(1) comments from referees/public is written in bold type.

(2) author's response is written in normal type.

(3) author's changes in the manuscript is written in italic red type.

Reply to Referee Comment #1 (RC1)

Thank you for your feedback and suggested revisions. We would also like to thank you for the many useful references you provided us with. We appreciate your time and effort in reviewing our preprint.

We have considered the comments and taken action accordingly. We have made changes to address the majority of the issues raised by the reviewer.

All the study is conducted on quartz microstructures, as also stated "we focused on the microstructure of quartz-rich metamorphic rocks—quartz is the main component of the rocks we collected and its deformation stress is assumed to be representative of the region", and those results are extrapolated to be relevant for the unit. However, as presented in the geological setting (methods section), the unit is composed by several rock types with different compositions. Additionally, the quartz-rich metasediments are composed of abundant mica. Even if a brief part of the discussion considers this point, I think that it needs much more attention. In this respect, the authors should also expand their citations, using relevant literature discussing deformation mechanisms in quartz-rich metasediments in subduction in other subduction zones, such as Trepmann & Seybold, 2019 (https://doi.org/10.1016/j.gsf.2018.05.002), Condit et al., 2022 (https://doi.org/10.1029/2021GC010194), Tulley et al., 2020 (DOI: 10.1126/sciadv.aba1529), Giuntoli et al. 2022 (https://doi.org/10.1029/2022JB024265). Among others, those articles' results and implications should be discussed. In particular, the role of phyllosilicates in the bulk deformation needs much more attention, also expanding on phase mixing between quartz and phengite (see for example Hunter et al., 2016 http://dx.doi.org/10.1016/j.jsg.2015.12.005). The discussion should be expanded in this regard.

Line 340: And what about the solution seams of Fig. 6a? Those seems to be composed by phyllosilicates and are continuous. Please discuss this point here

Thank you for your comments regarding the deformation of quartz-rich metasediments that also contain significant amounts of mica, and the presence of several rock types with different compositions. After reading the recommended literature we propose the following revisions.

In the quartz schist units targeted in this study, mica minerals are present and may influence deformation. In our preprint, we wrote that mica does not contribute to deformation because it does not form an interconnected network. However, Hunter et al. (2016) pointed out that under a deformation temperature of 490–530°C, even if they do not form an interconnected network, the appearance of mica with a volume ratio of less than 10% may inhibit quartz deformation and concentrate deformation in the mica. Furthermore, it has been pointed out that the basal glide of phengite is weak and may undergo significant deformation when the von Mises criterion is satisfied under deformation conditions like our samples (Condit et al., 2022). In the light of these considerations, we reassessed the effect of mica deformation and deformation heterogeneity in rocks around our samples.

1. Rock around sample ASM2, 3, 4

When mica (relatively weak phase) grains do not form an interconnected network, both the mica and quartz deform at the same strain rate and are subjected to different stresses (mica distributed within a load-bearing quartz: LBF in Handy (1994)). This condition applies to samples ASM2, 3, and 4. In this situation, the estimated stresses would be larger than the stresses experienced by the mica. However, the stress received by the whole rock body is, in this case, the sum of the stress received by each mineral multiplied by the volume fraction of the mineral (e.g., Condit et al., 2022; Handy, 1994). Thus, even if the mica is subjected to a stress of 0 MPa and the volume fraction of the mica mineral is 20%, the stress on the rock body is 0.8 times the estimated stress and the estimated stress can be considered to be a good approximation to the stress of the whole rock body.

In summary, the estimated stresses are almost identical to the stresses received by the surrounding rock body. However, the stresses received by the phengite may be even smaller, as the strength of the mica is assumed to be lower than the strength of the quartz undergoing dislocation creep at the temperature conditions discussed in our study.

2. Rock around sample ASM1

It is likely that the obtained stress is considered to be largely representative of the stresses undergone by the pelitic and psammitic schists of the chlorite zone.

2.1. Interpretation from outcrop and thin section observations

In the area around sample ASM1, both psammitic and pelitic schists are deformed by quartz pressure solution creep in the microlithon domains, and the developed foliation may have been deformed by phyllosilicate slip (Fig. 7a in revised manuscript). As foliation develops as a layer, it is considered that the foliation and microlithon domains are subjected to the same stress and deformed at different strain rates (Condit et al., 2022). Both quartz veins (Fig. 7b in revised manuscript; Fig. 2) and strain fringes (Fig. 7a in revised manuscript) are developed in the microlithon domain, but no boudin or other structures attributable to differences in strength could be identified (Fig. 7a in revised manuscript; Fig. 2a). Therefore, quartz veins, strain fringes, and microlithon domains are considered to have had almost the same strength, i.e, were subjected to the same shear stress and strain rate.

In Sample ASM1, stresses were estimated from quartz veins in psammitic schist. We also estimated shear stress experienced by strain fringes in the pelitic schist (data will be added in the revised paper). From these results, we conclude it is likely that the obtained stress is representative of the stresses undergone by the pelitic and psammitic schists of the chlorite zone.

2.2. Interpretation from quartz rheology

2.2.1. Stress distribution

Estimated differential stresses were 32.3–71.7 MPa. In a quartz deformation mechanism diagram drawn using the thin-film pressure solution creep flow law (Table 1: Rutter, 1976; Schmidt and Platt, 2022) and dislocation creep flow law

(Table 1: Lusk et al., 2021), the conditions of the vein and fringe in sample ASM1 (Table 2: grain size = 20–35 μm; the effective width of grain boundary = 0.339 μm (no phyllosilicates)) is located at the dislocation creep deformation dominant region (Fig. 1a), and microlithon domain condition (Table 2: grain size = 10–20 μm; the effective width of grain boundary = 10.170 μm (presence of phyllosilicates)) is located in the thin-film pressure solution creep dominant region (Fig. 1b), consistent with geological observation. Therefore, the above interpretation from outcrop and thin section observations is supported in terms of quartz rheology.

2.2.2. Strain rate distribution

In this case, the strain rate of the microlithon domain is estimated to be twenty times higher than that of dynamically recrystallized grains in the quartz vein and fringe (Fig. 1). However, dynamically recrystallized grains in quartz vein and fringe are considered to have been formed by the recrystallization of quartz fiber grains that are elongated parallel to the stretching lineation (Fig. 7a in revised manuscript; Fig. 2b). These fiber grains are formed associated with the opening of the vein and the formation of the veins contributes to the strain of the rock. Therefore, the strain rate experienced by the quartz veins and fringes is considered to be the sum of the strain rate associated with the formation of quartz fiber grains and the strain rate associated with quartz dislocation creep. This additional contribution from dislocation creep may have allowed the quartz vein and microlithon to deform at the same stress and strain rate.

The strain rate of thin-film pressure solution creep depends on grain size. Grain size estimation using this method is difficult for structures with significant grain growth inhibition by different minerals, and the grain size of the microlithon domain used in the discussion is an assumption. Although this is not a problem for rough strain rate comparisons such as the present study, an accurate grain size estimation method is required for more quantitative strain rate evaluations.

2.3. Stress fluctuation

Trepmann & Seybold (2019) observed quartz veins that formed and developed simultaneously with ductile deformation and documented microstructures indicating dislocation glide and recrystallization associated with rapid stress loading from the seismogenic zone and subsequent stress relaxation, as well as the pressure solution creep of surrounding rock and opening and sealing of the veins (crack-seal veins) associated with gradual internal stress loading and subsequent stress relaxation. The structures observed in sample ASM1b area are similar to the latter and may reflect multiple stages of stress concentration and relaxation with a time interval of several hundred years (Trepmann & Seybold 2019). In this case, the stress measured from the quartz vein in sample ASM1 may be affected by a stress fluctuation. However, considering that dynamic recrystallization requires strains of at least 0.2 (e.g., Stipp and Tullis, 2003) and that the calculated strain rate is approximately $10^{-13}s^{-1}$, dynamically recrystallized grains require at least 30,000 years to form. Therefore, the influence of stress fluctuation over a period of a few hundred years can be considered almost negligible.

2.4. Summary

In summary, we consider the obtained stress to be representative of the stresses undergone by the surrounding pelitic and psammitic schists. Such situations are only likely to occur when the deformation conditions are located near the boundary between the dislocation creep domain and the pressure solution creep domain. The change in the deformation mechanism between the vein or fringe and microlithon domains can be attributed to differences in the degree of grain growth inhibition and activation of pressure solution creep due to the presence or absence of the quartz-mica boundary.

Table 1 Flow law used in this study

Formula	Description	Reference
$\dot{\varepsilon} = \frac{A_{ps} V_m c D_{gb} \omega \sigma \rho_f}{R T d^3 \rho_s}$	Thin film pressure solution flow law (s^{-1})	Rutter (1976) Schmidt and Platt (2021)
$\dot{\varepsilon} = A_{dsl}{}^{-9.3} f_{H_2O}^{0.49} \sigma^{3.5} \exp\left(-\frac{Q+PV}{RT}\right)$	Dislocation creep flow law (s^{-1})	Lusk et al. (2021)

Table 2 Parameters of dislocation creep and pressure solution creep flow law

Parameter	Description	Value	Reference
A_{ps}	Geometric constant	44	Den Brok (1998)
V_m	Molar volume of solid (m^3mol^{-1})	2.269×10^{-5}	Berman (1988)
c	Solubility of solid in fluid phase (mole fraction)	2.954×10^{-2}	Fournier and Potter (1982)
D_{gb}	Grain boundary diffusivity (m^2s^{-1})	7.00×10^{-21}	Farver and Yund (1997)
ω	Effective width of grain boundary (μm)	0.339, 10.170	Dobe et al. (2021) Hickman and Evans (1995)
ρ_f	Density of fluid (kgm^{-3})	1058	Burnham (1969)
ρ_s	Density of solid (kgm^{-3})	2650	Schmidt and Platt (2022)
A_{dsl}	Geometric prefactor	$10^{-7.9}$	Lusk et al. (2021)
σ	Differential stress (uniaxial, MPa)	32.3–71.7	This study
f_{H_2O}	Water fugacity (MPa)	65	Holland and Powell (2004)
R	Gas constant ($Jmol^{-1}K^{-1}$)	8.314	
T	Temperature (K)	593	This study
Q	Activation enthalpy ($Jmol^{-1}$)	118000	Lusk et al. (2021)
P	Pressure (MPa)	500	This study
V	Activation volume (cm^3mol^{-1})	2.45	Lusk et al. (2021)
d	Grain size (μm)	15, 20-35	This study

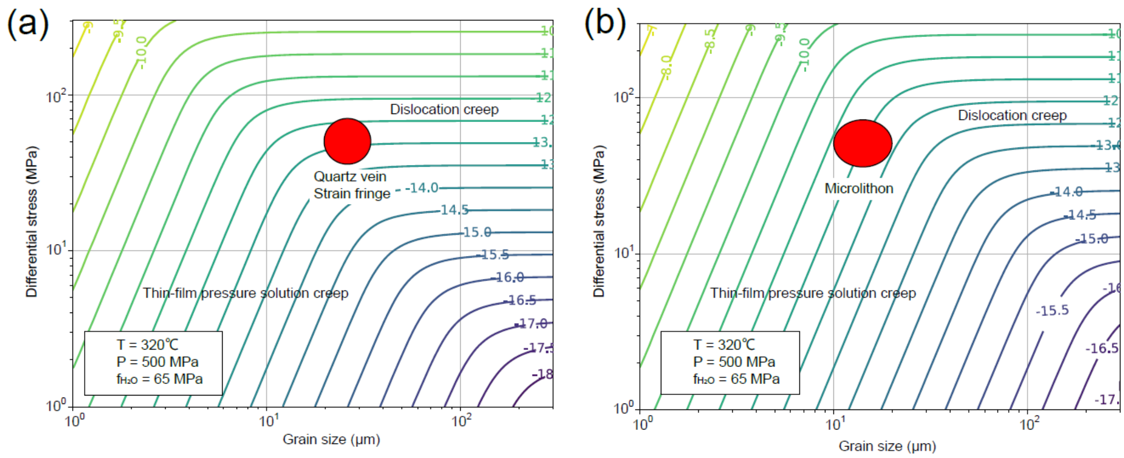

Figure 1: Deformation mechanism diagram of (a) quartz vein/strain fringe condition and (b) microlithon condition. The contour line indicates the exponential part of the strain rate (given for uniaxial conditions and needs to be multiplied by √3 if converting to simple shear strain rate (Lusk et al., 2021)).

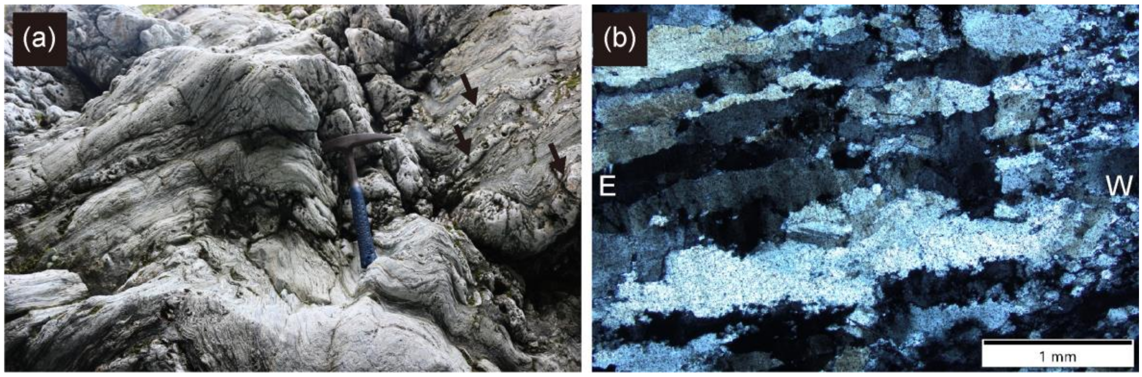

Figure 2: (a) Outcrop photo showing foliation-subparallel veins (black arrows) in psammitic schist. Both foliation and veins were folded by later deformation (Du), but partly preserved unfolded structure, in which we collected sample ASM1b. (b) Microstructure of quartz vein (sample ASM1b). Large fibrous quartz grains that are elongated parallel to lineation and small recrystallized quartz grains were observed. XZ plane. Crossed nicols.

3. Deformation heterogeneity within different lithologies and stress in the subduction plate interface

Tulley et al. (2020) compared the flow laws for various rocks with the strength of hydrous metabasalt inferred from the geological structure and quartz recrystallized grain size. The results showed that mica-containing metasediments can be harder or softer than hydrous metabasalt or amphibolite, depending on temperature conditions. It was also shown that the strength of hydrous metabasalt is reduced by pressure solution creep and slip of phyllosilicates, which plays an important role in deformation along the subduction boundary. Therefore, the discussion of deformation other than quartz, pelitic, and psammitic schist is important for the discussion of rock deformation at subduction boundaries.

In this study, no microstructural observations or stress estimates of quartz schist and basic schist in the chlorite zone, or pelitic and basic schist in the garnet and albite zones have been made. However, previous studies showed that the basic schist in the oligoclase biotite zone appears to be less affected by Ds deformation than other rock bodies (e.g., Mori and Wallis., 2010), indicating that the associated strain is smaller. In addition, the quartz schist in the garnet zone has well-developed sheath folds (Wallis, 1990; Endo and Yokoyama, 2019), which are not observed in the surrounding lithologies suggesting that the strain in the quartz schist is particularly high. It is therefore possible that each rock body was deformed at a different strain rate and may have been deformed at the same stress. To investigate this, stress estimates should be made from the quartz domains for each type of schist, and the strength relationship between the other domains and the quartz domains in each schist should be investigated from structural observations to constrain the deformation strength of each rock type. If the flow laws of the constituent minerals are known, they may be combined to estimate the deformation of the entire rock body (Condit et al., 2022). It is also important to focus on lithological boundaries to confirm the presence or absence of structures that are attributable to strength contrasts. These are topics for future research.

In the revised paper, Sec. 4.1 "Stress recorded by quartz microstructure and in the subduction plate interface" in preprint was removed, and the above text, figures, and tables were revised to fit in with the text of the paper and added as Sec. 5.2 "Stress *recorded by quartz microstructure and in the subduction plate interface" (line 506 to 608 in marked-up manuscript version). This text is placed after Sec. 5.1 "Tectonic stage of sample deformation" because the deformation temperature of sample ASM1 was required for the above discussion.*

Changes were also made to the Abstract (line 25 to 26 in marked-up manuscript version) and Conclusion (line 759 to 761 in marked-up manuscript version) to reflect changes in the text.

And what about the role of ultramafic rocks? These are not discussed, yet present in the unit.

Line 350: And what about the role of ultramafic slivers?

Shear zones by antigorite serpentinite exist at the boundary between mantle wedge-derived serpentinite and pelitic schist (Kawahara et al., 2016). Although the area examined in our study is on the oceanic plate side of the subduction boundary region, it is possible that different minerals and different stress and strain conditions existed on the overriding plate side. Further research is needed on this as well.

In the paper, the above text was added to Sec 5.2 "Stress recorded by quartz microstructure and in the subduction plate interface" (line 609 to 612 in marked-up manuscript version).

Along this line of thoughts, I think that the discussion needs to be expanded considering the results obtained by similar studies conducted on other orogens (differential strain rates and deformation mechanisms related to deep slow earthquakes). Regarding the latter point, the discussion states only "Therefore, the estimated stress may represent the initial conditions from which slow earthquakes in the same domain nucleated".

In Sample ASM1, traces of pressure solution creep and dislocation creep, such as dynamically recrystallized grains in quartz veins and strain fringes in microlithons, are visible. On the other hand, the partly recrystallized quartz fibers in quartz veins (Fig. 2b) and phyllosilicate foliation suggest that brittle deformation such as vein opening and phyllosilicate slip also occurred at the same time. This indicates that the quartz vein was opened by nearly lithostatic pore fluid pressure and fiber quartz grains were formed, followed by recrystallization of these fiber grains, and repeating of this sequence in the rock deformed by quartz pressure solution creep combined with slip along phyllosilicates led to the formation of the present structure (Fig. 2a). Although inclusion bands were not observed, this is a feature similar to crack-seal veins, and the formation process is similar to the structures inferred by Giuntoil et al. (2022) and Ujiie et al. (2018). In particular, it may be compared with the results of the slow earthquakes study by Giuntoil et al. (2022), which suggests that dislocation creep, pressure solution creep, phyllosilicate slip, and vein formation caused slow earthquake cycles and associated fluid migration. The stress estimates in Sample ASM1 are considered to be representative of the surrounding rock body and may therefore be used as stress conditions at the time that deep slow earthquakes were initiated. Compared with the differential stresses and strain rates estimated from recrystallized quartz grains in Giuntoil et al. (2022) (43 to 55 MPa (upper bond) and $10^{-14}s^{-1}$ to $10^{-13}s^{-1}$(lower bond)), the results from sample ASM1 (34.7 to 71.7 MPa and $10^{-11.4}s^{-1}$ to $10^{-11.8}s^{-1}$ in uniaxial deformation, which must be multiplied by √3 for simple shear strain rate (Lusk et al., 2021)) show higher strain rates. These differences may reflect the faster strain rates in the Sanbagawa subduction zone, associated with rapid subduction velocities (24 cm/yr).

As discussed above, Trepmann & Seybold (2019) observed pressure solution creep of the surrounding rock and opening and sealing of the veins (crack-seal veins) associated with gradual internal stress loading and subsequent stress relaxation. The structures found in the ASM1 area are similar to these structures and may reflect multiple stress concentrations and relaxations on a scale of several hundred years. Whether this structure can generate slow earthquakes may be constrained in terms of frequency, by examining the time scale of formation of each vein, the number of veins, and the time scale taken to form the entire vein seen in the outcrop.

In the paper, Section 5.4 "Relationship with deep slow earthquakes" was prepared according to the description above (line 682 to 722 in marked-up manuscript version).

More geological context is needed (see specific comments in the attached PDF), in particular for the reader to picture the relation between the different rock types and the relation between minerals marking the fabrics. Additionally, could you add a figure with field photos (e.g. where these samples were collected, main structures,...)

We added some geological context according to comments in the attached PDF. To picture the relation between different rock types, we added geological cross section to the geological map in Fig. 3 (line 212 to 215). To picture the relation between minerals marking the fabrics, Sec.2 "Geological setting", Sec. 4 "Results" and Sec. 5 "Discussion" were revised according to comments. We also added some field photos as Fig. 6a and Fig. S1 (supplement).

Finally, as EBSD was performed, please also show pole figures for the <a> axis for all analysed samples and EBSD maps, such as grain size maps, KAM maps, IPF maps. This is to improve documentation and to support your interpretation of deformation mechanisms and grain size used for piezometry.

In addition to the <c> axis, pole figures for the <a> axis are added. Also, mis2mean, KAM, and IPF Z maps were added as evidence for dislocation creep and dynamic recrystallization. The results of grain boundary estimation and selection of recrystallized grains, which are necessary to calculate grain size, are shown for the case of substituting the piezometer of Cross et al. (2017) and the case of substituting the piezometer of Shimizu (2012), respectively. In adding the information, the analysis and interpretation of the results of Condit et al. (2022) and Giuntoli et al. (2022) were very helpful. Thank you for recommending the literature.

Figures including optical microscope images, inverse pole figure map, mis2mean maps, kernel average misorientation maps, grain boundary maps, and grain size distribution maps were prepared and added to the paper. Due to its large size, it was added as a supplement (Fig. S2 to S8), with the exception of sample ASM2XZ (Fig. 8). Correspondingly, the text has also been changed (e.g., line 329 to 332 in marked-up manuscript version).

Comment in pdf

Line 29: maybe better to approximate to 15-30 km?

Thank you for pointing this out. *We have made the correction (line 30 in marked-up manuscript version).*

Line 77: What is the reference for this strain rate? For what geological setting? Please, specify

If it is assumed that the plate motion causes the material in the plate boundary region to deform by simple shear, and the thickness of the subduction zone is w (we assumed 100 m to 10 km) and the subduction rate is v (we assumed 3cm per year), then the strain rate of rocks along the subduction interface can be calculated as $v/w = 10^{-13}\ s^{-1}$ to $10^{-11}\ s^{-1}$.

We have made the correction (line 79 to 84 in marked-up manuscript version).

Line 81: Specify here also the rock type

Thank you for pointing this out. *We have made the corrections: quartz, pelitic, and psammitic schist (line 88 to 89 in marked-up manuscript version).*

Line 99: Is it common to have geological settings under method section? Please, check with journal guidelines

Thank you for pointing this out. *Sections 2.1 and 2.2 in preprint were titled "Geological setting" and are removed from the Method.*

Line 108: Please, specify rock types composing such unit. This applies for all units.

Thank you for pointing this out. We have made the corrections:

According to Aoya et al. (2013b) and Endo and Yokoyama (2019),

Eclogite unit: pelitic schist, quartz (siliceous) schist, basic (mafic) schist, marble, pelitic-psammitic gneiss, siliceous gneiss, mafic gneiss, metagabbro, diopside hornblende rock, and ultramafic rocks. *(line 118 to 120 in marked-up manuscript version)*

Kinouzu unit: psammitic schist, pelitic schist, quartz(siliceous) schist, calcareous schist, and mafic schist. *(line 113 to 114 in marked-up manuscript version)*

Shirataki unit: pelitic schist, psammitic schist, quartz (siliceous) schist, basic (mafic) schist, metagabbro, and ultramafic rocks. *(line 123 to 124 in marked-up manuscript version)*

Mikabu unit: metachert, metabasalt, metagabbro, volcaniclastic rock, and ultramafic rocks. *(line 114 to 115 in marked-up manuscript version)*

Oboke unit: psammitic schist and pelitic schist. *(line 130 to 131 in marked-up manuscript version)*

Line 113: Meaning what? Please specify

We apologize for the confusing text. We have rewritten it as follows.

"After the Eclogite unit was juxtaposed with the subducting Shirataki unit within the subduction boundary, they underwent the same metamorphism at 89 to 85 Ma (Endo et al., 2012). This metamorphism overprints the eclogite metamorphism and is referred to as the main metamorphic stage." (line 126 to 130 in marked-up manuscript version)

Line 115: Better metamorphic stage or event

Thank you for pointing this out. *We have made the correction (line 130 in marked-up manuscript version).*

Line 118: As there are several stages, you need to specify for what stage this is valid

We apologize for the confusing text. There are four metamorphic grades (zones). However, these four metamorphic grades (zones) are the result of one metamorphism being subjected to different four depth conditions.

The text has therefore been amended as follows.

"The main metamorphism is divided into four metamorphic grades (Fig. 1) based on constituent minerals in metapelite (Higashino, 1990)." (line 118 to 119 in preprint)

⇒"As a result of the main metamorphic stage, we can identify four metamorphic zones based on constituent minerals in metapelite (Higashino, 1990; Fig. 1). These mineral zones can be related to the depth to which the metamorphism occurred." (line 134 to 137 in marked-up manuscript version)

Figure 1: Please, provide informations about the lithology not only for the eclogite unit, but for the entire map. You could overlay info about metamorphic zonation on such map.

Thank you for pointing this out. *Lithology information will be deleted, and a geological map of the same area will be produced and placed side by side (Fig. 1b; line 150 to 155 in marked-up manuscript version). As this study focuses on the shirataki unit, lithology other than the shirataki unit has been omitted for simplicity of geological map.*

Line 134: remove type

Thank you for pointing this out. *We have made the correction. (line 156 in marked-up manuscript version)*

Line 135: What are the relations between those and the previous rock types?

Thank you for pointing this out. *We added the following text.*

"Ultramafic bodies are mantle wedge-derived rock bodies and differ in origin from schist derived from subducted material. It is suggested that the rocks of garnet to oligoclase-biotite zone were subducted to depths below the Moho boundary and the hanging-wall mantle became tectonically entrained in these rocks (Aoya et al., 2013a)." (line 157 to 160 in marked-up manuscript version).

Line 136: Please, here specify again in what conditions this metamorphism took place
Line 137: Can you quickly summarize if this sequence has similar P-T conditions or not? Because like this the reader has an idea of those abbreviations.
I see that you provide a few info in the figure, but please add also something here.

The text has been amended as follows.

"The main metamorphism that formed the Shirataki unit has four recognized ductile deformation phases, named Dr, Ds, Dt, and Du deformation, respectively (Wallis, 1990; Fig. 2b, 2c)." (line 161 to 162 in marked-up manuscript version).

⇒" Each of the four metamorphic zones formed by the main metamorphic stage has a distinct P (pressure)-T (temperature) path (Fig. 2a). Moreover, the rocks in all metamorphic zones show evidence for four phases of ductile deformation, named Dr (burial), Ds (exhumation starting at near the peak metamorphic conditions), Dt (exhumation after the peak metamorphic condition), and Du (slight burial after exhumation) deformation, respectively (Wallis, 1990; Fig. 2b, 2c). Dt and Du are non-penetrative and it is unlikely they had a major influence on exhumation or burial." (line 162 to 167 in marked-up manuscript version).

Line 141: I do not understand this sentence. Are the amphibole porphyroblasts zoned? What kind of amphibole is? In what rock type?

We apologize for the confusing text. The text has been revised as follows.

"Compositional zoning of amphibole in and outside the porphyroblasts indicates that the Dr deformation was formed during the subduction, burial phase (Wallis et al., 1992)." (line 170 to 171 in marked-up manuscript version).

⇒"The lack of compositional zoning of hornblende, barroisite, or glaucophane cores to actinolite-winchite rims for grains of amphibole contained in the core of the albite porphyroblasts (preserving Dr deformation features) in hematite-bearing metabasite indicates that the Dr deformation was formed during the burial phase related to subduction (Wallis et al., 1992)." (line 172 to 174 in marked-up manuscript version).

Fig. 2: Here you need to add P-T and time values.

Thank you for your valuable comments. Deformation temperature pressure conditions vary according to metamorphic grade, making it difficult to fill in specific values. Moreover, absolute time values are not determined. Therefore, the text has been amended as follows:

"(c) Main metamorphism P–T–D path of the Shirataki unit (Aoya, 2001) modified by Kouketsu et al. (2021)." (line 188 to 189 in marked-up manuscript version).

⇒ "(c) Deformation phases in the Shirataki unit (after Kouketsu et al., 2021). This P-T path

corresponds to each metamorphic zone P-T path in the main metamorphism in Fig. 2a." (line 189 to 190 in marked-up manuscript version).

The Fig. 2c was also modified to clarify the correspondence between Fig. 2a and Fig. 2c.

Line 154: Specify what kind of amphibole

We apologize for the confusing text. The text has been revised as follows.

"However, compositional changes of amphibole in the porphyroblasts and of Na-pyroxene in equilibrium with albite of the garnet zone suggest that part of the Ds deformation occurred during a pressure drop and temperature increase, i.e., before the peak metamorphic temperature was reached (Wallis et al., 1992; Enami et al., 1994)." (line 193 to 196 in marked-up manuscript version).

⇒ "However, amphibole formed at highest temperatures (barroisite or hornblende) in the porphyroblasts rim (formed during Ds deformation), and compositional changes of Na-pyroxene in equilibrium with quartz and albite of the garnet zone suggest that part of the Ds deformation occurred during a pressure drop and temperature increase, i.e., before the peak metamorphic temperature was reached (Wallis et al., 1992; Enami et al., 1994)." (line 196 to 199 in marked-up manuscript version).

Line 169 to 172: This is sample description, not methods. Additionally, please describe all the rock forming minerals of the sample

The following revised text has been moved to the beginning of Sec. 4 "Results":

"Five samples were collected at four locations to obtain deformation information under a wide range of temperature and pressure conditions (Fig. 3: ASM1–5). ASM1 is a sample from deformed quartz veins, which are in psammitic schist and are oriented subparallel to the foliation, and samples ASM2–5 are from quartz schist. Samples strongly affected by Dt or Du deformation were not used in this study." (line 219 to 222 in marked-up manuscript version)

⇒"Five samples were collected at four locations to obtain deformation information under a wide range of temperature and pressure conditions (Fig. 3). Samples strongly affected by Dt or Du deformation were not used in this study. Sample ASM1b is from a deformed quartz vein, which is part of a vein set developed in psammitic schist. The veins are oriented subparallel to the foliation (Fig. 6a). Sample ASM1a is from pelitic schist, and samples ASM2–5 are from quartz schist. The site where sample ASM2-5 was collected was covered by vegetation and the outcrop is not well exposed (Fig. S1). Psammitic schist and pelitic schist consist mainly of quartz, calcite, albite, phengite (Radvanec et al., 1994), chlorite, and graphite. Quartz schist consists mainly of quartz, phengite (Radvanec et al., 1994), albite, piemontite, ilmenite, and rutile."

(line 316 to 322 in marked-up manuscript version)

Line 204 to 207: This paragraph I think that it is not needed, at least here, might be moved to

discussion

Thank you for your valuable comments.

The relevant text has been deleted *(line 255 to 258 in marked-up manuscript version).*

In the following paragraphs, citations for BLG, SGR and GBM have been added *(line 259; line 274 to 275 in marked-up manuscript version).*

Line 257: Please, state here what menerals define the foliation

The text has been revised as follows.

(line 323 to 325in marked-up manuscript version): "The Ds foliation and stretching lineation of psammitic and pelitic schist around sample ASM1 is defined by pressure solution seams and quartz strain fringes developed around pyrite observed in the surrounding area Fig. 3; Fig. 6a)."

⇒"Ds foliation and stretching lineation of psammitic and pelitic schist around sample ASM1 is defined by pressure solution seams consisting of phengite, chlorite, and graphite and quartz strain fringes developed around pyrite (Fig. 3; Fig. 7a)."

Line 261: recrystallization?

Thank you for pointing this out. We have made the correction *(line 332 in marked-up manuscript version).*

Line 265: call it phengite you must have chemical analyses.

Thank you for pointing this out. We added a reference to chemical analyses. (Radvanec et al., 1994) *(line 322 and 323 in marked-up manuscript version).*

Line 328-330: This need to be moved to results section

The following revised text has been moved to the Sec. 4 "results":

"In sample ASM2-4, albite includes traces of a Dr foliation oblique to the external Ds foliation which is partly defined by the alignment of phengite. These observations suggest that both albite and phengite were formed before or synchronously with Ds, the timing of quartz deformation. This implies that albite and phengite have both been deformed along with the quartz."

(line 329 to 332 in preprint ⇒ line 345 to 348 in marked-up manuscript version).

The text of line 327 to 328 in preprint has been revised as follows.:

"In Sample ASM2–4, in addition to quartz (volume fraction 70–80%: inferred by indexing rate of EBSD analysis), albite and phengite are also significant mineral components (Fig. 6c–6f)." (line 327 to 328 in preprint).

⇒"In samples ASM2–4, in addition to quartz (volume fraction 70–80%: inferred by indexing rate of EBSD analysis), albite and phengite are also significant mineral components, which deformed along with quartz during Ds (Fig. 7c–7f)." (line 542 to 515 in marked-up manuscript version).

Line 342: This is a conference abstract not peer-reviewed. Please, find a better reference for this concept.

They recently published an article

https://www.sciencedirect.com/science/article/abs/pii/S0040195123000331?via%3Dihub

Thank you for pointing this out. We have removed the quotation from the relevant section when we revised the text.

Line 361: for what purpose?

The text has been revised as follows.

"The retrograde P-T gradient is the most important and this has been estimated as 0.3 GPa/100°C in the albite-biotite zone and 0.4 GPa/100°C in the garnet and chlorite zones (Fig. 6d and 6f in Okamoto and Toriumi, 2005)." (line 456 to 457 in marked-up manuscript version).

⇒"The retrograde P-T gradient is the most important to draw a retrograde P-T path, and this has been estimated as 3 MPa K^{-1} in the albite-biotite zone and 4 MPa K^{-1} in the garnet and chlorite zones (Fig. 6d and 6f in Okamoto and Toriumi, 2005)." (line 457 to 459 in marked-up manuscript version).

Line 398: Using the geothermal gradient provided above or the data from Enami et al., 2014? Please, specify

The text has been revised as follows.

"Estimates for the pressures at which samples ASM1 and 3 were deformed are about 0.55±0.1 GPa (21 km) and 0.7±0.2 GPa (27 Samples ASM2 and 4 were deformed at 0.45±0.1 GPa (17 km) and 0.5±0.1 GPa (19 km)." (line 497 to 499 in marked-up manuscript version).

⇒"Taking into consideration the peak pressure condition by Enami et al. (1994), the peak temperature condition by Kouketsu et al. (2021), the retrograde P-T gradient by Okamoto and Toriumi (2005), and estimated deformation temperature, pressures at which samples ASM1 and 3 were deformed are estimated as 0.55 ± 0.1 GPa (21 km) and 0.7 ± 0.2 GPa (27 km). Samples ASM2 and 4 were deformed at 0.45±0.1 GPa (17 km) and 0.5±0.1 GPa (19 km)." (line 499 to 502 in marked-up manuscript version).

Line 406: Please, add a ref here

We added references.

(e.g., Tagami and Takeshita, 1998) *(line 617 to 618 in marked-up manuscript version).*

Line 477: All your samples, except 3. 1 does not count, as the T is inferred by the onset of SGR

The text has been revised as follows.

"In Fig. 9, the samples with blue circles are considered to have formed later in the exhumation process than the other samples." (line 724 to 725 in marked-up manuscript version).

⇒"In Fig. 9, the samples with blue circles are considered to have formed later in the exhumation process than sample ASM3." (line 724 to 725 in marked-up manuscript version).

Line 481: Here I do not understand: those P estimates are linked to the deformation temperatures? Please specify, also discussing how you extract those from the PO-T path

The text has been revised as follows.

"Using the known P–T path we derived pressures for these samples of 0.7±0.2 GPa (27 km) for ASM3, 0.5±0.1 GPa (19 km) for ASM4, and 0.35±0.1 GPa (13 km) for ASM5." (line 731 to 732 in marked-up manuscript version).

⇒"Using the peak pressure condition by Enami et al. (1994), the peak temperature condition by Kouketsu et al. (2021), the retrograde P –T gradient by Okamoto and Toriumi (2005), and estimated deformation temperatures, we derived deformation pressure conditions for these samples of 0.7±0.2 GPa (27 km) for ASM3, 0.5±0.1 GPa (19 km) for ASM4, and 0.35±0.1 GPa (13 km) for ASM5." (line 727 to 730 in marked-up manuscript version).

Line 494: Well, only sample 3, all the others are much lower than RCMT

The text has been revised as follows.

"As shown in Fig. 9, many samples recorded deformation temperatures close to the peak and therefore represent conditions close to the onset of exhumation." (line 752 to 753 in marked-up manuscript version).

⇒" As shown in Fig. 9, there are few plots of deformation temperature conditions as low as ASM5, and almost all data recorded deformation closer to the onset of exhumation." (line 748 to 750 in marked-up manuscript version).

Line 494: But still within error, this is important to be stated here

The text has been revised as follows.

"In contrast, the estimated differential (shear) stress of sample ASM5, which is the final recorded stage of ductile deformation during ascent in this region, was found to increase significantly, ranging from 92.8 to 127.1 MPa (46.4 to 63.6 MPa)." (line 750 to 752 in marked-up manuscript version).

⇒" In contrast, the estimated differential (maximum shear) stress of sample ASM5, which is the final recorded stage of ductile deformation during ascent in this region, are 92.8–127.1 MPa (46.4–63.6 MPa). This is a significant stress increase although the uncertainties in absolute estimates are large." (line 746 to 748 in marked-up manuscript version).

Line 620 to 622: Can you cite a conference abstract? Please, check with journal rules

Thank you for pointing this out. *The relevant citation has been deleted.*

References

Aoya, M.: P-T-D Path of Eclogite from the Sambagawa Belt Deduced from Combination of Petrological and Microstructural Analyses, J. Petrol., 42(7), 1225–1248, 2001.

Aoya, M., Endo, S., Mizukami, T., and Wallis, S. R.: Paleo-mantle wedge preserved in the Sambagawa high-pressure: Metamorphic belt and the thickness of forearc continental crust, Geology, 41 (4), 451–454, doi:10.1130/G33834.1, 2013a.

Aoya, M., Noda, A., Mizuno, K., Mizukami, T., Miyachi, Y., Matsuura, H., Endo, S., Toshimitsu, and S., Aoki, M.: Geology of the Niihama District. Quadrangle Series 1:50,000, GSJ. AIST., Tsukuba, 2013b.

Berman, R. G.: Internally-Consistent Thermodynamic Data for Minerals in the System Na_2O-K_2O-CaO-MgO-FeO-Fe_2O_3-Al_2O_3-SiO_2-TiO_2-H_2O-CO_2, J. Petrol., 29 (2), 445–522, https://doi.org/10.1093/petrology/29.2.445, 1998.

Burnham, C. W., Holloway, J. R., and Davis, N. F.: The thermodynamic properties of water to 1000°C and 10, 000 bars, Geol Soc. Amer. Spec. Paper, pp.96, ISBN 13: 9780813721323, 1969.

Condit, C. B., French, M. E., Hayles, J. A., Yeung, L. Y., Chin, E. J., and Lee, C. A.: Rheology of Metasedimentary Rocks at the Base of the Subduction Seismogenic Zone, Geochem. Geophy. Geosy., 23 (2), https://doi.org/10.1029/2021GC010194, 2022.

Cross, A. J., Prior, D. J., Stipp, M., and Kidder, S.: The recrystallized grain size piezometer for quartz: An EBSD-based calibration, Geophys. Res. Lett., 44 (13), 6667–6674, doi:10.1002/2017GL073836, 2017.

Den Brok, S. W. J.: Effect of microcracking on pressure-solution strain rate: The Gratz grain-boundary model, Geology, 26 (10), 915–918, https://doi.org/10.1130/0091-7613(1998)026<0915:EOMOPS>2.3.CO;2, 1998.

Dobe, R., Das, A., Mukherjee, R., and Gupta, S.: Evaluation of grain boundaries as percolation pathways in quartz-rich continental crust using Atomic Force Microscopy, Sci. Rep., 11 (1), 1–10, https://doi.org/10.1038/s41598-021-89250-z, 2021.

Enami, M., Wallis, S. R., and Banno, Y.: Paragenesis of sodic pyroxene-bearing quartz schists: implications for the P-T history of the Sanbagawa belt, Contrib. Mineral. Petr., 116, 182–198, doi:10.1007/BF00310699, 1994.

Endo, S. and Yokoyama, S.: Geology of the Motoyama District. Quadrangle Series 1:50,000, Geol. Soc. Japan., Tsukuba, 2019.

Farver, J. and Yund, R.: Silicon diffusion in a natural quartz aggregate: constraints on solution-transfer diffusion creep, Tectonophysics, 325 (3–4), 193–205, https://doi.org/10.1016/S0040-1951(00)00121-9, 2000.

Fournier, R. O. and Potter II, R. W.: An equation correlating the solubility of quartz in water from 25° to 900°C at pressures up to 10,000 bars, Geochim. Cosmochim. Ac., 46 (10), 1969–1973, https://doi.org/10.1016/0016-7037(82)90135-1, 1982.

Giuntoil, F., Viola, G., and Sørensen, B. E.: Deformation Mechanisms of Blueschist Facies Continental Metasediments May Offer Insights Into Deep Episodic Tremor and Slow Slip Events, J. Geophys. Res-Sol. Ea., 127 (10), https://doi.org/10.1029/2022JB024265, 2022.

Handy, M. R.: Flow laws for rocks containing two non-linear viscous phases: A phenomenological approach, J. Struct. Geol., 16 (3), 287–301, https://doi.org/10.1016/0191-8141(94)90035-3, 1994.

Hickman, S. H. and Evans, B.: Kinetics of pressure solution at halite-silica interfaces and intergranular clay films, J. Geophys. Res-Sol. Ea., 100 (87), 13113–13132, https://doi.org/10.1029/95JB00911, 1995.

Holland, T. J. B. and Powell, R.: An internally consistent thermodynamic data set for phases of petrological interest, J. Metamorph. Geol., 16 (3), 309–343, https://doi.org/10.1111/j.1525-1314.1998.00140.x, 2004.

Hunter N. J. R., Hasalová, P., Weinberg, R. F., and Wilson, C. J. L.: Fabric controls on strain accommodation in naturally deformed mylonites: The influence of interconnected micaceous layers, J. Struct. Geol., 83, 180–193, https://doi.org/10.1016/j.jsg.2015.12.005, 2016.

Kawahara, H., Endo, S., Wallis, S. R., Nagaya, T., Mori, H., and Asahara, Y., Brucite as an important phase of the shallow mantle wedge: Evidence from the Shiraga unit of the Sanbagawa subduction zone, SW Japan, Lithos, 254–255, 53–66, https://doi.org/10.1016/j.lithos.2016.02.022, 2016.

Kouketsu, Y., Sadamoto, K., Umeda, H., Kawahara, H., Nagaya, T., Taguchi, T., Mori, H., Wallis, S., and Enami, M.: Thermal structure in subducted units from continental Moho depths in a paleo subduction zone, the Asemigawa region of the Sanbagawa metamorphic belt, SW Japan, J. Metamorph. Geol., 39 (6), 727–749, doi:10.1111/jmg.12584, 2021.

Lusk, A. D. J., Platt, J. P., and Platt, J. A.: Natural and Experimental Constraints on a Flow Law for Dislocation-Dominated Creep in Wet Quartz, J. Geophys. Res-Sol. Ea., 126 (5), https://doi.org/10.1029/2020JB021302, 2021.

Mariani, E., Brodie, K. H., and Rutter, E. H.: Experimental deformation of muscovite shear zones at high temperatures under hydrothermal conditions and the strength of phyllosilicate-bearing faults in nature, J. Struct. Geol., 28 (9), 1569–1587, doi:10.1016/j.jsg.2006.06.009, 2006.

Mori, H. and Wallis, R. S.: Large-scale folding in the Asemi-gawa region of the Sanbagawa Belt, southwest Japan, Isl. Arc., 19 (2), 357–370, https://doi.org/10.1111/j.1440-1738.2010.00713.x, 2010.

Okamoto, A. and Toriumi, M.: Progress of actinolite-forming reactions in mafic schists during retrograde metamorphism: An example from the Sanbagawa metamorphic belt in central Shikoku, Japan, J. Metamorph. Geol., 23 (5), 335–356, doi:10.1111/j.1525-1314.2005.00580.x, 2005.

Radvanec, M., Banno, S., and Okamoto, K.: Multiple stages of phengite formation in Sanbagawa schists, Miner. Petrol., 51, 37–48, 1994.

Rutter, E., H.: A Discussion on natural strain and geological structure - The kinetics of rock deformation by pressure solution, Philos. T. R. Soc. A., 283 (1312), 203–219, https://doi.org/10.1098/rsta.1976.0079, 1976.

Schmidt, W. L. and Platt J. P.: Stress, microstructure, and deformation mechanisms during subduction underplating at the depth of tremor and slow slip, Franciscan Complex, northern California, J. Struct. Geol., 154, https://doi.org/10.1016/j.jsg.2021.104469, 2022.

Shimizu, I.: Steady-State Grain Size in Dynamic Recrystallization of Minerals, in: Recrystallization, edited by Sztwiertnia, K., Intech, 371–386, doi:10.5772/33701, 2012.

Tagami, M. and Takeshita, T.: c-Axis fabrics and microstructures in quartz schist from the Sambagawa metamorphic belt, central Shikoku, Japan, J. Struct. Geol., 20 (11), 1549–1568, doi:10.1016/S0191-8141(98)00044-3, 1998.

Trepmann, C. A. and Seybold, L.: Deformation at low and high stress-loading rates, Geosci. Front., 10(1), 43–54, https://doi.org/10.1016/j.gsf.2018.05.002, 2019.

Tulley, C. J., Fagereng, A., and Ujiie, K.: Hydrous oceanic crust hosts megathrust creep at low shear stresses, Sci. Adv., 6(22), DOI: 10.1126/sciadv.aba1529, 2020.

Ujiie, K., Saishu, H., Fagereng, Å., Nishiyama, N., Otsubo, M., Masuyama, H., and Kagi, H.: An Explanation of Episodic Tremor and Slow Slip Constrained by Crack-Seal Veins and Viscous Shear in Subduction Mélange, Geophys. Res. Lett., 45(11), 5371–5379, https://doi.org/10.1029/2018GL078374, 2018.

Wallis, S. R.: The timing of folding and stretching in the Sambagawa belt: The Asemigawa region, central Shikoku, J. Geol. Soc. Japan., 96(5), 345–352, doi:10.5575/geosoc.96.345, 1990.

Wallis, S. R., Banno, S., and Radvanec, M.: Kinematics, structure and relationship to metamorphism of the east-west flow in the Sanbagawa Belt, southwest Japan, Isl. Arc., 1(1), 176–185, doi:10.1111/j.1440-1738.1992.tb00068.x, 1992.

Reply to Referee Comment #2 (RC2)

Thank you for your feedback and suggested revisions. We appreciate your time and effort in reviewing our preprint.

We have considered the comments and taken action accordingly. We have made changes to address the majority of the issues raised by the reviewer.

The manuscript carefully distinguishes various ductile deformation stages and then focuses on the main deformation stage. This main stage, however, represents early (and in one case late) exhumation. My concern is to what extent shear stress during exhumation can be applied to rapid subduction as the title suggests.

Thank you for pointing this out. We have made the correction as follows:

The deformations we have studied were recorded during the early and late stages of the exhumation. However, the orogen-oblique stretching lineation of the Ds deformation is thought to reflect deformation closely related to rapid (24 cm/yr: Engebretson et al., 1985; Ishii & Wallis, 2020) and oblique subduction of the subducted Izanagi Plate (e.g., Wallis, 1992; Wallis et al., 2009). For these reasons we consider that the deformation under consideration formed as the result of rapid subduction.

Moreover, if deformation of subducted sediments were driven by a combination of Couette flow (simple shear) driven by the subducting plate, and Poiseulle flow (channelized flow) driven by a pressure gradient produced by the buoyancy of the subducted sediment (e.g., Fig.4 in Platt et al., 2018), it is possible that exhumation of these rocks is associated with stable subduction. In this case, what we observed can be the area close to the overriding plate within the plate boundary domain.

In the paper, additions have made to Sec. 2.2 "Deformation of Shirataki unit during the main metamorphic stage" according to the description above. (line 206 to 209 in marked-up manuscript version).

The authors focus only on the quartz-rich regions. As outlined in the geological setting, the rocks are highly heterogeneous. The authors shortly

address the fact that ultramafic bodies are minor and can be neglected. Even if so, figure 3 clearly shows that the quartz shists are not the major lithology and that they are intercalated by pelitic and mafic shists. Such heterogeneities can cause stress concentration and result in larger scale stress gradients. Expanding the discussion in this direction as well as discussing relevant literature is needed.

Thank you for pointing this out. We have made the correction.

Tulley et al. 2020 compared the flow laws for various rocks with the strength of hydrous metabasalt inferred from the geological structure and quartz recrystallized grain size. The results showed that mica-containing metasediments can be harder or softer than hydrous metabasalt or amphibolite, depending on temperature conditions. It was also shown that the strength of hydrous metabasalt is reduced by pressure solution creep and slip of phyllosilicates, which plays an important role in deformation along the subduction boundary. Therefore, the discussion of deformation other than quartz schist, pelitic, and psammitic schist is important for the discussion of rock deformation at subduction boundaries.

In this study, no microstructural observations or stress estimates of quartz schist and basic schist in the chlorite zone, or pelitic and basic schist in the garnet and albite zones have been made. However, previous studies showed that the basic schist in the oligoclase biotite zone appears to be less affected by Ds deformation than other rock bodies (e.g., Mori and Wallis., 2010), indicating that the associated strain is smaller. In addition, the quartz schist in the garnet zone has well-developed sheath folds (Wallis, 1990; Endo and Yokoyama, 2019), which are not observed in the surrounding lithologies suggesting that the strain in the quartz schist is particularly high. It is therefore possible that each rock body was deformed at a different strain rate and may have been deformed at the same stress. To investigate this, stress estimates should be made from the quartz domains for each schist, and the strength relationship between the other domains and the quartz domains in each schist should be investigated from structural and textual observations to constrain the deformation strength of each schist. If the flow laws of the constituent minerals are known, they may be combined to estimate the deformation of the entire rock body (Condit et al., 2022). It is also important to focus on lithological boundaries to confirm the presence or absence of structures that are attributable to strength contrasts, and this is a topic for future research.

Shear zones by antigorite serpentinite exist at the boundary between mantle wedge-derived serpentinite and pelitic schist (Kawahara et al., 2016). Although the area examined in our study is on the oceanic plate side of the subduction boundary region, it is possible that different minerals and different stress and strain conditions existed on the overriding plate side. Further research is needed on this as well.

In the revised paper, Sec. 4.1 "Stress recorded by quartz microstructure and in the subduction plate interface" in preprint was removed, and the above text, figures, and tables were revised to fit in with the text of the paper and added as Sec. 5.2.3 "Deformation heterogeneity within different lithologies and stress in the subduction plate interface" (line 590 to 612 in marked-up manuscript version).

Furthermore, heterogeneities also occur on a micro scale. The piezometers were applied to quartz-only domains. The authors argue that the presence of sheet silicates inhibits grain growth and might cause wrong estimates on differential stresses. The authors argue further that sheet silicates do not form a network. However, in figure 6a it seems the sheet silicates form a continuous layer. Again, such heterogeneities can cause stress gradients. It would be interesting to see how much variation in shear stress is obtained between quartz-only domains and more heterogenous domains. And if significant these uncertainties should be included into the discussion. Knowing that additional measurements need time and effort, I think the manuscript would already benefit if these points were addressed theoretically in the discussion.

Thank you for your comments regarding the deformation of quartz-rich metasediments that also contain significant amounts of mica. We propose the following revisions.

●Sample ASM2,3,4

The estimated stresses are almost identical to the stresses received by the rock body. However, the stresses received by the mica minerals may be even smaller, as the strength of the mica is assumed to be lower than the strength of the quartz dislocation creep under the temperature conditions treated in our study.

Detail of the above discussion is stated in lines 40–69 of the reply comment for RC1.

●Sample ASM1

It is likely that the obtained stress is considered to be largely representative of the stresses undergone by the pelitic and psammitic schists of the chlorite zone. Such situations are only likely to occur when the deformation conditions are located near the boundary between the dislocation creep domain and the pressure solution creep domain. The change in the deformation mechanism between the vein/fringe and microlithon domains can be attributed to the difference in the degree of grain growth inhibition and activation of pressure solution creep due to the presence or absence of the quartz-mica boundary.

Detail of the above discussion is stated in lines 70–149 of the reply comment for RC1.

In the revised paper, the above text, figures, and tables (lines 40–176 of the reply comment for RC1) will be added as Sec. 5.2.1 "Stress recorded by sample ASM2, 3, 4 and stress received by surrounding quartz schist" and Sec. 5.2.2 "Stress recorded by sample ASM1 and stress received by surrounding psammitic and pelitic schists". (line 513 to 589 in marked-up manuscript version)

Line 70: "Shear stress is equal to half the differential stress." Only the maximum shear stress is equal to half the differential stress. Indeed, on line 37 the author write that shear stress is used for absolute maximum shear stress. I would suggest to strictly write maximum shear stress. The data presented are estimates on the maximum shear stress and for the discussion it is crucial to use accurate terms.

Thank you for pointing this out. *We have made the correction (e.g., line 10 in marked-up manuscript version).*

Figure 1: the unit boundary of the smaller eclogite units is hardly distinguishable from small ultramafic bodies. I suggest using different

colors for the boundary and the ultramafic bodies. (Actually, the color for ultramafic bodies in figure 3 is different)

Thank you for pointing this out. Lithology information will be deleted, and a geological map of the same area will be produced and placed side by side (Fig. 1b; line 151 to 155 in marked-up manuscript version). As this study focuses on the shirataki unit, lithology other than the shirataki unit has been omitted for simplicity of geological map.

Figure 2c: Can you add PT values here? Or otherwise plot the ductile deformation stages in 2a.

Thank you for your valuable comments. Deformation temperature pressure conditions vary according to metamorphic grade, making it difficult to fill in specific values. Therefore, the text has been amended as follows:

"The main metamorphism that formed the Shirataki unit has four recognized ductile deformation phases, named Dr, Ds, Dt, and Du deformation, respectively (Wallis, 1990; Fig. 2b, 2c)." (line 161 to 162 in marked-up manuscript version).
⇒" Each of the four metamorphic zones formed by the main metamorphic stage has a distinct P (pressure)-T (temperature) path (Fig. 2a). Moreover, the rocks in all metamorphic zones show evidence for four phases of ductile deformation, named Dr (burial), Ds (exhumation starting at near the peak metamorphic conditions), Dt (exhumation after the peak metamorphic condition), and Du (slight burial after exhumation) deformation, respectively (Wallis, 1990; Fig. 2b, 2c). Dt and Du are non-penetrative and it is unlikely they had a major influence on exhumation or burial." (line 162 to 167 in marked-up manuscript version).

"(c) Main metamorphism P–T–D path of the Shirataki unit (Aoya, 2001) modified by Kouketsu et al. (2021)." (line 188 to 189 in marked-up manuscript version).
⇒ "(c) Deformation phases in the Shirataki unit (after Kouketsu et al., 2021). This P-T path corresponds to each metamorphic zone P-T path in the main metamorphism in Fig. 2a." (line 189 to 190 in marked-up manuscript version).

The Fig. 2c was also modified to clarify the correspondence between Fig. 2a and Fig. 2c.

Figure 4: Can you also add pole figures?

Thank you for pointing this out. We have made the correction.

Fig. 4 is related to Sec. 3.2 " Differential (maximum shear) stress estimation ", so it has been added to Fig. 5, which is related to Sec. 3.3 "Deformation temperature estimation by quartz c-axes fabric opening-angle thermometer ". (Fig. 5a in marked-up manuscript version)

Table 3: The Cr+Ho data are a based on a corrected version of the Cross et al. piezometer after Holyoke et al. This is only mentioned in the discussion part. Please add some details also in the method section for better understanding of the present table.

Thank you for pointing this out. The following text has been added to the method section.

"We also used the piezometer of Cross et al. (2017) with a correction for measured values by Griggs apparatus, which is proposed by Holyoke and Kronenberg (2010). In this case, the stress value is 0.73 times the value obtained by piezometer of Cross et al. (2017)." (line 276 to 279 in marked-up manuscript version).

Once again, we sincerely appreciate the opportunity to address your comments and concerns. If you have any further comments or queries, please do not hesitate to contact us.

Yours sincerely

Authors.

References

Aoya, M.: P-T-D Path of Eclogite from the Sambagawa Belt Deduced from Combination of Petrological and Microstructural Analyses, J. Petrol., 42 (7), 1225–1248, 2001.

Berman, R. G.: Internally-Consistent Thermodynamic Data for Minerals in the System Na_2O-K_2O-CaO-MgO-FeO-Fe_2O_3-Al_2O_3-SiO_2-TiO_2-H_2O-CO_2, J. Petrol., 29 (2), 445–522, https://doi.org/10.1093/petrology/29.2.445, 1998.

Burnham, C. W., Holloway, J. R., and Davis, N. F.: The thermodynamic properties of water to 1000°C and 10, 000 bars, Geol Soc. Amer. Spec. Paper, pp.96, ISBN 13: 9780813721323, 1969.

Condit, C. B., French, M. E., Hayles, J. A., Yeung, L. Y., Chin, E. J., and Lee, C. A.: Rheology of Metasedimentary Rocks at the Base of the Subduction Seismogenic Zone, Geochem. Geophy. Geosy., 23 (2), https://doi.org/10.1029/2021GC010194, 2022.

Cross, A. J., Prior, D. J., Stipp, M., and Kidder, S.: The recrystallized grain size piezometer for quartz: An EBSD-based calibration, Geophys. Res. Lett., 44 (13), 6667–6674, doi:10.1002/2017GL073836, 2017.

Den Brok, S. W. J.: Effect of microcracking on pressure-solution strain rate: The Gratz grain-boundary model, Geology, 26 (10), 915–918, https://doi.org/10.1130/0091-7613(1998)026<0915:EOMOPS>2.3.CO;2, 1998.

Dobe, R., Das, A., Mukherjee, R., and Gupta, S.: Evaluation of grain boundaries as percolation pathways in quartz-rich continental crust using Atomic Force Microscopy, Sci. Rep., 11 (1), 1–10, https://doi.org/10.1038/s41598-021-89250-z, 2021.

Endo, S. and Yokoyama, S.: Geology of the Motoyama District. Quadrangle Series 1:50,000, Geol. Soc. Japan., Tsukuba, 2019.

Engebretson D. C., Cox A., and Gordon R. G.: Relative Motions Between Oceanic and Continental Plates in the Pacific Basin, Geol. Soc. Am., doi:10.1130/SPE206-p1, 1985.

Farver, J. and Yund, R.: Silicon diffusion in a natural quartz aggregate: constraints on solution-transfer diffusion creep, Tectonophysics, 325 (3–4), 193–205, https://doi.org/10.1016/S0040-1951(00)00121-9, 2000.

Fournier, R. O. and Potter II, R. W.: An equation correlating the solubility of quartz in water from 25° to 900°C at pressures up to 10,000 bars, Geochim. Cosmochim. Ac., 46 (10), 1969–1973, https://doi.org/10.1016/0016-7037(82)90135-1, 1982.

Handy, M. R.: Flow laws for rocks containing two non-linear viscous phases: A phenomenological approach, J. Struct. Geol., 16 (3), 287–301, https://doi.org/10.1016/0191-8141(94)90035-3, 1994.

Hickman, S. H. and Evans, B.: Kinetics of pressure solution at halite-silica interfaces and intergranular clay films, J. Geophys. Res-Sol. Ea., 100 (87), 13113–13132, https://doi.org/10.1029/95JB00911, 1995.

Holland, T. J. B. and Powell, R.: An internally consistent thermodynamic data set for phases of petrological interest, J. Metamorph. Geol., 16 (3), 309–343, https://doi.org/10.1111/j.1525-1314.1998.00140.x, 2004.

Holyoke, C. W. and Kronenberg, A. K.: Accurate differential stress measurement using the molten salt cell and solid salt assemblies in the Griggs apparatus with applications to strength, piezometers and rheology, Tectonophysics, 494 (1–2), 17–31, doi:10.1016/j.tecto.2010.08.001, 2010.

Hunter N. J. R., Hasalová, P., Weinberg, R. F., and Wilson, C. J. L.: Fabric controls on strain accommodation in naturally deformed mylonites: The influence of interconnected micaceous layers, J. Struct. Geol., 83, 180–193, https://doi.org/10.1016/j.jsg.2015.12.005, 2016.

Ishii, K. and Wallis, Simon. R.: High- and low-stress subduction zones recognized in the rock record, Earth. Planet. Sc. Lett., 531, doi:10.1016/j.epsl.2019.115935, 2020.

Kawahara, H., Endo, S., Wallis, S. R., Nagaya, T., Mori, H., and Asahara, Y., Brucite as an important phase of the shallow mantle wedge: Evidence from the Shiraga unit of the Sanbagawa subduction zone, SW Japan, Lithos, 254–255, 53–66, https://doi.org/10.1016/j.lithos.2016.02.022, 2016.

Lusk, A. D. J., Platt, J. P., and Platt, J. A.: Natural and Experimental Constraints on a Flow Law for Dislocation-Dominated Creep in Wet Quartz, J. Geophys. Res-Sol. Ea., 126 (5), https://doi.org/10.1029/2020JB021302, 2021.

Mariani, E., Brodie, K. H., and Rutter, E. H.: Experimental deformation of muscovite shear zones at high temperatures under hydrothermal conditions and the strength of phyllosilicate-bearing faults in nature, J. Struct. Geol., 28 (9), 1569–1587, doi:10.1016/j.jsg.2006.06.009, 2006.

Mori, H. and Wallis, R. S.: Large-scale folding in the Asemi-gawa region of the Sanbagawa Belt, southwest Japan, Isl. Arc., 19 (2), 357–370, https://doi.org/10.1111/j.1440-1738.2010.00713.x, 2010.

Platt, J. P., Xia, H., and Schmidt, W. L.: Rheology and stress in subduction zones around the aseismic/seismic transition, Prog. Earth Planet. Sci., 5 (24), https://doi.org/10.1186/s40645-018-0183-8, 2018.

Rutter, E., H.: A Discussion on natural strain and geological structure - The kinetics of rock deformation by pressure solution, Philos. T. R. Soc. A., 283 (1312), 203–219, https://doi.org/10.1098/rsta.1976.0079, 1976.

Schmidt, W. L. and Platt J. P.: Stress, microstructure, and deformation mechanisms during subduction underplating at the depth of tremor and slow slip, Franciscan Complex, northern California, J. Struct. Geol., 154, https://doi.org/10.1016/j.jsg.2021.104469, 2022.

Tulley, C. J., Fagereng, A., and Ujiie, K.: Hydrous oceanic crust hosts megathrust creep at low shear stresses, Sci. Adv., 6 (22), DOI: 10.1126/sciadv.aba1529, 2020.

Wallis, S. R.: The timing of folding and stretching in the Sambagawa belt: The Asemigawa region, central Shikoku, J. Geol. Soc. Japan., 96 (5), 345–352, doi:10.5575/geosoc.96.345, 1990.

Wallis, S. R.: Vorticity analysis in a metachert from the Sanbagawa Belt, SW Japan, J. Struct. Geol., 14 (3), 271–280, doi:10.1016/0191-8141(92)90085-B, 1992.

Wallis, S. R., Anczkiewicz, R., Endo, S., Aoya, M., Platt, J. P., Thirlwall, M., and Hirata, T.: Plate movements, ductile deformation and geochronology of the Sanbagawa belt, SW Japan: Tectonic significance of 89-88 Ma Lu-Hf eclogite ages, J. Metamorph. Geol., 27 (2), 93–105, https://doi.org/10.1111/j.1525-1314.2008.00806.x, 2009.

Other Changes

The following amendments were made to improve the accuracy of the text.

"Quartz grains in microlithon domain become finer due to grain growth inhibition by different minerals such as phyllosilicates (Fig. 7a)." was added in line 333 to 335 in marked-up manuscript version.

"Depth is calculated assuming thickness of granitic upper crust (2700kg m^{-3}) is 20 km and that of gabbroic lower crust (3000kg m^{-3}) is 10 km." was added in line 459 to 460 in marked-up manuscript version.

"Applied grain sizes were arithmetic mean and were calculated from the grain boundaries for Shimizu (2012)." was added in line 662 to 663.

"Even taking these effects into account, the obtained stress values in this study are greater than those of Takeshita (2021). This may be due to the fact that the EBSD-based grain boundary estimation method makes it possible to consider smaller grains." was added in line 680 to 681 in marked-up manuscript version.

The text in Appendix B has been amended to supplement the relationship between dislocation density and grain size. (line 787 to 826 in marked-up manuscript version)

Fig. 4 was modified because the particles did not correspond between (c) the grain boundary map and (d) the grain size histogram.

Fig. 7 (d) (e) (f) and Fig. 10 have incorrect scales and have been corrected.

Tables 1, 2, and 3 were rewritten as new Tables 1 and 2.

To improve readability, the layout and the name of legends of Fig. 9 has been partially changed.

The layout of Table A1 has been changed.

To improve readability, the layout of Figs. 12, 13 and 14 have been partially changed. In addition, a numerical error in the error calculation was found (line 847 in marked-

up manuscript version) and corrected.

Minor grammatical and expressive corrections were made in several other places.