

Dear Dr. Kaitlin Keegan,

We sincerely appreciate your thoughtful comments that will help improve our manuscript. Here we present our responses to the comments. Editorial comments are in blue, our responses are in black, extracts from the revised manuscript are in italics.

L5: add 'the' before 'equal-'

Changed as suggested.

L13: should be 'suggests' here

Yes. Changed as suggested.

L29: should be '...flow changes, the rate of change of the flow rate depends on...'

Yes. Accurate. Thank you. Changed as suggested.

L31: remove 'forcing' after 'gravitational' because it is redundant

Changed as suggested.

L58: either add 'the' before 'laboratory' or use the phrase 'in a laboratory setting'

Changed to "achieved in a laboratory setting".

L67: should be 'This discrepancy leads to an uncertainty as to whether...'

Changed as suggested.

L80-81: 'The results could help our understanding of the...'

Changed as suggested.

L86: remove 'for' here

Changed as suggested.

L93: within the text, spell out Figure here (and other places). When referencing the figure in parentheses within the text, use the abbreviation 'Fig.'

Thank you. Figure references within the text are changed to Figure, in 21 places.

L109: add 'in' before 'a nominal' here

Changed as suggested.

L112: add 'the' before 'nominal' in both places in the last sentence here.

Changed as suggested.

L116: is 'attached to' a better way to describe the setup than 'stuck to'?

Yes. Changed as suggested.

L148: add 'the' before 'ECAP' here

Changed as suggested.

L157: within 15 minutes of what?

We separate this sentence.

Now in Line 156-157: “*This process was conducted using a band saw in a cold room maintained at  $-10^{\circ}\text{C}$ . The cutting was done within 15 minutes, and the thermal effects.....*”

L169: you can remove ‘reason’ from the sentence here. ‘The EDS data were collected separately from the EBSD because the operating voltage for EDS (below 15 kV) needs to be lower than that used for EBSD (30 kV) to obtain high-quality data for graphite.’

Changed as suggested.

L179-180: add a dash between ‘X-rays’

Changed as suggested.

L215: should this be ‘produces’ here, instead of ‘producing’?

Yes. Sorry for this. Changed as suggested.

L244: do you mean ‘where the shear stress drops to zero.’ here?

Yes. Changed to “*where the shear stress drops to zero*”.

L245: add ‘at’ before ‘the corner’

Changed as suggested.

L253: lower case ‘we’ here

Changed as suggested.

L254: it might be clearer to say ‘our samples’ here, instead of ‘the samples’

Yes. Changed as suggested.

L272: should be a comma instead of a semicolon here

Changed as suggested.

L288: ‘oranges’ should be ‘orange curves’

Changed as suggested.

L294: should be ‘..required by this model...’

Changed as suggested.

L299: ‘most’ instead of ‘mostly’

Changed as suggested.

L303: ‘Before moving on to discussion,...’ is a little confusing. Consider changing this phrase to ‘Here, we note...’

Changed as suggested.

L304: should be '...due to the fact that EBSD...' here

Changed as suggested.

L305: need 'a' between 'in' and 'limited', and between 'such' and 'large'

Changed as suggested.

L306: add 'which is' before 'insufficient' here

Changed as suggested.

L308: '...dominated by a few very large grains.' might convey what you mean better

Changed as suggested.

L309: '...that pole figures drawn using all orientation data represent the CPOs in these samples well.'

Changed as suggested.

L310: "In this discussion,..."

Changed as suggested.

L316: make 'c' italics here

Sorry for this. Changed as suggested.

L345: add a comma after 'So'

Changed as suggested.

L356: I think you mean "Extrapolating from their results,..." here

Yes. You are right. Changed as suggested.

L371: 'a' should be 'the' and 'zones' should be singular

Changed as suggested. We have also replaced the "a" to "the" in line 370.

L373: 'techniques'

Changed as suggested.

L374: the semicolon should be a comma

Changed as suggested.

L384: add 'the fact' before 'that the stress...' here

Changed as suggested.

L399: add 'the' before 'effects'

Changed as suggested.

L405: I think you mean 'retains' instead of 'remains' here; consider adding a transition phrase to begin the second sentence here, like 'Thus,...'

Yes, retains is a better choice. And “Thus,” is added to the second sentence.

L411: make ‘c’ italics here

Changed as suggested.

L428: add ‘it’ before ‘disappears’

Changed as suggested. And the “remains” is changed to “retains” in the line above.

L436: I think that you mean ‘retains’ instead of ‘remains’ here

Changed as suggested.

L440: I think you mean “The resulting angle…” here

Changed as suggested.

L443: add a comma after ‘Here’

Changed as suggested.

L449: ‘systems’ should be singular here

We think it should be plural. There are several non-basal slip systems (for example, prismatic and pyramidal slip systems). During deformation, slip may occur on more than one slip systems.

L479: ‘…the CPO has a significant influence…’

Changed as suggested.

L482: ‘correct’ might be a better word than ‘right’ here

Yes. Changed as suggested.

L484: add ‘rather is’ before ‘calculated’

Changed as suggested.

L485: ‘controls’ should be singular; consider changing this second use of ‘thus’ to something else like ‘ultimately’

Yes. Thank you. Changed as suggested.

L488: again, I think you mean ‘retains’ here

Changed as suggested.

L498: should be ‘constraints’ here

Changed as suggested.

L499: ‘which could allow for the extrapolation of laboratory…’

Changed as suggested.

L506: ‘retains’

Changed as suggested.

Figure 1 caption: should 'stuck to' be 'attached to'?

Yes. Changed to “*attached to*”.

Figure 4: title above panel (f) should say 'reconstructed'

Changed as suggested.

Figure 10 caption: 'sub-areas'

Changed as suggested.

Figure 11 caption: '...from the following studies:'

Changed as suggested.

Figure S2 caption: 'plane normal to the shear plane...'

Changed as suggested.

We also made a few corrections and modifications in words and citations. We think these can clarify some parts in the manuscript. Line numbers are with respect to the new version.

Line 3: “*The development of CPOs is governed by two pivotal mechanisms: recrystallization dominated by subgrain/lattice rotation and by strain-induced grain boundary migration (GBM)*” is changed to

“*The development of CPOs is governed by the relative importance of two pivotal recrystallization mechanisms: subgrain/lattice rotation and strain-induced grain boundary migration (GBM)*”.

Line 33: Added citation of Monz et al., 2021.

Line 40: We want to make it clear that we mean the c axes are normal to the basal planes.

“... *characterized by the alignment of the {0001} axes (c axes), normal to the basal planes*” is changed to “...*characterized by the alignment of the {0001} axes (c axes, which are normal to the basal planes)*”.

Line 50: This is what we inferred. So we changed “*typically exhibit*” to “*are inferred to have*”.

Line 52: Changed citations to Jacka and Maccagnan, 1984; Jacka and Li, 2000; Qi et al., 2017.

Line 54: Added citations of Guillope and Poirier, 1979; Poirier, 1985; Urai et al., 1986.

Line 60: We want to make our descriptions more accurate for citations.

The sentence is changed to “*Natural ice samples from shear zones have strong single (Thomas et al., 2021) or double c-axis clusters (Jackson and Kamb, 1997; Jackson, 1999; Thomas et al., 2021) with the primary cluster perpendicular to the shear plane. Where shear strain is quantified, the double clusters switch to a single cluster at  $\gamma > 5$* ”

*(Hudleston, 1977)."*

Line 97: The sentence is changed to *"The channels are mirror-finished, and are coated with a layer of solid soap..."*

Line 160: *"Sample mounting to copper ingots to go into the SEM was done..."*

Line 161: The sentence *"A small piece of the sample..."* is now moved to the end of the paragraph.

Line 175: The original sentence sounds like the unindexed points were used to analyze. We separate the sentence into two.

*"Orientation data from EBSD with a 15- $\mu$ m step size were combined with element data from EDS to identify unindexed points. The combined data were then used to analyze..."*

Line 180: The sentence *"Note that due to the relatively low..."* is moved from originally line 184 to here. And the sentence *"Consequently, the data..."* (used to go after sentence *"Note that..."*) can be removed.

Line 202: *"...a method similar to that of Figure 2 in Qi et al. (2019), based on an approach used by Bouchez and Duval (1982)."*

Line 269: *"the strength of..."* is removed, as weaker means we are talking about strength.

Line 272: *"The logarithm of the ratio of data-point number in the primary and the secondary clusters increases with increasing strain"* is changed to

*"The ratio of number of data points in the primary and the secondary clusters increases with increasing strain".*

Line 295: *"of  $\sim 10^{\circ}$ "* changed to *"at  $\sim 10^{\circ}$ ".*

Line 369: *"...for which CPOs with substantial measured grain have been reported"* changed to

*"...for which CPOs with a large number of grains have been measured".*

Line 453: *"tend to exhibit"* changed to *"are inferred to have".*

Figure 11 captions: in the first sentence, we removed citation of Etchecopar, 1977, as his simple model has been removed in the previous version.