

Review of Okuda et al.

This manuscript presents results from friction experiments on Brucite gouge under a range of normal stress and saturation conditions. The results indicate that wet Brucite exhibits a low base friction coefficient and velocity-weakening frictional behavior under low normal stresses. The authors also present microstructural analyses to supplement their experimental results. They use these observations to suggest that Brucite could play an important role in hosting slow earthquakes in a hydrated mantle wedge.

The results are new, interesting and definitely merit publication. However, the authors make multiple strong statements that are not adequately backed up with evidence. Additionally, the manuscript in general and the introduction in particular relies heavily on slow earthquakes in the mantle wedge, without appropriately acknowledging deep slow earthquakes in the plate interface. Finally, the text has multiple grammar and writing errors which need to be corrected prior to publication.

Overall, I believe the manuscript must undergo some moderate/major changes prior to publication. I enumerate my recommendations by line/section below:

1. Abstract line 25-27: “Brucite Mantle wedge”. This is one example of a strong statement that, in my opinion, is not adequately backed up by the results. This could be one explanation, yes. But to say that this is the ‘only mineral’ and explains the occurrence of slow earthquakes is bold.
2. Lines 44-49: This is a long sentence that should be broken down for readability.
3. Lines 54-55: “Because Brucite is stable....mantle wedges.” I understand that ‘stable’ here does not refer to frictional stability. However, because it is being used in the context of sliding friction, this makes for a very confusing sentence. I recommend some alternate wording to indicate the presence/detectability of Brucite.
4. Lines 56 – 62: “Only a few...temperature”. This is a good introduction describing the friction of Brucite. However, it lacks any information about the stress state of these experiments in literature. Since, this manuscript is about the role of normal stress, it would be useful to mention the stresses used for these expts.
5. Lines 62-65: Another sentence that could be broken down to enhance readability.
6. Lines 65 – 69: “Although....mantle wedges” These statements are made matter-of-factly but the links between them are not clear to me and don’t follow very easily. I don’t understand why brucite is key to understanding slow earthquakes just because there have been observations of slow earthquakes at mantle wedge depths. This might also be a good spot to introduce slow earthquakes as a transitional phenomenon between dynamic seismicity and stable creep.

7. Lines 70 -85: This paragraph is probably better suited near the introduction to the frictional behavior of Brucite. Right now, the authors talk about Brucite friction, then about the mantle wedge, then back to Brucite friction and normal stress.
8. Lines 83-85: Again, this role of Brucite is being boldly overstated at this point as the only conceivable possibility.
9. Line 90: Is WAKO a company?
10. Line 94: What is the thickness of these gouge layers? Also, was there any mechanism to prevent the gouge 'paste' from squeezing out of the sides in the wet experiments?
11. Line 100: How did you ensure/measure saturation? Presumably mixing the brucite with distilled water alone simply ensures that the gouge is wet, not that it is saturated and all the pore volume is filled with water.
12. Lines 125-126: Are these cohesion values from literature? If so, please cite your sources.
13. Lines 149-150: Not sure if I agree with this entirely. Yes, within the framework of the aging law in sliding of rough interfaces, the d_c reflects asperity diameter in some fashion. However, in the context of gouge experiments with a given porosity, one may also consider the alternative interpretation of d_c as the width of a localized shear zone (Marone & Kilgore, 1993) as an appealing definition.
14. Lines 153-154: I understand the point the authors are trying to convey here, but this statement is very strong. Yes, there is an ongoing debate as to the choice of a 'right' constitutive law. However, stating that the value of $a - b$ is 'more' critical needs additional evidence or citations. One might argue that the roles of d_c , stiffness k etc. are just as important.
15. Lines 221-223: "The $a-b$... Values." Why does an identical $a-b$ value for up and downsteps necessarily imply that normal stress conditions control this? For a given set of velocities, $a-b$ is independent of the normal stress anyway, so I don't understand this connection.
16. Lines 231 - 234: "Although...smaller than b_1 ". Yes, b_2 is often smaller than b_1 and its effect is small, but is d_{c2} also smaller? Often, in a 2 state variable framework, $d_{c2} \gg d_{c1}$.
17. Figure 4: Please annotate that column 1 is all upsteps and column 2 is downsteps.
18. Lines 257-268: Many of these observations are also consistent with recent works by Kenigsberg et al. (2019, 2020 - JGR) on clay-rich gouges although they document clear Y and P foliations. This may be worth noting.
19. Lines 310-315: Based on your own sketches in Figs. 5-6, it appears that the deformation could well be accommodated, at least in part, by the Riedel shears. Since there appears to be no additional measurements of gouge compaction/dilation, it seems like the interpretive

statements on the location and direction of deformation may be overstated. Also, by stating “constant gouge thickness”, do you imply that there was no layer thinning observed in your experiments due to mass loss? This is very surprising.

20. Lines 316-319: Not sure I understand this statement. Anthony and Marone (2005) refer to the smoothness of grain boundary contacts whereas I assume here you refer to boundary shears, which are more or less ubiquitous regardless of the smoothness of grain boundary contacts. I don't believe they are directly comparable as you have done here.
21. Section 4.2 : This section is very well thought out and logically organized. I congratulate the authors on this effort. However, it does contain a number of grammar errors which should be thoroughly cleaned up.