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The role of mechanical stratigraphy on the refraction of strike-slip faults

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Fault and fracture plane refraction within multilayer systems is widely reported in literature for high-angle normal faults. Here, we describe instead the effects of stress refraction upon faults developed within a compressional strike-slip regime. Strongly refracted sinistral strike-slip faults within the mechanically layered turbidites of the Marnoso Arenacea Formation (MAF) of the Italian Northern Apennines help to better understand the processes of fracture nucleation, propagation and overall mechanical behaviour within multi-layered sequences. The MAF is characterized by an alternation of sandstone (strong) and carbonate mudstone (weak) layers. The refracted faults developed due to overall NNE-SSW shortening and post-date almost any other observed structure except for a set of late extensional faults. Paleostress analysis excludes the possibility that the present attitude of the refracted faults results from rotation through time. The studied faults display the coexistence of shear and hybrid (tensile-shear) failure modes, and developed as shear fractures (mode II) within the weak layers and as dilatant fractures (mode I-II) within the strong layers. The dilatant components are invariably characterized by the presence of blocky calcite infill, almost completely absent in the shear fractures affecting the weak layers, confirming the already recognized importance of preferential fluid migration along the $\sigma2$ direction in this kind of structures.
Detailed field mapping and structural characterization help us to conclude the following:
- Mode I and II fractures are preserved at different scales (from a few metres up to several tens of metres), but become progressively less evident with larger amounts of displacement (i.e. in more mature faults), where shear fractures become dominant;
- Dilatancy and offset in sandstone layers tend to increase with increasing layer thickness;
- Sandstone layers < 5 cm thick behave mechanically like the weak mudstone layers and are cut by shear fractures without noticeable dilation;
- In weak mudstone layers, the angle between shear fractures and bedding decreases with the increasing thickness of the mudstone beds;
- Contrary to refracted normal faults and Hill-type meshes, the studied faults appear to nucleate within the weak layers and only successively propagate through the strong layers, where they localize at first as branching shear fractures, then as dilatant fractures.

Ongoing numerical modelling with FLAC software (ITASCA Consulting Group) supports most of the field observations and is expected to give more constraints upon the mechanical parameters steering the failure processes and on the highly variable and locally transient orientation of the stress field during deformation.