Solid Earth Discuss., 6, C913–C919, 2014
www.solid-earth-discuss.net/6/C913/2014/

Solid Earth
Discussions
Open Access

Interactive comment on "Finite lattice distortion patterns in plastically deformed zircon grains" *by* E. Kovaleva et al.

E. Kovaleva et al.

elizaveta.kovaleva@univie.ac.at

Received and published: 9 September 2014

We are grateful for our reviewers for their valuable contributions to improve this manuscript.

Answer to reviewers comments:

Specific comments from Dr N. Timms:

1. Question about crystal anisotropy, shear modulus, Poisson ratio. Even though the Young's modulus plot finally was considered to be correct, the image has been removed and the corresponding section in the text also. This discussion has to be contributed to some other topical manuscript that would be more appropriate for it.

2. Various rheological terminology – the confusing terms as viscosity and elasticity were removed. Instead of viscosity, in respect to the host phases, the terms "strong" and "soft" are used now.

3. An answer was given earlier in interactive discussion

4. An answer was given earlier in interactive discussion

Technical corrections from Dr N. Timms:

1. P1801 lines 11-12: appropriate references are incorporated

2. P1801 lines 12-13: the phasing is changed

3. P1801 lines 23-25: the missing references are added

4. P1802 lines 6-8: the phrasing is changed

5. P1802 lines 15-17: the phrasing is changed

6. P1802 lines 19-23, 28: wording has changed

7. P1803 line 7: changed

8. P1804 line 21: incorrect statement is removed

9. P1805 lines 6-7: wording has changed

10. P1809 line 3, 8: corrected

11. P1814 line 10: corrected

12. P1822 line 17: corrected, also everywhere through-out the text

13. P1829 line 17: corrected

14. P1833 section 8.4: Thanks!

15. P1834 section 8.5: deleted

16. P1835-1836, section 8.6 “grain shape”: the reference for Kaczmarek et al., 2011 is more appropriate for the section 8.2., where the orientation of differential stress with respect to the lattice orientation is discussed. Accordingly, it is inserted there. Discussion on Reddy et al., 2009 has been included in the section 8.6. “grain shape”

17. P1838-1839, section 9 “conclusions”: corrected Additionally:

18. Reference for Timms et al. (2012a) (“Inclusion-localized crystal-plasticity..”) has been added to the sections where inclusion-related deformation is discussed.

General comments from Dr S.Piazolo:

1. Table 1 with the basic information is provided and included in supplementary data section;

2. Required data is provided now in table 1.

3. The term “decoupling” means when the grain is able to slide along grain-matrix interface. Decoupling from the matrix can be identified not only (i) by presence of coating at the interface (quartz, for example) and by (ii) opening of voids at the interface; but also by (iii) evidence of sliding of inclusion in matrix, when the elements of inclusion and matrix are shifting with respect to each other (see, for example, Kenkman 2000, JSG). We use this term for the grains 28 (Fig.4) and 15a (Fig.5). For the grain 28 decoupling is very nicely shown by normal and reverse drag of the adjacent biotite (lower left, lower right), case (iii), and also there is a void parallel to the lower face of the grain, case (ii). For the grain 15a there is a void parallel to the left, upper and lower faces, case (ii), and along the right face there is recrystallized biotite, case (i). There were also decoupled grains from the same sample in the Fig. 9 B (drag of biotite, pressure shadow filled with titanite), Fig. 9 C (same, but not visible in the presented image). Despite, if the grains would be coupled, they would not be able to have differential stress and deform separately from the matrix (see e.g. Mancktelow 2008). The explanation was included in the the text.

4. Structure type vs. metamorphic grade is reflected now in fig. 13. However, taking into account only 2 sample locations mentioned in this study, we would rather not make any global conclusions. Information on zircon grain size distribution is now provided in the table 1.

5. Data provided in table 1.

6. We don’t know the finite strain for the samples and for metamorphic grade. Generally, I am not sure if different microstructures of zircon deformation can be directly linked with the macroscopic strain. Locally, at the microscopic scale, distribution of strain is inhomogeneous; deformation structures of zircon grains are also distributed inhomogeneously, depending more on closest host environment.

7. Figure 13 has been changed to reflect the statistics. Grain size distribution is provided in the table 1.

8. Grain images are given in the thin section reference frame, what is mentioned in methodology section. I don’t quite understand what does “strain/stress reference frame” exactly mean. We were trying to cut thin sections in x-z plane (normal to foliation and parallel to lineation), however, it is not always exactly so, for example, for the sample BH12-07 stretching lineation is at about 45 degrees to the thin section cut. This remark was added to the text. If “strain/stress reference frame” means something else, then, we don’t have any further information.

Figure captions are corrected.

We don’t give each grain its own category, there are several examples for each case from 1 to 4: for group III-1: grains BH12-05B_07 (fig. 3) and BH12-07A_04 (fig. 9 B); group III-2: grains BH12-07A_03a (Fig.9 A), BH12-07A_04 (Fig. 9 B), BH12-07B_15a (Fig. 5), BH12-07B_28 (Fig. 4), BH12-07B_31b (Fig. 9 C); group III-3: BH12-01B_22 (Fig. 6), BH12-07A_04 (Fig. 9 B); group III-4: BH12-04_11 (Fig. 7), BH12-07A_03a (Fig. 9 A) (see Table 2).

However, those are end-members, usually analyzed grains fall between the presented end members.

9. The rotation of fragments is unsystematic; in the misorientation axes distribution diagram the clustering is very weak. But the axes are not unsystematic, this term used inappropriate here. Thus, our poor wording is improved. The fragments came from breaking down of parent grain due to plastic and cataclastic deformation, possibly similar to what is shown in Rimsa et al., 2007, where the fragments are "rotated, but not dispersed".

10. We cannot provide data in CPO in the whole population of zircons, we can only talk about several cases of similar orientation, that is not a real CPO. So, inappropriate terminology removed from the text and corrected accordingly.

11. Referencing was expanded and improved as was suggested.

12. Specific comments are introduced to the discussion.

Specific comments from Dr S.Piazolo:

1. The sentence was rephrased. 1a. References for subgrain walls are added.

2. Information about adopted terminology has been moved to the methodology section.

3. The specification is introduced. Means "dissolution-reprecipitation" in fluid presence (e.g. Geisler et al., 2001; 2003).

4. Section is restructured, combined, changes and clarifications are made.

5. Words are replaced, the sampled rocks are specified.

6. We haven't noticed any systematic relationships between size and plastic deformation microstructures. As you can see from the presented samples, crystal-plastic deformation occurs in grains from 10 to more than 50 micrometers in size. Moreover, sometimes the same grains are deformed plastically and cataclastically at the same

time. The larger grains are more often being fragmented, however, I don't think that this discussion is appropriate in this manuscript. Separate research has to be done to answer these questions. Description of fig. 8 – rephrased in order to correspond.

7. "brittlely" – from a dictionary, the adverb from brittle. However, could be replaced for "cataclastically" that is better.

8. Replaced!

9. The section 4.3 about EBSD method is shortened and missing information on filtering, etc. is added.

10. Reorganized, introduction to each distortion type is added. Regarding the pole figures – the data is always shown for the whole grain (or part of the grain which is mapped with EBSD), as highlighted in the EBSD map. Only in one case data is shown for 2 distinct areas that are highlighted by rectangles (Fig. 11). Information added to the methodology section.

11. Discussion of "indenter" interpretation is added.

12. Division into groups is abolished, now we just discuss several possible "cases", section is shortened where is possible. Statistics on subgrain size in each sample is added to the Table 1. About the decoupling we gave the explanation above, so, it should be clear now.

13. Section about CPO is deleted and discussion of data is rephrased.

14. Section 7 is restructured.

15. Shortened, discussion is only with respect to presented data.

16. Inappropriate sections are deleted.

17. Combined and shortened.

18. Sections are shortened and combined.

19. Section is reduced and reorganized. About unfluence of temperature - see interactive comment we gave to Dr Timms. Apparently yes, it doesn't play a significant role here. There could be no clear trend in internal misorientation for each distortion pattern, as misorientation is mainly controlled by host environment, and distortion pattern, as we suggested, is controlled by dislocations formation/motion rate. We made an attempt to rework the model, however, if the reviewers decide that it is still not convincing, we will remove the image 15.

20. Conclusions are corrected accordingly.

Interactive comment on Solid Earth Discuss., 6, 1799, 2014.