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Faulting in porous carbonate grainstones

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In the recent past, a new faulting mechanism has been documented within porous carbonate grainstones. This mechanism is due to strain localization into narrow tabular bands characterized by both volumetric and shear strain; for this reason, these features are named compactive shear bands. In the field, compactive shear bands are easily recognizable because they are lightly coloured with respect to the parent rock, and/or show a positive relief because of their increased resistance to weathering. Both characteristics, light colours and positive relief, are a consequence of the compaction processes that characterize these bands, which are the simplest structure element that form within porous carbonate grainstones. With ongoing deformation, the single compactive shear bands, which solve only a few mm of displacement, may evolve into zone of compactive shear bands and, finally, into well-developed faults characterized by slip surfaces and fault rocks. Field analysis conducted in key areas of Italy allow us to documented different modalities of interaction and linkage among the compactive shear bands: (i) a simple divergence of two different compactive shear bands from an original one, (ii) extensional and contractional jogs formed by two continuous, interacting compactive shear bands, and (iii) eye structures formed by collinear interacting compactive shear bands, which have been already described for deformation bands in sandstones. The last two types of interaction may localize the formation of compaction bands, which are characterized by pronounced component of compaction and negligible components of shearing, and/or pressure solution seams. All the aforementioned types of interaction and linkage could happen at any deformation stage, single bands, zone of bands or well developed faults.

The transition from one deformation process to another, which is likely to be controlled by the changes in the material properties, is recorded by different ratios and distributions of the fault dimensional attributes. The results of field analysis are consistent with length (L), displacement (D) and thickness (T) of single compactive shear bands clustering around given values, peculiar to the individual lithologies, and does not point out to any scale relationship among these parameters. On the contrary, in zones of shear bands and well-developed faults the D values are maximum in the central portion of individual elements. Differently from what characterize the well-developed faults, in which the slip increments are solved along the main slip surfaces, within zones of compactive shear bands the displacement varies according to the number of individual single bands, so that an increased displacement is related to an higher number of bands. As a consequence, the T-D plot concerning zones of compactive shear bands and well-developed faults show two different populations, which suggest that well-developed faults are much efficient to resolve displacement, with respect the zone of shear bands, because they include sharp slip surfaces. The petrographical and petrophysical properties of the tectonic features described above, which have been assessed by mean of detailed laboratory analyses, are consistent with the single compactive shear bands and zones of shear bands behaving as seals for underground fluid flow with respect to the host rock. These features, strongly present within the fault damage zones of well-developed faults, may compartmentalize the fluid flow in faulted carbonate reservoirs.