

Interactive comment on “Myrmekite and strain weakening in granitoid mylonites” by Alberto Ceccato et al.

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General Comments Ceccato et al. use EBSD to characterize the microstructures of naturally deformed granodiorite mylonites from the middle crust, and based on these microstructures, they interpret a progression in activity of the deformation mechanisms that resulted in strain localization. They show that the nucleation of myrmekite resulted in a grain size reduction that ultimately produced phase mixing, leading to grain size sensitive deformation and effective strain localization. This work is an important contribution to our understanding of how quartzofeldspathic rocks deform in the middle crust where the rheology-controlling minerals of the crust (quartz and feldspar) undergo a variety of deformation mechanisms that are aided by metamorphic reaction and reaction with fluids. The microstructural data from the mylonites are of high quality and

C1

described adequately, and they use the deformation conditions of these mylonites to infer rheology from published flow law data. The deformation mechanism maps derived from flow law data allow them to interpret a temporal variation in deformation mechanisms and infer the magnitude of weakening based on differences in strain rates between the lesser-deformed granodiorite and the sheared myrmekite shear zones.

The manuscript would benefit from some substantial reorganization in three main areas: 1) the methods, 2) the figures, and 3) separation of data/interpretation. Regarding the methods: the methods (at least the basics) should be in the main body of the manuscript and not in the supplementary material. As written, there are not any methods in the main body. Some of the post-processing details for EBSD can stay in the supplementary material, but the instruments, working conditions, etc., need to be in the main text. Regarding the figures: there is a tendency for important and primary EBSD data to be relegated to supplementary figures, whereas the flow law derivation in the main body of the manuscript is extremely detailed, and much of it can be moved to the supplementary material for readers who wish to follow it in more detail. I recommend moving the supplementary figure EBSD maps out of the appendix, and incorporating them into the main set of figures within the manuscript. This is important because they are the primary data upon which the interpretations are made. My last point is that there are a number of interpretive statements located in the geologic setting and in the data sections; these should be clearly separated from descriptive data and moved to the discussion.

The writing seems a little rushed, and is not as polished as it could be for the results and interpretations to have maximum impact. Many paragraphs are lacking strong topic sentences, and are instead effectively callouts to the figures. Strengthening the topic sentence would make the results more impactful and easier to understand. In places there are phrases rather than complete sentences, or under-developed paragraphs consisting of one sentence. In addition, there is some awkward or convoluted phrasing, and there are, at times, little continuity of thought between sentences within a

C2

paragraph. The manuscript would benefit substantially from careful revision to address these issues.

I recommend that the authors make these revisions and also consider the more specific comments/recommendations (highlighted below) prior to publication.

Specific Comments: Abstract, Page 1, Line 11. Rephrase for clarity of reading: Here we use EBSD to investigate the microstructure of a granodiorite mylonite. . .

Page 1, Line 11. Is it important to focus the end of the sentence on weakening of coarse-grained pegmatite? It seems like a distraction given that the focus of the paper is not on pegmatites. It may be best to remove this last phrase so that the sentence is more focused on replacement being a weakening mechanism during ductile deformation, which will provide much more continuity with the next sentence about deformation and shearing of myrmekite.

Page 2, Line 14. There needs to be a stronger link between the sentence that ends with the Viegas et al. reference and the next one that starts with 'Fine grain size'. This should be done with the second sentence (i.e., 'Fine grain size. . .') so that the weak plag + qtz aggregate is explained as a result of phase mixing and ultramylonites. As written, it does not explicitly link phase mixing and ultramylonites to the samples targeted in this study.

Page 2, Line 16. Rephrase sentence to make it easier to read: Though the key role of myrmekite in strain localization has been recognized, it has not been accompanied with a quantitative analysis, etc. . .

Page 2, Line 18. The Introduction should be broken up into at least two paragraphs. Make a new paragraph starting with the sentence: 'Here we present the detailed analysis. . .' so that the objectives of the work are clearly separated from the background and disciplinary context.

Page 2, Lines 18-20. The sentence beginning with 'Here we present. . .' is awkwardly

C3

written, and needs to do a better job summarizing the findings of the work. As written, I am not sure if the authors wish to emphasize the two-fold nature of the work (e.g., 1) analysis of myrmekite evolution and 2) grain size reduction and strain localization), or if they mean to portray this as the temporal evolution of some process, i.e., starting with myrmekite evolution and finishing with strain localization in the mylonites. The problem hinges on the part of the sentence between the words 'quartz' and 'grain size'. There either needs to be a conjunction word between 'quartz' and 'grain size' (to? and?) because it's not grammatically correct as written. This is why it is difficult to understand whether 'grain size reduction' just applies to quartz, or to both quartz and plagioclase, and calls into question the intent of the authors.

Page 2, Lines 21-23. These sentences are confusing as written, making it hard to understand which mylonites are being studied. If the shear zones nucleate along joints filled with quartz and epidote, where is the K-spar coming from? Are there two types of shear zones, one set of SZs within the granodiorite and the other set in the quartz- and epidote-filled joints? Does one grade laterally into the other? Please revise for clarity.

Page 2, Line 5. I recommend you remove the word 'precursor'. It is implied that the joints are precursory by saying shear zones exploited them.

Page 3, Section 3. Sample description and microstructure. The writing in this section is a little disjointed, with abrupt changes between sentences. Some better linkage between sentences to provide a smoother train of thought would be helpful.

Page 3, Lines 6-9. The sentence beginning with 'Nucleation..' is effectively a comparison of the field descriptions with what has been documented in the literature for other locations. Such a comparative statement is best left to the discussion rather than in a section devoted to field description.

Page 3, Line 13. I think this section is a little incomplete. There is only a statement describing the shear zones for epidote-filled joints, but the authors state in the previous section that there are also quartz-filled joints upon which shear zones nucleate and

C4

also regular joints (no filling) that serve as precursors to shear zones. I recommend that the authors add field descriptions of the shear zones associated with quartz-filled joints and “plain” joints.

Page 3, Lines 15-16. Rearrange the sentence and break into two sentences for clarity: Polished thin sections of granodiorite mylonite were prepared for the study of microstructure and of crystallographic preferred orientation (CPO). The rock chips were cut parallel to the lineation and perpendicular to the shear plane (XZ plane of finite strain ellipsoid).

Page 3, Line 18. Specify which minerals were analyzed by microprobe.

Page 3, Line 20. The description of EBSD and electron microprobe methods and analytical conditions must be reported in the main body of the manuscript, not hidden in the Appendix.

Page 3, Line 22. The sentence beginning with ‘The magmatic plagioclase’ is awkwardly written, too long, and hard to understand. It reads like the oscillatory zoning has a range in composition rather than the plagioclase having a range in composition.

Page 3, Lines 24-28. The sentence beginning with ‘Various grain size reduction...’ is phrased in an interpretive rather than descriptive way. Please rephrase in terms of objective description to be consistent with the “Sample description and microstructure” section title.

Page 4, Line 2. There is too abrupt of a change when the data from Figure 2 are introduced. This should be another paragraph, or at least have some more explanatory text about the volume percentage data before it is introduced. Page 4, Line 7-8. Why isn’t there a photo of the ultramylonites included in Figure 1? All the rest of the mylonites described in this section have a corresponding picture, so this would be good to include for sake of completeness.

Page 4, Line 10. This section is under-developed. These sentences read like a table

C5

of contents rather than a data section. It should either be fleshed out into paragraphs where the data are explained, or this brief summary of figure content should be merged into the text in Section 4.1 onward.

Page 4, Line 17. Figure 7a is called out before Figures 3, 4, 5 have even been introduced. The figures should either be renumbered so that the call outs are in numerical order, or these out-of-order callouts should be removed. There is another error of this nature in Line 18 with respect to Figure 6a.

Page 5, Line 1. This sentence is strongly interpretive for a data section. It interprets the origin of the sheared myrmekite, but I suggest keeping the sample/microstructure description objective here and to wait for the Discussion to make the interpretation.

Page 5, Line 9. The callout refers to figure 6e, but there is no 6e (only a-d).

Page 5, Line 6. I find the figure callouts hard to follow here. We are flipping between Figure 4 and 6, without 5 being called out yet. Perhaps rearrange the figure order to keep it more organized.

Section 4.3. The paragraphs in this section are lacking strong topic sentences to lead the paragraphs, so that the data are a bit hard to follow. Revise such that a topic sentence gives a summary of the contents of the remainder of the paragraph so that the reader has an idea of what trends are being described.

Page 5, Line 28. Only (100) and (010) are planes. The [001] data are directional and should be described as such.

Page 7, Line 6. “Phase spatial distribution...” This sentence is interpretive and the importance of that interpretation is discussed in the next few sentences. I agree this is important, but the interpretation and its importance in a disciplinary context should be in the discussion rather than in the data section.

Page 10, Lines 15-18. Are these differential stresses calculated from grain size piezometry? How are the strain rates calculated? The delivery of the stress values and strain

C6

rates is not thorough enough here; if grain size piezometry is an analysis taken on in the work, it needs to be explicitly stated.

Page 10, Line 24. There is something grammatically incorrect about this sentence; revise to clarify what is meant by the last phrase.

Page 10, Section 6.3. In the interest of brevity, it might work well to put some of the flow law derivations and calculations into the supplemental online material.

Page 11, Line 11. It is worth noting here that this is a wet plagioclase flow law, and it would be good to quote the amount of water present in these experiments.

Page 15, Lines 5-6. There needs to be a stronger topic sentence than the one that begins Section 6.3.1. As written, it's essentially just a callout to Figure 8, but a more powerful topic sentence would give better direction to the paragraph. The sentence should instead focus on the primary results of the deformation mechanism maps.

Page 15, Line 26. The authors state that they consider both constant stress and constant strain rate conditions, but are there any geologic data from the mylonites that support these assumptions about constant stress/strain rate? This should be justified or explained in a little more detail.

Technical Corrections: Abstract Line 14. Plagioclase of in pristine myrmekite.. Intro Line 12. ...shearing of myrmekite results into in a a fine-grained... Intro Line 18. Add comma after 'myrmekite-derived'. Intro Line 29. 'Flow-laws' should not be hyphenated. Intro Line 30. Use present tense (allows) instead of past tense for the verb 'allowed'. Page 3, Line 1. Add the word 'was' before 'emplaced'. Page 3, Line 19. 'Mineral abbreviations after Kretz' is not a complete sentence and should be revised. As written, it reads more like a figure caption than the main body text of a manuscript. Page 3, Line 21. Please make a new paragraph beginning with the sentence 'The Rieserferner granodiorite...'. Page 3, Line 28. Add the word 'a' between the words 'makes' and 'transition'. Page 3, Line 29. Substitute the word 'extending' for the word 'extended'

C7

to make the sentence correct. Page 8, Line 3. Insert the word 'is' between 'what' and 'reported'. Page 9, Line 1. 'myrmekite show' should be 'myrmekite shows'. Page 10, Line 23. This should read 'different contributions' rather than 'different contribution'. Page 13, Line 1. Remove the hyphen between 'two-rheological'. Page 13, Line 2. Place the adverb (iteratively) before the verb (applying). Page 13, Line 7. The word 'follow' should be replaced with 'follows'. Make this same correction in Lines 11 and 13 and on Page 14, Line 4. Page 14, Line 2. This should read 'is composed of' rather than 'is composed by'. Page 14, Line 4. The word proportion should be replaced with 'proportions'. Page 14, Line 4. Reorganize the last part of the sentence like this: 'are then calculated as follows, respectively'. Page 14, Line 27. Change the capital A in the word 'All' to a lower-case a. Page 15, Line 23. Delete the word 'occur'. Page 16, Line 8. The article 'the' should be placed between the words under and constant in the phrase 'Under constant strain rate assumption...'. Page 16, Line 10-11. This should read: 'Strain rates on the order of...'.
Figure 1: Figure 1a: Label the minerals with the abbreviations qtz, bt, etc., to support the caption and to match Figure 1b. Figure 1c: label the myrmekite directly on the figure. Figure 1d: the caption refers to K-spar, but only plagioclase is identified here. Is this the correct figure? Figure 1f: why is the note about CL image after EBSD scan included? There is no EBSD map area labeled here, so it's hard to understand where in the figure the reader is supposed to look for this. Furthermore, is this an important and necessary point to include? Consider deleting if it's not central to the story.

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Figures SOM1-5. These figures are commonly called out in the text and contain important primary data, so they need to be in the main text with the rest of the figures rather than in supplementary materials. These maps are more insightful on process than just the phase maps in the standard figures, so this is an important change to make.

Interactive comment on Solid Earth Discuss., <https://doi.org/10.5194/se-2018-70>, 2018.

C8