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Interactive comment on "Permeability and seismic velocity anisotropy across a ductile-brittle fault zone in crystalline rock" *by* Quinn C. Wenning et al.

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We would like to thank Telemaco Tesei for thoroughly reading and commenting on our paper. The comments have improved the previous manuscript. The comments from the reviewer are included with our 'Author response.' Where appropriate we have made changes in the manuscript, which are commented and highlighted in the attached PDF (Reviewer Comment 1 are also included). For justification see the 'Author response' associated with each comment below:

Review 2

Wenning et al. present a solid dataset about permeability and elastic properties of core rock materials coming from a shear zone in an underground research facility, with the aim to better understand seismic properties and potential for exploitation of such shear zones. The paper is well written, and combines some microstructural work with solid laboratory measurements of permeability and seismic wavespeeds. 1. My only major comment on this manuscript is with regard to the terminology used to present the data. The manuscript is presented, in particular in the abstract, as a study of brittle fault zone overprinting a ductile shear zone. Judging from the microstructures presented in figure 2 and from the location of samples in figure 1, measurements were performed only on cores of a ductile shear zone rather than a brittle fault (i.e. on mylonites and ultramylonites). The authors often refer to ultramylonitic shear bands as "fault core" and mention the importance of inheritance of ductile structures on brittle structures. It is true that localized small scale fracturing, possibly concomitant with hydrothermal alteration and dissolution-precipitation mechanisms, may have acted during the exhumation of the shear zone in the so-called "transition zone" TZ. However the shear zone appeared to be essentially ductile, with only a late reactivation as a brittle fault in the zone named "DZ" within the ultramylonites. DZ rocks, i.e. the only clearly brittle rocks presented, were not characterized in this study, which in turn focused on essentially purely ductile shear zones. Therefore the brittle overprint, supposedly influenced by ductile structures, were not investigated. The conceptual model of the shear zone is correctly depicted by the authors in the discussion section, however I think that they should clearly term the ultramylonites "shear zones" and not fault cores, and avoid using the common terminology of brittle faults, to avoid confusion in the readership. The think that the title may be misleading in the same way. Something like "permeability and seismic velocity anisotropy of ductile shear zones enveloping a brittle fault" would be more appropriate, I reckon.

Author Response: We are in agreement that a change in terminology is in order. We have chosen to change the previously named mylonitic fault core (MFC) to simply mylonitic core (MC). By removing fault, we remove association to brittle deformation. We choose to keep the term 'core' since the transition zone and mylonitic core are all part of the whole shear zone (as depicted in Figure 1c). We acknowledge the suggestion for the title change, but feel that the current title will reach a broader audience studying ductile-brittle transitions.

A part from this point I have only a few other minor comments on this manuscript (below) and I think this should be accepted for publication after minor modifications. Telemaco Tesei (Durham University)

2. Minor Comments P=page L=line P1, L15-16: a few references could be appropriate here.

Author response: The two references in the previous sentence serve as the foundation for this paragraph, and the following paragraphs describe in detail the work that has been done. We changed the references to read (see reviews: Sibson, 1994; Faulkner et al., 2010) in the sentence before as opposed to 'e.g.' in the previous sentence.

3. P2, L16-17: a couple of references to mechanical/geological studies of reactivation of previously ductile faults/materials: Bolognesi, F. and Bistacchi, A., 2016. Weakness and mechanical anisotropy of phyllosilicate-rich cataclasites developed after mylonites of a low-angle normal fault (Simplon Line, Western Alps). Journal of Structural Geology, 83, pp.1-12. Donath, F. A., 1961. Experimental study of shear failure in anisotropic rocks. Geological Society of America Bulletin, 72(6), 985-989, doi:10.1130/0016- 7606(1961)72[985:ESOSFI]2.0.CO;2.

Author response: We agree, these references has been added.

4. P3, L1: are these two shear zones "ductile"? Or are they clay-rich fault cores/principal slip zones?

Author response: They are ductile. Added "foliated ductile shear zones"

5. P4: L13 "boundaries".

Author response: corrected the spelling error.

6. P4 L 24: I would make another reference to figure 2 here.

Author response: made the reference to figure 2.

7. P5, L4: I would state clearly state the dimensions of the core here (or add a table, but it is impractical to read), before saying that they are not suitable for deformation experiments or seismic velocity experiments, and therefore only permeability measurements were performed on these samples. P5, L7. the samples size mentioned here suggest that for some samples the length/width ratio may be between roughly 1 and 2, contrary to previously stated

Author response: The paragraph was reordered and reworded to make this point clearer and follow additional recommendations from 'Reviewer Comment 1:'

New paragraph: In order to determine the spatial relationship of the physical properties in the shear zone a continuous set of samples was cored every 0.1 m in the transition zone from 19.6 m to the boarder of the first MFC at 20.1 m. Abundant fractures in the damage zone between the two MFCs prevented continuous coring. Two mutually perpendicular core samples, one parallel (x1) and one perpendicular (x3) to the Grimsel granodiorite foliation were taken to characterize the physical property and anisotropy changes as a gradient away from the fault core. Sampling farther than 19.5 m was not possible due to previously made overcoring stress measurements (Figure 1c). In order to optimize the number of samples, the x1 direction was taken $\sim$15 degrees off axis from the lineation (Figure 1d). Foliation perpendicular samples could not be taken at 19.5 and 20.1 m because of breaks in the core. The x1 and x3 samples were bored out of the core using a diamond drill bit ($\sim$2.54 cm inner diameter) with water as the cooling fluid. The 2.49 to 5.56 cm long samples were grinded and polished to craft parallel ends. To characterize the MFC, parallel and perpendicular to foliation samples were taken at 20.2 and 23.6 m, respectively. A maximum length ($\sim$ 2.49 cm) to diameter ($\sim$ 2.53 cm) ratio of approximately 1:1 in the MFC samples, due to the extremely fissile nature of these rocks. Additionally, these two samples come from separate but similar MFC at the base of the borehole due to limited sample material. Since the seismic velocity measurements require longer samples due to signal noise and wave propagation issues, the MFC samples are only long enough to perform only permeability measurements. Additionally, two sets of perpendicular samples were taken 5 and 7 m from the start of the borehole as a background Grimsel granodiorite reference.

8. P8, L2. The “void” is strange in this sentence. I would simply say “lack of ” or “don’t have” open microcracks.

Author response: changed to “. . . the samples do not have visible open microcracks,. . .”

9. P8 L10: indicate that. . .

Author response: we prefer “. . ., indicating hydrothermal alteration occurred.”

10. Figure 1: “Mapped” is spelled wrong in the inset of Fig. 1A.

Author response: Good catch, it is now corrected.

11. Figure 3: in the caption, mention the experimental conditions, in particular the effective confining pressure.

Author response: Added the measurement conditions to the figure caption.

12. Figure 4 caption: mention which core the measurements are taken from, and at which experimental conditions.

Author response: Added that the depth corresponds to the sample name in Table 2.

Please also note the supplement to this comment:
https://www.solid-earth-discuss.net/se-2018-15/se-2018-15-AC2-supplement.pdf

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