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Polygonal deformation bands in sandstone

Marco Antonellini and Pauline Nella Mollema

Department of Biological Geological and Environmental Sciences, University of Bologna, Bologna, Italy (m.antonellini@unibo.it)

We report for the first time the occurrence of polygonal faults in sandstone, which is compelling given that layer-bound polygonal fault systems have been observed so far only in fine-grained sediments such as clay and chalk. The polygonal faults are dm-wide zones of shear deformation bands that developed under shallow burial conditions in the lower portion of the Jurassic Entrada Fm (Utah, USA). The edges of the polygons are 1 to 5 meters long. The shear deformation bands are organized as conjugate faults along each edge of the polygon and form characteristic horst-like structures. The individual deformation bands have slip magnitudes ranging from a few mm to 1.5 cm; the cumulative average slip magnitude in a zone is up to 10 cm. The deformation bands heaves, in aggregate form, accommodate a small isotropic horizontal extension (strain < 0.005). The individual shear deformation bands show abutting T-junctions, veering, curving, and merging where they mechanically interact. Crosscutting relationships are rare. The interactions of the deformation bands are similar to those of mode I opening fractures.

Density inversion, that takes place where under-compacted and over-pressurized layers (Carmel Fm) lay below normally compacted sediments (Entrada Sandstone), may be an important process for polygonal deformation bands formation. The gravitational sliding and soft sediment structures typically observed within the Carmel Fm support this hypothesis. Soft sediment deformation may induce polygonal faulting in the section of the Entrada Sandstone just above the Carmel Fm.

The permeability of the polygonal deformation bands is approximately 10-14 to 10-13 m2, which is less than the permeability of the host, Entrada Sandstone (range 10-12 to 10-11 m2).

The documented fault networks have important implications for evaluating the geometry of km-scale polygonal fault systems in the subsurface, top seal integrity, as well as constraining paleo-tectonic stress regimes.