Solid Earth Discuss.,
https://doi.org/10.5194/se-2019-110-AC2, 2019

Solid Earth
Discussions
Open Access
EGU

Interactive comment on "Fracturing and crystal plastic behavior of garnet under seismic stress in the dry lower continental crust (Musgrave Ranges, Central Australia)" *by* Friedrich Hawemann et al.

Friedrich Hawemann et al.

friedrich.hawemann@fu-berlin.de

Received and published: 20 August 2019

We want to thank the anonymous reviewer for his critical review and suggestions. Below is a list of all comments from the reviewer (RC), answers from the authors (AC) and manuscript changes (MC).

—

Reviewer 2, general comment

RC: The main message of this manuscript is the occurrence of crystal plasticity in garnet at temperatures well below the laboratory derived data for the onset of crystal

Printer-friendly version

Discussion paper

plastic deformation in garnet. The authors, therefore, state that laboratory data fail to explain the natural observations. Of course laboratory experiments are most often very simplified rendering extrapolation to natural systems rather challenging. Though, I miss a bit the explanation why the laboratory data does not match natural observations. Is it because the samples in the laboratory were even drier than the natural rock delaying the onset of crystal plastic deformation in the laboratory? Obviously there were some fluids present due to the occurrence of biotite. Though in some parts of the manuscript, the authors state that a Ca-rich garnet forms instead of epidote, because of the low water activity (line 290). Perhaps there was enough water around to facilitate crystal plastic deformation but not enough to stabilize epidote? I think it would improve the manuscript to discuss the role of fluids on crystal plastic deformation in more detail. This might also explain the discrepancy between laboratory data and the natural observations.

AC: We have added text in several places to expand the discussion of the apparent discrepancy with laboratory data, in particular considering the potential effects of strain rate and role of fluids. We agree that this should have been treated in more detail, which is why we now have a rather more nuanced approach, considering factors that may have an influence rather than just stating that there is a difference.

—

Reviewer 2, specific comments

RC: Line 71: In this context I think crystal plastic deformation instead of ductile deformation is more appropriate.

AC: agree

MC: changed sentence: “between brittle and crystal plastic deformation of garnet”

-

RC: Lines 276-278: Did you investigate/find garnet crystals that were cut by a pseudo-

tachylyte? Both studies that you cite, Austrheim et al. (2017) and Papa et al. (2018), demonstrate garnet crystals that are situated right next to a pseudotachylyte-bearing fault. I mention this, because as strain rate and stresses decrease very rapidly with increasing distance, the required stresses and/or strain rates at a few mm to the fault might not be sufficient anymore to extensively fragment garnet.

AC: In the text, we clearly state that "Granulite facies garnet porphyroclasts in Musgravian peraluminous gneisses mylonitized during the Petermann Orogeny are almost invariably fractured, irrespective of their proximity to pseudotachylyte (Fig. 3)." This is different than what was observed in the examples of Austrheim et al. (2017) and Papa et al. (2018) mentioned above, which is why we made such a clear statement originally. On the basis of this observation, we argue in the text that the whole rock was affected by high stresses during transient seismic events and that garnet fracturing is not restricted to the localized damage zone of a propagating fracture (Petley-Ragan et al, 2019; Austrheim et al., 2017) or thermal shock immediately adjacent to the high temperature pseudotachylyte (Papa et al., 2018).

-

RC: Line 286: Delete 'of some'.

AC: agree

MC: Typing error corrected.

-

RC: Lines 291-292: So everything is dry, but suddenly there is biotite? You should discuss the presence/absence of hydrous minerals a bit more.

AC: Biotite is a typical mineral of granulite facies assemblages up to the point of melting (with biotite then providing the water for "anhydrous" melting) and even then biotite is a common mineral in the restite assemblage. "Kinzigite", which is a typical "dry" lower-crustal granulite facies rock, is actually defined as having garnet + biotite. As

Printer-friendly version

Discussion paper

noted by Pennacchioni and Cesare (1997), under upper amphibolite facies conditions, newly grown biotite can actually act as a sink for any free water available and the same will be true for the “dry” high pressure upper amphibolite (“sub-eclogitic”) facies conditions relevant to the current study. Pennacchioni, G. & Cesare, B., 1997. Ductile-brittle transition in pre-Alpine amphibolite facies mylonites during evolution from water-present to water-deficient conditions (Mont Mary nappe, Italian Western Alps). Jour. Metm. Geol. 15, 777-791.

-

RC: Lines 304-305: Shimada et al. (1983) experimentally investigated that the angle changes from around 30 to approx. 45âŮę with increasing pressure.

MC: The reference was added to the text: “This plot is only qualitative, since the angle of internal friction could decrease towards higher pressure (Shimada et al., 1983).”

-

RC: Lines 311-313: See comment above. As water seems important you should perhaps quantify the amount of water? There is some water present in the other field studies mentioned, but not very much. How should the presence of a fluid help to fragment the rock?

AC: As noted already in Wex et al. (2018), for the relevant pressure and temperature conditions, the presence of kyanite as the result of plagioclase breakdown, to the exclusion of clinozoisite / epidote, implies a water activity of less than ca. 0.004, according to Wayte et al. (1989) (as is also noted again in the current manuscript). The examples from Holsnoy all have extensive development of clinozoisite during eclogite formation.

-

RC: Figure 5: The difference between fracture types I and II is not very clear to me. The magnification at which the image was taken is quite low and therefore it is difficult to see subgrains.

AC: The step-size for this map was 2 micrometres, which is obviously a compromise due to the large area of the garnet, and individual points are still visible in the figure. Unfortunately, we do not have a higher resolution scan for the specific area. We hope that the subgrains are still visible as slight changes in colour and grey-values, as seen and highlighted in the red area. We admit that there is no genetic difference between the proposed fracture sets I and II and have therefore dropped any differentiation between the two.

MC: Figure 5 was changed in regard to the labelling of the fractures and the text was changed accordingly.

Interactive comment on Solid Earth Discuss., https://doi.org/10.5194/se-2019-110, 2019.