

Solid Earth Discuss., referee comment RC2
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Comment on se-2021-39

Ben Laurich (Referee)

Referee comment on "Micromechanisms leading to shear failure of Opalinus Clay in a triaxial test: A high-resolution BIB-SEM study" by Lisa Winhausen et al., Solid Earth Discuss., <https://doi.org/10.5194/se-2021-39-RC2>, 2021

REVIEWERS' COMMENTS

The authors present a sketch of a grain-scale deformation model for Opalinus Clay based on one sample that has been deformed in a triaxial test and whose postexperimental microstructure was analysed using broad-ion-beam scanning electron microscopy. Figures show the strain-stress evolution of the sample failure (shear / mixed mode), detailed micrographs and a generalized scheme that comprises the author's findings.

The main finding is that the laboratory deformed sample developed dilational bands, while such a feature has not been reported for naturally faulted samples of the same material. It suggests that at least in the early evolution of shear of OPA there is an increase in porosity and permeability.

The second finding is that there are microstructural indicators for ductile behaviour. Foremost bending of elongated clay grains.

General appreciation

The manuscript is short and yet comprehensive. It is well structured, the English is good. The origin of all presented data is mostly clear and exceptionally well visualized.

Hence, I suggest to accept this manuscript with minor changes.

A detailed, line-by-line review with additional comments can be found in the attached word file.

Main critical points:

- Although dilation bands in OPA are shown for the first time, the finding of high permeability in the early strain evolution is not a novel finding. Veins along fractures in the so-called Main Fault of the Mont Terri Rock Laboratory have long been reported as indicators for paleo-fluid flow by numerous authors (see attached word file). This should be addressed.
- The use of the term "ductile": The stress-strain curve shows bulk brittle behaviour, yet there are two indicators for an uncritical strain evolution in parts of the sample: (1) bend and delaminated clay grains as well as (2) finely distributed brittle shear within deformation bands / cataclastic flow. These three scale-depended phenomenon (bulk, grain-scale and deformation band-scale) could be better distinguished and elaborated more. For each occasion of the term "ductile": To what scale does this refer to? Optional it could also be addressed: At what condition (P, T, strain rate) might a rather stiff mica grain bend? At what condition does a calcite grain break? At what condition does sub-critical fracture growth happen instead of seismic fracturing?
- Terminology: There is a little inconsistency in the use of deformation band, deformed zone, strain zone, shear zone, fracture and crack. I gave some suggestions on how to improve that in the world file. From du Bernard (2002), there is the term "dilation band", too.
- A statement on subsample positioning is missing. Might there be a spatial relation on strain localization and strain rate to the subsample position? The crack likely nucleated at the sample center, where there is a high abundance of fractures, that distribute the bulk strain while at the sample edge there is only one fracture. Has brittle deformation started once that first single fracture reached the samples' edge to create one sample through-going, cohesionless discontinuity? Might a shear zone at the samples' edge represents a more brittle deformation, while a shear zone from the samples' center might have preserved more of the prior-to-failure, uncritical fracture growth microstructure? A subsample off-center in the middle, such as in Fig. 6 providing insight in the most less and slowly strained shear zones?
- The title could be shortened, see attached word file

I do not wish to remain anonymous and wish the authors good luck for the publication of this nice work.

Please also note the supplement to this comment:

<https://se.copernicus.org/preprints/se-2021-39/se-2021-39-RC2-supplement.zip>