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Solid Earth Discussions

Interactive comment on "Magnetic properties of pseudotachylytes, Jämtland, central Sweden" *by* Hagen Bender et al.

Hagen Bender et al.

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Dear editor and reviewers,

Here we address the comments raised by the two reviewers of the manuscript. Our answer to a comment is bounded by dashed lines, to make it easier to separate comment and question. Significant changes have been made to the manuscript, in order to attempt clarification of the objective and message of the paper. We have also made a change to the authorship list, whereby Bjarne Almqvist is now listed as lead author and Hagen Bender is the second author. This change in authorship has been approved by all authors of the manuscript.

The title of the paper has changed to: "Magnetic properties of pseudotachylytes from

western Jämtland, central Swedish Caledonides"

Thank you for your consideration. Bjarne Almqvist and Hagen Bender ——————

Anonymous Referee #1 Received and published: 9 September 2019 In its present shape, the manuscript requires major revisions before being possibly published in Solid Earth. What is the message of the paper? The objectives are not clear at all. The structural analysis is confused and the conclusions are neither exciting nor convincing.

—————— The objective of the study was originally to obtain detailed kinematic information on faulting that had occurred in the internal part of the Köli nappe in the central Swedish Caledonides. However, the study did not end up with a clear-cut answer in response to the initial goal that was set. This is part of the reason why the message and objective do not appear clear. However, we believe that we make observations of magnetic properties and fabric of the pseudotachylytes that are of general interest and can benefite other researchers that are targeting magnetic fabrics in pseudotachylytes. We have attempted in the revised manuscript to elucidate the objective of the study and make it clearer what the message of the paper is.

In the study of magnetic fabrics there is an inherent challenge in measurement of small samples, which is highlighted. Unfortunately, we cannot do much about the data itself. Despite this issue we would like to stress that we do obtain meaningful magnetic fabrics, which correspond to the structural reference frame (i.e., foliation and lineation). ——————

Although I am not a specialist of rock magnetism, the same can be said regarding the magnetic analysis (see below).

1/ Comments on structural analysis As a structural geologist and regular reader of Solid Earth, I am disappointed by the structural analysis of pseudotachylyte-bearing fault zones presented here. Particularly, shear senses are poorly constrained and explanations are somewhat confusing. Clarification and reformulation are needed. ——

———

We have tried to accommodate the comments, criticisms and suggestions of the reviewer in order to improve the manuscript. The shear sense is unfortunately not known.

———

The pst (pseudotachylyte) macroscale is somewhat disappointing. Photographs are scarce and poorly informative. PST microscale description is confused. Pst microscale description should consist of a description of matrix, newly crystallized minerals, survivor clasts and other specific features (sulfide droplets, flow folds and so on). Lines 32-34 : why is it important to compare the pst data with kinematic data from post-orogenic extensional faults?

——— We have added text to this sentence to indicate that it is of relevance to understand the relationship between the late orogenic stage top W extension and the formation of brittle deformation pseudotachylytes.

——— Lines 65-69 : the authors state that ''mylonitic shear sense indicators : : : were not observed". Can this missing information be found in the literature? How can the authors discuss the evolution of the nappe complex (with in-sequence and out-of-sequence thrusting and so on) if the early kinematics are unknown?

——— We have added text to indicate that shear sense indicators in mylonites have been mapped regionally by Bender et al. (2019) in the lower and middle Köli nappe. In addition, there is a body of work, including Bender et al. (2018) that show dominant top to E shear sense indicators, which prompted the the out-of-sequence thrusting model.

———

Lines 72 and following. Fractured fault rocks are not fault rocks, they are usually referred to as ''fractured host rock" or fractured protolith". My feeling is that altered pst should not be distinguished from unaltered pst in the fault rock catalog, since formation

is the same for both psts.

——— We have changed the wording to "fractured host rock". The pseudotachylyte rocks have been grouped together now as suggested by the reviewer, but we make distinctions between preserved and altered pseudotachylyte, as this is important for further working with the properties of the pst.

———

Lines 79-80 : ''Deflection: : : respectively" : this sentence is confusing. No photograph of the structures used for establishing the sense of shear. What injection vein asymmetry do the authors refer to?

——— This sentence has been removed in the revised manuscript

———

Lines 81-84 : what are these N-S faults? Do they cross-cut the thrust-sheet bounding faults? More generally, what is the relationship between pst and pst magnetism and those late-stage high-angle normal faults???

——— We have added text to the end of this paragraph to indicate the likely origin of these N-S striking faults. They are likely late structure that cut across the thrust-sheet bounding faults.

———

Line 160 : what is the meaning of the sentence ''Only : : : pseudotachylyte"?

——— We have removed this sentence and added a sentence in section 3 on the pseudotachylyte terminology. The reason for the original statement is that for the rocks that are investigated it was not initially clear that they were pseudotachylyte.

———

Lines 165-166: is calcite a secondary, newly formed mineral? If yes, it is not a survivor

clast. Please clarify. It seems that calcite has nothing to do with pst formation. It should be described separately from psts. And what is the usefulness to describe calcite that has nothing to do with pst as well as with pst magnetic properties???

——————— We have rewritten this sentence and indicate that calcite is most likely a survivor clast. We describe the presence of calcite for completion of the description of the fault rock microstructure and petrography.

——————— Line 170 : could it be sanidine?

——————— We have noted that this could potentially be sanidine or anorthoclase, and made reference to a paper by Lin (1994), where K-feldspar microliths were identified in glassy pseudotachylyte.

———————

2/ Comments on magnetism analysis Given the poor quality of the manuscript, I cannot spend time checking the magnetic side of the analysis presented in the manuscript. Data look scare and poorly understood. Conclusions are not exciting. The authors fail to apply the Ferré et al analysis leading to the reconstruction of focal mechanisms of pst-generating earthquakes.

——————— Yes, in this study we fail to apply the method of Ferré to reconstruct direction and sense of seismic slip. However, we believe we make some interesting observation that may be of use to other researchers working in this topic. We believe that a valid question that can be considered from this study, where more than 100 samples were studied in a detailed, systematic and careful way, is why the method failed to provide an answer on the fault kinematics? Perhaps the obvious answer is that the samples used in the study were not suitable for kinematic analysis (even though the magnetic fabric reflect the petrofabric), and this may be a useful result as well. . .

———————

Line 282: What is the meaning of this sentence ‘’Fault vein margins: : :fault zone”.

What does ‘’Seismic faulting in these veins” mean? The remaining part of this section (lines 283 to 296) is confusing and should be seriously reconsidered.

——————— We have rewritten the first two sentences of this paragraph to make the meaning of the sentences clearer (the sentences are used to place the magnetic results in perspective to the structural results). The remainder of the paragraph has been rewritten to improve the clarity of the text.

———————

3/ Phrasing concerns Line 36 : what is a magmatic assemblage in a pst? I would use ‘’neoformed” or newly crystallized” or something like that since a pst is not exactly a magmatic rock.

——————— We changed the phrasing to “newly crystallized”

———————

Line 37 : delete ‘’commonly”.

——————— done

———————

Line 58 : What is a calcareous volcanic rock?

——————— The word ‘calcareous’ has been removed

———————

Line 60 : I cannot understand the meaning of ‘’their strike follow the shape of the synform”. Please reformulate.

——————— We have reformulated this sentence and hopefully made it clearer

———————

Line 66 : the lineation is not carried by biotite and boudinaged amphibole, it is carried

by a foliation.

——————— The sentence has been rephrased to indicate that the orientation of biotite and amphibole crystals in the foliation plane show the lineation

———————

Line 91 : add ‘’to” after ‘’parallel”.

——————— done

———————

Line 97 : replace ‘’is” by ‘’are”.

——————— done

———————

Line 146 : I do not like ‘’Microstructural appearance of host and fault rocks”. Better use more accurate words.

——————— The headline of the section has been changed to “Microstructural description of host and fault rocks”

———————

Line 148 : I do not feel confortable with ‘’porphyroblastic biotite”. Porphyroblasts commonly consist of feldspar, garnet, staurolite and so on. I doutd that biotite can form prophyroblats.

——————— We have changed the wording to ‘Large biotite crystals’, in order to avoid the terminology related to porphyroblasts.

———————

Line 152 : Which cataclastic fault rock do you refer to?

——————— It is unclear to us here what the reviewer means about the cataclastic fault rock in this text line. The paragraph itself describes the host rock microstructure and petrography.

———————

Line 162 : I would replace ‘’partial melting” by ‘’melt corrosion”.

——————— Changed to “melt-assisted corrosion”

———————

Lines 179-180 : the sentence is unclear and is redundant. 4/ Other issues A lot of references are cited in the text but miss in the list. Please complete.

——————— Missing references have been added.

———————

Photomicrographs are in some cases poorly legible. Some annotation or drawings could improve legibility. Captions are not helpful and should be reformulated. For instance, line 450. Caption of Fig. 3 is unclear. ‘’Figure 3. Macroscopic appearance of a foliation-parallel fault vein exhibiting different kinds of fault rock. For detailed description, see text. Characterization of fault rock types is also based on microscopic observations. The image represents the XZ plane of the ductile finite strain ellipsoid.” A fault vein consists of pst, not of different kinds of fault rocks. What the ‘’ductile finite strain ellipsoid”? Why not the brittle one? Psts are brittle structures.

——————— We have rewritten the figure caption of figure 3, to try to make it clearer. We have also look at other figure captions in order to make them more descriptive and helpful.

——————— Interactive comment on Solid Earth Discuss., https://doi.org/10.5194/se-2019-128, 2019.

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