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Joints initiation as dilatancy bands: Insights from experiments and field evidencing.

Jean-Pierre Petit (1), Alexandre Chemenda (2), Si-Hung Nguyen (2), Julien Ambre (2), and Cédric Jorand (2)

(1) Géosciences Montpellier, Université Montpellier 2, Montpellier, France, (jean- pierre.petit7@wanadoo.fr), (2) Géoazur, Université de Nice-Sophia Antipolis, CNRS, France (chem@geoazur.unice.fr)

The mechanical origin of joints has been debated for nearly a century. The present day widely accepted interpretation is done through the fracture mechanics approach: joints are seen as mode I fractures initiating form defects. They propagate with the separation of the fracture walls due to strong stress concentration at the fracture tips under remote tensile stress. In this view, joints propagate as open fractures and the plumose structures or hackles (these terms cover a wide variety of diverging fractographic features) are believed to result from the fracture front breakdown due to the loading mode change (the origin of this change remains not clear). This view is not consistent with the results of extension tests conducted on a synthetic physical rock analogue (granular, frictional, cohesive and dilatant) material GRAM1 (Chemenda et al., 2011). Within a certain range of mean stressσ, two types of discontinuities/fractures perpendicular to the least (axial) stress were obtained. The mode I cracks form at very low σ and at the least stress at fracturing σ_3^{ax}around the tensile strength of the materialσ_t. These fractures have smooth wall surfaces and do not bear the expected plumose features. Conversely, the *postmortem* opening (separation of the walls) or the discontinuities obtained at higher $\sigma$and slightly tensile or even compressiveσ_3^{ax}values, exhibit faint/delicate plumose patterns strikingly similar to those on the geological joint walls: Being formed far above $-\sigma_t$, they cannot correspond to a mode I rupture. The SEM examination of section of unopened discontinuities revealed a steady structure of dilatancy (dilation) band with a heterogeneous porosity increase over a width of several grains. Similar structures at SEM scale have been found in the dolomicrites (fine grained dolomitic rock) of the hettangian "cubic dolomite" of the Larzac plateau border (South of France). We examined very discreet traces (parallel to plumose bearing systematic joints) corresponding to embryonic (not open yet) joints. As in GRAM1, the dolomicrite shows a porosity increase along a band. Dilatancy is expressed by dolomite grain decohesion and separation within the band whose thickness is of several grain diameters. There are two main reasons for which such natural bands were not detected previously: (1) the band tend to open during exhumation (it is a zone of weakness) leading to the separation of the two walls with destruction of the dilatancy band texture and mineral infilling; (2) if no opening occurs, as soon as he band is formed, diagenetic/epigenetic processes can rapidly cancel the initial structure, the trace of the band appearing a great magnification as a tiny mineralized vein. Such transformation must be very frequent in sedimentary rocks, but it can be absent when the mineral solubility is limited as for the presented dolomicrite example. These observations support the idea that natural joints could form following two different mechanisms: (1) as closed propagating dilatancy bands at high pressure (depth) conditions, evolving towards true fractures with separation of plumose bearing walls. We propose to call such extension fractures "dilatancy joints"; (2) as "mode I joints" characterized by smooth surface forming in shallower conditions under tensile effective stress approachingσ_t.