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Preliminary results of the microstructural and textural characterization of compaction bands affecting four porous carbonate formations

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Based upon the nature and organization/shape of the constituting elements (grains, pores, cement, minerals etc.), which are strongly related to the depositional setting, and in relation to their diagenetic evolution, carbonate rocks are characterised by a wide range of porosity (f). The progressive burial of calcium-rich sediments, subsequently to deposition, is responsible for the progressive change of the boundary conditions (i.e. stress field, pressure and temperature, fluid composition) controlling the diagenetic processes. The interplay among the different boundary conditions and the resulting rock rheology is responsible for the development of tectonic structures within the lithified sediments. These structures may be sub-horizontal in origin, parallel to bedding and orthogonal to the loading vertical axis. In this case, the bed-parallel loading-related tectonic structures are, mechanically speaking, anti-cracks consisting in pressure solution seams, in low-f [U+F020] carbonates, and/or compaction bands in high-f carbonates.
Concerning bed-parallel compaction bands, a few papers recently documented these elements in carbonate rocks. By integrating field observations and laboratory analysis, this study aims to identify and characterize the microstructure and texture of bed-parallel compaction bands present in four different porous carbonates formations, Orfento, Bolognano, Ragusa and Favignana's carbonate grainstones, respectively. These carbonates are characterized by different ages, depositional settings, diagenetic and tectonic histories.
The Orfento Formation, late Cretaceous in age, crops out in the Majella Mountain of central Italy. This formation consists of a carbonate grainstone with a porosity of about 30% and a maximum overburden comprised between 700 and 1200 m. The Bolognano Formation, Miocenic in age, also crops out in the Majella Mountain. The lower member of this formation is made up of a carbonate grainstone with a porosity ranging between 20 and 30% and maximum overburden of about 1000 m. The Ragusa Formation, Miocenic in age, crops out in the Hyblean Plateau of Sicily. This formation is comprised of a carbonate packstone with around 14% of clay content and a porosity comprised between 10 and 35%. The maximum overburden of the Ragusa Formation is comprised between 200 and 450 m. The Lower Pleistocene carbonate grainstones of Favignana, offshore Sicily, are characterized by a porosity comprised between 30 and 50% and almost no overburden (up to 30 m).
Notwithstanding the compositional, textural and petrophysical differences among the studied carbonate host rocks, we document bed-parallel compaction bands that display, in the field, similar morphological and geometrical characteristics. These characteristics, previously identified as typical for deformation bands, are the positive relief, a lighter color with respect to the host rock, both "bridge" and "eye" structure, and a zonal occurrence. In this work we present the preliminary results of microstructural and textural analyses carried out on thin sections obtained from representative samples of compaction bands collected from each carbonate formation.
Based upon the results of our detailed textural analysis, we document both grain and pore size variations within the compaction bands with respect to the parental rock. All the analyzed bed-parallel structures are characterized by lower values of porosity relative to their surrounding host rock, with values down to about 0% (2D observations). The grain size reduction is mainly due to inter-granular pressure solutions, which is predominant in the Orfento Formation. Due to their petrophysical properties, bed-parallel compaction bands should determine a significant heterogeneity and vertical anisotropy in both seismic velocities and hydraulic properties of granular carbonate rocks. On this regard, by mean of detailed density analysis at thin-section scales, we are currently investigating the amount and distribution of stylolites within bed-parallel bands. Preliminary results show that stylolites postdate the bands, which is therefore consistent with a localization of pressure solution controlled by the compactive mechanism due to overburden.