by mean of sclerometric analyses (in order to compute the Unconfined Compressive Strength, UCS, of the individual lithotypes) and, finally, on traditional fracture analysis. A careful sample collection of key hand specimens was also performed to perform, in the laboratory, optical microscope, cathodeluminescence and digital image analyses.

The results of this research allow us to quantify the relationships among the petrophysical rock properties, its compositions and the depositional environments in which they were deposited. These factors, together with the diagenetic evolution of the study carbonates, affected both their porosity and overall strength and, therefore, influenced the failure modes and fracture distribution. Summarizing the results, we assess that: (i) jointing was enhanced in carbonate rocks with UCS values > 55 N/mm2 (ii) spacing of joints perpendicular to bedding is positively correlated to the bed thickness; (iii) pressure solution was strongly enhanced by small amounts of clay (2-3% in volume) and good sphericity of carbonate grains; moreover, the dissolution processes took place in carbonate rocks characterized by UCS values comprised between 45 and 50 N/mm2; (iv) compaction/shear banding occurred only in porous grainstones (porosity > 10%,UCS values < 45 N/mm2) with peculiar pore types and distribution (and predominance of skeletal grains).