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Comment on egusphere-2022-1487

Anonymous Referee #1

Referee comment on "Water release and homogenization by dynamic recrystallization of quartz" by Junichi Fukuda et al., EGUsphere,
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These comments are intended for the editor and authors.

In this short paper, Fukuda et al. compare the water content of quartz in three granitic samples using infrared spectroscopy. Water has a major affect on the rheology of quartz, but the details of this are complicated and not well understood. The paper is fairly clearly written, the figures are of excellent quality, and I enjoyed reading the paper and learned some things. I must point out here that while I am familiar with recrystallization of quartz, I have not studied water contents in quartz and the reader of this review should keep that in mind while considering my comments.

My main concern about the paper is the small sample size (N=3) and use of only one technique to investigate the samples. As far as I know, IR measurements are not particularly expensive or laborious to make, although IR mapping may be relatively novel (I'm not sure). So my sense is that the study is well below the average published contribution in terms of the intellectual rigor involved in its production. Also, other studies have already shown similar results—the authors cite two previous studies (Finch et al., 2016; and Kronenberg et al., 2020) showing decreased water concentration associated with recrystallization in natural samples. Adding another data set like this to the literature is valuable, however I am accustomed in published work to see significantly more data presented and/or a more detailed analysis that makes more progress towards some outstanding question. There does not seem to any specific question being targeted or addressed by the study, other than "how does water content in this shear zone change during recrystallization?".

I recommend that additional samples are analyzed or some complimentary technique is added to the study before publication. For example, EBSD maps of the samples would allow a quantification of the degree of recrystallization and subgrain formation involved in changing water contents. Also, the authors infer the presence of subgrains in their thick sections, but this could be proven and quantified using EBSD. The authors also infer different types of recrystallization in strongly deformed and weakly deformed samples

which I find puzzling—such differences could also be quantified using EBSD.

Below are some additional comments.

13-15. Bulges form on host grains, so I don't understand how they can also be a few hundred microns distant. Please clarify the language.

14-16. How can it be that small amounts of deformation involve bulging recrystallization, but large amounts of deformation are inferred to have experienced mainly subgrain rotation recrystallization? Is a switch in recrystallization mechanism over time being inferred, or did deformation occur at different conditions in different places (problematic for the study, since there is a tacit assumption that deformation conditions were similar in the three different samples). Alternatively, possibly there is not as much clarity about the deformation mechanisms as the author's think (EBSD analysis could help a little with this).

20. Language issue: "is released" is problematic. "can be released" or "was released" would be better. There are scenarios where very dry quartz is recrystallized in the presence of water, and during this process water is added to the quartz. By saying "is" it sounds like the authors are making a universal claim.

29 "several" better than "a few"

Section 2 Samples: I would also like to see more attention paid to the deformation history of these samples. Are they from a strike slip, thrust, or normal sense deformation environment? Are they foot wall or hanging wall? Do we have information about the temperature of deformation? Is there information about the initial distance between these samples when deformation occurred (how similar do we really expect them to be)? Does previous work in the area suggest that the deformation of the three samples occurred simultaneously (at different strain rates), or was there a sequence of overprinting at progressively lower temperatures?

96. "By imaging" is quite vague.

101-102. These piezometers were calibrated using some samples that also experienced subgrain rotation recrystallization, not just bulging. Also, (line 106) the Cross piezometer uses a subset of the same samples Stipp used, so it's absurd to say that Cross et al is useful for samples that experienced subgrain rotation recrystallization, while Stipp piezometer is for bulging. In any case, it doesn't seem necessary to separate out two kinds of piezometers anyway because only rough estimates of stress are produced.

110-113. Inaccurate language: There is much more to preparing thin sections than by dissolving resin in acetone.

111-112. Similarly, this language about the dial gauge seems incomplete.

150-151. For those ignorant of such things (like myself): can we assume that the same IR calibration for quartz gives accurate values of water content in feldspars? A note and reference here or in the methods would be useful.

155-156. This observation, that water content is less between recrystallized and unrecrystallized areas of the same sample is very important. It strengthens conclusions drawn from sample to sample differences in water content. The authors might want to emphasize this more elsewhere in the paper.

163-164. It is very difficult, perhaps impossible, to truly distinguish a small subgrain from a small grain in a thick section (when the grain size is much smaller than the thickness of the slide). I don't doubt that there are subgrains, but the language here is misleading.

169-170. Figure 8a is too zoomed out to see any subgrains (it seems from the placement of "(Fig. 8a)" that we are to see subgrains in the figure).

183-184. It is suggested later in the paragraph that small optically invisible inclusions can also provide a similar magnitude IR signal. So why presume that it is the large inclusions that are responsible here? Couldn't it be the case here that the signal is also mainly from submicroscopic inclusions? You could substantiate your claim by measuring the density of inclusions as compared to the IR results in the sample (is there a correlation?), or cite some earlier work if this has been addressed before.

185. Change "do not differ" to "do not differ substantially" (means of 500 vs 800 are different)

185-187. This is a big claim (that it must be because of invisible inclusions… how would that happen? show us micrograph images of the two areas?). Can the same technique be used to verify the presence of small inclusions that Stunitz used?

190-193. I don't know much about IR detection of water, but I imagine that the signal strength might depend on the size of inclusions (microscopic vs sub-microscopic). If so, it would affect this supposition. Add some information on this if possible.

193-194. Confusing language. Change “are comparable” to “correspond to”

195-197. I’m not following the logic here. Why “therefore”? This idea of redistribution seems odd to me. It seems like, overall, water left the system during deformation, so it seems unlikely it would increase in the host crystals—is that what is being implied (“higher water contents…due to the redistribution of fluid inclusions”)?

210. Section 5.2. It is unclear to me what the main point(s) of this section is. I read it a few times and it feels like a loose collection of thoughts and information from the literature about water in recrystallized quartz. I’m not sure if any new idea is being presented, or what exactly the new data contribute to the previous understanding.

219. “development of dynamic recrystallization” wording is linguistically problematic. Replace with “development of dynamically recrystallized grains” or “dynamic recrystallization”.

229. “which may be due to the transition from subgrains to recrystallized grains” This could be tested with EBSD.

244. This is a hypothetical statement. Use “were” instead of “is”

244-245. Just a thought (no need to address it): If the water can be “distributed homogeneously in grain boundaries as thin films,” is there any concern that it can be added or lost during the process of making thick sections? What happens if the samples are heated before IR analysis (this might remove grain boundary water)? Could test for this with IR analysis before and after a heating.

252-254. This sentence is confusing me. Why is thought to be “continuously supplied”? What is the significance of “textural modifications” here?

254. “Intracrystaline parts” language is unclear. “Crystal interiors” makes more sense to me (if that is what is meant).

278. Change “original fluid inclusions can be redistributed” to “water from original fluid inclusions can be redistributed”

286-288. I'm not following this logic. Why is diffusion invoked to explain host vs rxld grain water in these samples? All you need is to remove water in recrystallized grains, and the remaining host quartz just holds onto its water (no diffusion necessary except perhaps to redistribute from large to small inclusions).

290-291. The words "that lead to the development of equilibrium texture" may not be necessary, and ideas of "equilibrium" are often complicated (are they really equilibrium? How would we know?). Also it would be necessary to explain what is meant by "equilibrium texture;" do you mean "equilibrium microstructure" (texture for some people means CPO, but I don't think it's what is meant)? Probably best to just trim the sentence by removing these words.

294.-295. I think it is being suggested that formation of subgrains releases an intermediate amount of water. Can this really be inferred with the available data? Consider also the possibility that measuring a mixture of recrystallized grains and undeformed grains also gives an intermediate value. It is very difficult (or impossible) to tell, optically, in a thick (100 μm) sample what is a subgrain and what is a recrystallized grain… EBSD could help clarify what is happening, I believe.

297-299. What is the "equilibrium state" of water during deformation? This concept would need to be explored before ending the paper with this sentence. Is it related to temperature, presence of other minerals? Equilibrium between water in quartz and what? Has this been quantified in the literature, and if so what is the significance of the value found (can it be used to quantify anything, water fugacity maybe?)?

629. "addition" not "addiction"

629-633. suggestion: I find the language "former and latter" confusing. Try more direct language, i.e. just say "in the weakly deformed sample" rather than "in the former sample."

630. It says water distributions in host grains in the undeformed sample…are "not comparable" with the shapes of host grains (Figs 5–7). This is a strange statement because the size of grains in the undeformed sample is much bigger than the IR maps, so how is this known?

Discussion. What is the bigger significance of these findings? It was already known that water can be released during deformation.

FIgure 1. Label A and B. Need inset showing location in Japan. The lower map should be

clear about what the black lines are…are they faults, intrusive contacts, depositional contacts, roads (they seem to be a mix of these things)? Also the blobs with various deformed status are confusing—is this really the only part of the Wariyama granite that is deformed? Is the deformation related to any of the faults/contacts shown?

Figure 5, 6, 7, 8. Color scale for the IR maps should be the same so that they can be directly compared visually. For example in line 185-187, it says that regions of two samples have the same water content, but we can't visually "see" this easily the way the figures are currently colored. This would also help compare figures 6 and 7, which are of the same sample. The change will also help the reader intuitively grasp the main result of the paper (the strongly deformed sample will show up as mostly blue, whereas the undeformed sample will be red).

Some questions I am left with:

How significant would the change in water content be in terms of rheology of the samples?

The undeformed quartz is heterogeneous in terms of water content. Water weakens quartz. So one might expect that deformation would occur mainly in areas of high water content. However, the host quartz remaining in weakly deformed quartz has more water, on average, than the undeformed quartz—not what you'd expect if recrystallization were focused in the high-water areas. How do you explain this? Perhaps it is a result of the small data set (i.e. one of the samples is anomalous in terms of water content)