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Interactive comment on "Relationship between microstructures and resistance in mafic assemblages that deform and transform" *by* Nicolas Mansard et al.

Luca Menegon (Referee)

luca.menegon@geo.uio.no

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Review of "Relationship between microstructures and resistance in mafic assemblages that deform and transform", by Mansard et al.

Dear Authors and Editor, First, I apologize for the late submission of my review report.

This manuscript presents a detailed experimental study of the feedback between mineral reactions and deformation in "wet" mafic assemblages deformed under high P, T conditions with a Griggs-type solid medium apparatus. The experimental samples have been investigated in detail with electron microscopy (including EBSD) and image analysis techniques.

The work aims to test the role of synkinematic mineral reactions on the rheology of mafic assemblages of different compositions. Depending on different rates of reaction progress and of the associated microstructural development, the stress-strain behaviour and the extent of weakening varies in the different assemblages. The results highlight that differences in mechanical strength depend on the microstructural evolution of the assemblage, which in turn is determined by the rate and the type of synkinematic mineral reactions. The Authors assume that faster reaction rates depend on the higher intracrystalline water content in the starting material. The results are also discussed in terms of the strain localization potential of pyroxene vs amphibole-dominated mafic assemblages.

The conclusions are largely supported by the results, and further highlight the fundamental feedback between mineral reactions, deformation, and strain localization. The paper is very well written and illustrated, the experimental work and the microstructural analysis are meticulous, and the overall dataset is of high quality. I definitely recommend this article for publication in Solid Earth. I have only a few suggestions for minor revisions, keyed to line numbers. Congratulations to the Authors on this very good piece of work.

Line 62: if I may, I suggest to add the work by degli Alessandrini et al (Lithos 2017), as it investigated in detail the effect of reactions on the rheology of pyroxene-bearing mafic assemblages deformed at lower crustal conditions.

Line 136: please add information on the grain size of the starting material to justify the spot size of 40 x 40 mm2 used for the FTIR analysis. Many grains of the starting material look considerably smaller than this sport size in the BSE images.

Line 221: it might be correct that mineral reactions preferentially occur in strongly deformed areas, but likewise it might be that layers of reaction products (that originally nucleated in a different position) are transposed and smeared off along the foliation.

This is typically the case, for instance, in recrystallized myrmekite (see Ceccato et al., 2018). I would argue that mineral reactions in shear zones tend to form at sites of stress (and elastic strain) concentrations (which are typically those facing the instantaneous shortening axis), so that perhaps low-strain samples are more appropriate to identify the nucleation sites of mineral reactions.

Lines 226-232: the cpx-forming reactions in the amph-plag assemblages are dehydration reactions, which typically result in the formation of melt even at 800-900 °C (e.g., Wolff and Willie, 1994). Is there any microstructural evidence of melt pseudomorphs, and has the melt-in curve been calculated in the thermodynamic modelling in order to ensure that the experiments were performed fully into the solidus field?

Lines 276-282: please add sketches of the SC-SC' fabrics in Figs. 10a-c to better summarize these observations.

Line 303: whilst the SC' fabric is clear in Fig. 12c, Fig. 12a looks more an SC fabric. Please add sketches/annotations to highlight the fabric elements.

Line 312: I understand that the pole figures are plotted as one point per grain; please provide the total number of the plotted grains, the step size and the average grain size of amphibole, so that the reader can make their judgement on the data acquisition and processing routines. How many data points did you consider representative to define an individual "grain"? Amphibole grain size in Fig. 13 looks < 1 micron, so I wonder whether many of you "grains" are actually individual data points that might encompass more than one single grain. Please clarify.

Line 360: is there any evidence of dislocation creep been potentially active in the strong phases? Do you have EBSD maps of porphyroclasts that could help understand this?

Line 400: please see my comment to line 221. Perhaps the reaction products nucleated elsewhere and were transposed/smeared along the porphyroclast tails with increasing strain. From some BSE images, it seems that the entire porphyroclasts are locally rimmed by reaction products (e.g., Fig. 7c, Figs. 10), so I wonder what the original nucleation site was.

Lines 494-497: this is a very interesting and plausible interpretation. But the follow up question is how did the H2O stored in the interior of strong porphyroclasts become available for the reactions? Did microfracturing play a role here? Any evidence?

Line 532: syn-kinematic mineral reactions are very important for the deformation of mafic systems also at higher metamorphic grades (see degli Alessandrini et al., 2017). Here you also document dehydration reactions and their role on deformation.

With best wishes, Luca Menegon

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