Solid Earth Discuss.,
https://doi.org/10.5194/se-2018-70-AC2, 2018

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

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Received and published: 14 October 2018

Response to Anonymous Referee #1 comments (se-2018-70-RC1)

"…In this paper, there are so many supplementary figures. These figures frequently referred in the main text, and then it is complicated and disturbs our understanding the manuscript. Some supplementary figures should be appeared as figures in the manuscript. The order of figures is somewhat strange. The results of image analysis of grain size and shape (Figs. 6 and 7) should be appeared prior to the results of phase spatial distribution analysis (Fig. 5)."

Response: We have included Figures SOM2 and SOM4 in the main text (they are the new Figures 5 and 6), as they indeed show important EBSD data. We prefer to leave the other supplementary Figures in the SOM, as they contain data that complement and expand the figures presented in the main text. The figure order reflects the order in which figures are cited in the text. Results of image analysis are described in a paragraph after the EBSD data, therefore the figures follow the same order. The text has been changed in order to respect the order of figures: results of grain size and aspect ratio analyses (Figs. 8 and 9) are now described in a separate section following the description of EBSD data.

“Descriptions of the rheological calculations (section 6.3) are little bit complicated, and then they are not easy to understand. I would like the authors to rewrite and reorganize some sentences in the section 6.3.”

Response: We have made the effort of maintaining the description of rheological calculation as simple as possible and as complete as possible. To achieve this, we have slightly modified the chapter and introduced subheadings.

“Although the authors described that micro-cataclastic process or micro-fracturing is a dominant grain size reduction mechanism of plagioclase in the samples analysed here, the microstructural observations indicative of the microcataclastic process or micro-fracturing of plagioclase are not described sufficiently.”

Response: We agree that referring to microcataclastic processes is misleading and we deleted this term, as there is no evidence in the microstructure of cataclastic deformation. However, the origin of the (few) low angle boundaries within myrmekitic plagioclase (e.g. Figs. 3 and SOM 1a) requires an explanation. Given (1) the abrupt misorientation of up to 8° across such boundaries, and (2) the overall very low internal strain of the myrmekitic plagioclase, we interpret such boundaries as originating as microcracks, and not as subgrain walls resulting from recovery during crystal plastic deformation. We clarified this interpretation in the revised text, Section 6.1.2. This answers also the specific comments (10) and (19).

Specific comments: (1) P4, L2-4: In Fig. 2a, there is no identification of myrmekite and

K-feldspar for the ultramylonite. Please identify them in Fig. 2a. In Fig. 2b, there are two red bars for the ultramylonite. Is this correct? If so, what do the two different bars represent?

Response: The identification of myrmekite in the ultramylonitic layer is impossible, given that the fine-grained ultramylonitic matrix is completely mixed and no distinct layers of sheared myrmekite can be identified. K-feldspar in the ultramylonite layer occurs as rare scattered porphyroclast (as now described in the revised manuscript). In the ultramylonitic layer of Fig. 2a, no K-feldspar porphyroclasts can be detected at this magnification, but they are locally present and a good estimate is 1% of the total volume. Fig. 2b has been modified and it now contains only one single red bar. This represents the amount (area fraction) of K-feldspar porphyroclasts in the ultramylonite.

(2) P4, L16-17: What is "monocrystalline structure"? This means plagioclase is a single grain? Please clarify the structural characteristics of plagioclase within in each lobe. Response: “Monocrystalline structure” means that the plagioclase is a single grain. Monocrystalline substituted with “single grain”.

(3) P4, L25-26: The quartz vermicules do not show any obvious CPO (Fig. 3d).

Response: Quartz vermicules do not show an overall CPO, but quartz vermicules WITHIN a single myrmekite lobe share a similar crystallographic orientation, as can be inferred from the clustering of few point data in the pole figures of Fig. 3d. The text has been modified accordingly.

(4) P4, L29: I do not know why "However". Please remove the word.

Response: “However” deleted.

(5) P5, L7: Please define "AR"

Response: AR: Aspect Ratio, now defined in the text.

(6) P5, L15. P9, L2: At least for me, some plagioclase grains in Area B in Fig. 4a is

elongated with the aspect ratio of >2. I would like to see the histogram for aspect ratio of plagioclase grains. Related topic also appears in P9, L2.

Response: Histograms for aspect ratio added in Figures 7e and 8d for quartz and plagioclase in sheared myrmekite, respectively.

(7) P5, L18: What does "in crystal direction" mean? It means "in the crystal coordinate system"? If so, please rephrase it.

Response: Sentence rephrased. "... misorientation axes in crystal coordinate system are almost uniformly distributed ..."

(8) P5, L19-20: two weak peaks? two strong (or distinct) peaks!

Response: "Weak" replaced with "distinct".

(9) P6, L12-15: If the pole figure of c-axis shows maxima close to Y kinematic direction, the quartz fabric pattern could be assigned to Type-II crossed gridle or single girdle with Y-point maxima. However, the authors described that the quartz fabric pattern was assigned to Type-I crossed girdle (P6, L13).

Response: Type-II crossed girdle.

(10) P8, L18–21: In this sentence, it has been described that grain size refinement of plagioclase involves micro-fracturing as suggested by misorientation analysis on the few low and high misorientation angle boundaries and CPO randomization. However, the authors have not discussed the mechanism of grain size refinement of plagioclase, based on their own microstructural observations. The following paper may be helpful to discuss this issue: Okudaira, T., Shigematsu, N., Harigane, Y. and Yoshida, K. (2017) Journal of Structural Geology, 95, 171–187.

Response: We have modified the paragraph trying to clarify the initial process of grain size refinement in plagioclase: "[...]Qtz grain coarsening reflects annealing of the pristine vermicular microstructure after the reaction front moved further into the Kfs (Fig.

3a), and was probably aided by dissolution-precipitation processes. Qtz coarsening implies simultaneous grain size refinement of Plg, which probably involved microfracturing, with the development of local micro-cracks in myrmekitic Plg.: Misorientation analysis on the few low and high misorientation angle boundaries inside pristine myrmekite (inside myrmekitic Plg) shows abrupt misorientations of as much as 8° across such boundaries, which could be interpreted as either micro-cracks or growth features considering the low internal distortion of grains (Figs. 3, SOM1). Microfractures could have originated from stress concentrations within the 3-D geometrically/mechanically composite structure of myrmekite (see figure 2 of Hopson and Ramseyer, 1990; Dell'Angelo and Tullis, 1996; Xiao et al., 2002). [. . .]". However the discussion here remains rather speculative, since the transition from pristine to sheared myrmekite is a dynamic process impossible to be frozen in a microstructure. The grain size refinement mechanisms during shearing of myrmekite are then discussed in the Section 6.2.1.

(11) P8,L32 – P9-L1 Kruse et al. (2001) and Miranda et al. (2016) suggested very limited deformation by dislocation creep for plagioclase aggregates in mylonites. As far as I know, Okudaira and Shigematsu (2012, Journal of Geophysical Research, 117, B03210, doi:10.1029/2011.JB008799) only described very limited deformation by dislocation creep for quartz aggregates in natural mylonites.

Response: We added a reference to the work of Okudaira and Shigematsu (2012).

(12) P9, L20: "... do not show any microstructure" may be "... do not show any deformation microstructure".

Response: Corrected.

(13) P10, L9-11: How about the effect of annealing during and or after deformation? The quartz grains associated with myrmekite may be annealed, and then some of quartz grains in monomineralic quartz layer may be also annealed at least partially.

Response: Quartz annealing probably occurs only in pristine myrmekite as a consequence of grain boundary area reduction processes and minimization of grain boundary surface energy that is expected to be high in vermicular- and in fine-grained myrmekitic quartz. On the other hand, quartz in monomineralic layers does not show microstructrues commonly considered indicative of annealing, such as 120° triple junctions, the grain shape is commonly elongate and flattened, and the grain size distribution is typically bimodal with a rather wide range. All of this suggests that quartz in the monomineralic layers was not affected by grain boundary area reduction and annealing.

(14) P11, L2: fh is water fugacity coefficient, not water fugacity itself? What is water fugacity coefficient?

Response: Yes, fh is water fugacity. “Coefficient” is redundant, deleted.

(15) P14, L2: Why would the composition of plagioclase be assumed to be An100, instead of An60? I do not understand the effect of the plagioclase composition.

Response: As reported in Rybacki and Dresen (2004), different compositions of plagioclase lead to different rheological behaviour and flow law properties. Therefore, to mimic the composition contrast between plagioclase in the granitoid rock and myrmekitic plagioclase we have adopted different plagioclase compositions in the rheological calculations for granitoid rock and myrmekite.

(16) Equations (23), (24) and (25): What does the superscript of 1 mean? Please describe them.

Response: All terms of the equations are now explained in the revised text.

(17) P14, L14: In this figure, the result of diffusion creep for quartz is not necessary.

Response: Diffusion creep of quartz in Fig. 8a. This is a deformation mechanisms map for quartz calculated with the reported flow laws for dislocation creep (Hirth et al., 2001) and thin-film pressure-solution creep (den Brok, 1998) adopted in the rheological calculation. It is important to report both deformation mechanism so one can evaluate the conditions at which the transition occurs. Thus, we prefer to keep the diffusion creep field in the figure.

(18) P14, L18–20: I cannot understand this sentence and Fig. 8c. This sentence means a mixture of plagioclase and quartz (i.e., ideal granitoid rock) deformed by dislocation creep. The other curves in Fig. 8c are necessary? It is very confusing.

Response: Yes, they are necessary for comparison with the other curves calculated to model the rheology of different aggregates, and for the discussion developed thereafter. Quartz and plagioclase are deformed by diffusion creep? Response: In the "ideal granitoid rock", plagioclase and quartz are deforming only by dislocation creep. The calculation scheme for myrmekite is similar to those for Fig. 8b? Response: The calculation scheme for myrmekite is the same as in Fig. 8b, as now specified in the text. However in the case of the "ideal granitoid rock", the flow law is calculated only for dislocation creep.

The two technical corrections have been incorporated in the revised text.

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