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Solid Earth
Discussions

Interactive comment on "Texture analysis of experimentally deformed Black Hills Quartzite" *by* Rüdiger Kilian and Renée Heilbronner

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First of all I would like to apologize for the delay in my review. In this paper, the authors performed detailed microstructural and texture analyses of three samples of Black Hills quartzite deformed experimentally in the dislocation creep regime 1 to 3 (Hirth and Tullis 1992). The chosen samples were deformed at relatively high bulk strains (gamma $\sim$3) under similar temperatures (temperature range of 65°C) and similar constant rates, and the only difference is the peak and flow stresses. Their results show that the samples deformed in the regime 1 and 3 are clear end members in terms of microstructures and textures (in terms of CPO), while the sample from regime 2 being the transitional member. The authors shows that the CPO strength increasing towards the regime 3 is directly related to the deformation intensity at the grain scale and on the contribu-

tion to dislocation creep regime, that also increases towards this regime. The paper is provocative as it proposes that peripheral quartz [c] axes are not related to basal <a> slip but due to nucleation and growth of specific fragments during microcracking in a high stress environment. By itself this is a very important observation/conclusion, as most of the papers showing similar patterns are interpreted in terms of basal <a> slip activity and sometimes even in terms of deformation temperatures (where the presence of this patterns indicating low temperatures). The authors performed a very detailed CPO analyses in terms of grain sizes, aspect/axial ratios and even proposed a new color-coding for misorientation analyses combining the crystal and sample reference frame. The paper is well written, although here and there one may find some very long sentences that are hard to follow (I've tried to specified them below), and the figures are in general quite good and very illustrative. This paper will certainly have a high number of citations in the future and certainly fits the topics published in the Solid Earth journal. Before publication nevertheless, the authors may want to consider the following comments/suggestions:

1) The authors suggested that the quartz grains with peripheral c-axes are not due to the activity of basal <a> slip, but result from stress-controlled growth of new grains. The authors mention that they "do not have any direct evidence of fracture/nucleation/growth" (lines 654-655), but compare their observations with other experimental work where the grains in the B domain seem to be first to form under high stresses. I am quite sure the authors had a careful look for the presence of fluid inclusions related to those peripheral, but I think the authors can improve the "speculation" about the origin of those grains. For instance, Karato and Masuda (1989 – Geology) demonstrated that fine grained quartz aggregate may have significant grain growth during high temperature experiments when water is present. In their case, flatten quartz grains with aspect ratios much higher than the deformation-induced flattening were observed during recrystallization at relatively low T and high deviatoric stresses, while in higher temperatures and low atrain rates, show small grain flattening. According to their model the difference in microstructures is due to the distribution of water in

different conditions: while in low deviatoric stresses the distribution of water is more isotropic, occurring in isolated pores. Under a high stress however, the fluid phase will form a film normal to sigma 3. This roughly means that the longest axis of these films will be parallel to sigma 1. Now assuming that this is the case, and assuming that quartz will "grow" more along the c-axis (e.g. Iwasaki et al. 1997 – Journal of Crystal Growth), that might explain the peripheral grains. The authors may also want to have a look in Masuda and Fujimura (1981 – Tectonophysics) I am not sure how elasticity would influence (comments from the authors, line 662), but I think it is worth to discuss also this possibility;

2) The authors mentioned that the in certain conditions, the quartz c-axes form not one maxima around Y, but two, separated by a certain angle. This is not visible in any of the images, and I think this is an important observation. In addition, it was not clear to me why do you form two maxima instead of one, and I think this part deserves a longer discussion;

3) I am aware that the authors performed an extensive literature review about the possibility (or not) of basal <a> slip occur in quartz, but this is not really presented in the manuscript. Because this is a very important point of the paper, I believe the full review they have performed will help to clarify a number of obscure points about quartz slip systems in general, and in particular (c)<a>;

4) The color-coding linking the misorientation information from the crystal reference frame and the sample reference frame is an innovative idea here, but the bottom half of the triangle is too dark in the printed version (they are fine in the computer). Maybe this is something related to the "contrast" in the colorcode that you can change? In addition, because everything is very dark, one cannot read what is written over there, so I recommend the authors to write in white. Also, because you are using a point group 321, would not be better to have a representation of 120° fundamental sector, instead of 60°

Minor comments include:

Line 25: "...not due to deformation by basal <a> slip, but possibly by..." – complete

Lines 33-42 – this sentence is too long and hard to follow, I recommend the authors to slip it in two or three shorter sentences;

Line 44 – "the underlying mechanisms and processes of texture development are poorly understood. In addition, the relationship between temperature and recrystallization mechanisms (...) or texture geometry and strain in polycrystalline materials are not always separated.

Line 53 - ...(e.g. Blacic, 1975). However, conclusions...

Line 70 – ...(stipp and kunze, 2008). In this sample, recrystallization...

Line 102 – Pt jacket

Line 113 – Forgot to insert the details here

Line 116 – why sample w1092 appear twice?

Line 126 – Crystal directions [0001],<11-20> and poles to planes (0001), ...

Line 134 – You mentioned here that "grains from different maps of identical stepsize...have been combined", you should add that the maps belong to the same sample;

Line 141 – "because of...", instead of "since";

Line 172 – can you clarify why you have used a misorientation of 9°, instead of 10 or 15°?

Line 226 – A schematic inset showing the directions for the IPF would be very helpful, particularly for those readers starting to work with CPOs;

Line 262 – Somewhere in this paragraph you have to state that theta is the angle

between the shear direction and the longest axes of quartz, this is not clear here;

Line 287 – Move this paragraph after Line 280, it makes more sense there;

Line 290 – It might be worth writing a sentence explaining what is the difference between aspect ratio and axial ratio;

Line 318 and Figure 7 – this figure needs a better explanation and a better labelling, it is not easy for a non-specialist to read these 2D histograms. In addition the axes in the graphics are not very clear

Line 350 – I suggest the authors to add one or two lines about the <a>-intransparency;

Line 374 – Where is the <7-2-56> in the IPFs?

Line 391 – “independent”, instead of “disrespect”

Line 400 – {m} does not have this crystallographic. . .

Line 494 – You may want to cite Hansen et al. 2012 JGR?;

Line 503 – 507 – this sentence is a bit confuse, I suggest the authors to rewrite it;

Lines 509 – 512 – You could possibly quantify that the newly formed grains in regime 1 are smaller and have less lattice distortion, meaning that they are less deformed, this seems to be the case at least for the grain sizes from Heilbronner and Kilian, the companion paper of this manuscript;

Line 556 – {a} or {m}?

Line 592 – 597 – sentence too long, please split in 2;

Line 598 – 599 – this sentence is confusing. . .did you mean “ Because the displacement rate is constant and the temperature differences are very small in the current experiments. . .”

Line 606 – as well as is repeated;

Lines 616 – 645 – I found this part a bit confusing, maybe the authors want to rephrase some of the sentences and clarify the text;

Line 669 – references needed after “. . .as an easy slip system.” – you may introduce them here if you consider my third comment;

Figures – I recommend the authors to increase the font sizes, particularly from the figures with a number of different pole figures. Also, I suggest the authors to use the ‘contourf’ option in their plots of Figure 5. I think a simple sketch showing the reference frame of the pole figures and illustrating the main directions used for the IPFs (in relation to the experiment assembly) will be very helpful

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